ABSTRACT

Title of Dissertation:	CLIMATE CHANGE AND POLITICAL CONTENTION – A MECHANISM-BASED FRAMEWORK
	Zafar Imran, Doctor of Philosophy, 2019
Dissertation directed by:	Research Professor Nancy Gallagher, School of Public Policy Professor Anand Patwardhan, School of Public Policy

This dissertation proposes a framework to systematically analyze the potential of climate change to cause social and political unrest. Extant literature generated on the topic seems to have come to a standstill in establishing whether such a link exists, as there is no clear evidence that climate-related stresses directly contributed to civil war onset. The framework put forth in this research makes the case that climate change *process*, contrasted from climate change variables aggregated at the country-year level, unfolds in a varied manner within and across societies. It is the interaction of changes in the natural system with a society's preexisting social, economic, and political processes, in addition to coping responses from vulnerable populations, that determine the nature and trajectory of social and political stresses. The dissertation contends, most notably, that the fundamental problem with the extant analytical approach has more to do with ontological assumptions than explanatory approaches

(qualitative vs. quantitative). Given the complexity and emergence inherent in the phenomenon under consideration, the positivist ontology is unsuited and incapable to reveal causal pathways linking climate change with predictors of social and political instability and conflict. This research uses critical realism as an ontological basis for the mechanism-based framework proposed in this dissertation. The framework is applied on the case study of Pakistan where direct and indirect effects of climate change are interacting with the country's political economy, and imposing social and political stresses to the extent of stoking a social movement organized and run by vulnerable farmers. Intra-annual changes in the Indus stream-flows, as well as temporal and spatial changes in the long-term trends of temperature and rainfall have destabilized Pakistan's agricultural sector. Coping responses taken by vulnerable populations appear to be not just ineffective but are producing system effects with society-wide implications. The result is a farmers' movement that is although in its early phases, has become a potent political force, and has resulted in more than 700 large increasingly violent protests in the last few years alone.

CLIMATE CHANGE AND POLITICAL CONTENTION – A MECHANISM-BASED FRAMEWORK

by

Zafar Imran

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2019

Advisory Committee:
Nancy Gallagher, co-Chair (Research Professor, School of Public Policy)
Anand Patwardhan, co-Chair (Professor, School of Public Policy)
Robert Sprinkle (Professor, School of Public Policy)
Alec Worsnop (Assistant Professor, School of Public Policy)
Julie Silva (Associate Professor, Department of Geographical Sciences)

© Copyright by
Zafar Imran
2019

Dedication

To the memory of John D. Steinbruner

Acknowledgements

This idea for this dissertation was conceived with much ease and in what appeared at the time as ideal circumstances. However, like most things in life, the journey to its completion has been paved with unforeseen challenges and adventures, some more difficult to overcome than others. I find myself fortunate that during all these times, I have been surrounded by kind and generous friends and colleagues.

I owe a debt of gratitude to my dissertation committee, especially my co-advisors, Prof. Nancy Gallagher and Prof. Anand Patwardhan for their guidance and support. Prof. Gallagher's unwavering faith in me has been a constant source of inspiration and strength.

Prof. Robert Sprinkle encouraged me to "stay rebellious" and to not be afraid of questioning conventional wisdom. He helped me in grounding my argument in historical debates surrounding the issues of climate change and collective action. Alec Worsnop was extremely generous in helping me sharpen my argument, and I benefitted immensely from his deep knowledge in the field of civil conflict. Prof. Julie Silva very kindly agreed to act in the role of Dean's Representative on my committee.

I would certainly be remiss if I did not acknowledge the continual mentoring and encouragement I received from Prof. Milton Leitenberg. In addition to being a constant source of support, over the years he shared thousands of articles, books, monographs, news reports, and conference proceedings on the topic of climate change and the threats its poses to social and ecological systems. His encyclopedic knowledge, mixed with his unfailing kindness and generosity is something without which I would not have been able to successfully finish this journey.

I am grateful for my dear friend, Francesca Perry. During times of complete seclusion that every graduate student goes through while writing a dissertation, she was always there to offer words of encouragement.

Finally, it would not be an overstatement to say that without the help of my sister, Nazia, this dissertation would not have been written. In addition to being a sounding board as well as reading countless drafts of my chapters, she generously funded the last phase of my research. I will always be in her debt.

This project was the brainchild of the late chair of my dissertation committee, Prof. John Steinbruner. I regret that he did not live to see the end product, for I know that he would have enjoyed it. In that regard, writing this dissertation was a big responsibility that I hope I was able to fulfill to some degree.

I am grateful for the time, attention and guidance of these friends. Any shortcomings that this work may have retained despite the guidance I received are my own.

Over the course of the past several years, my research was supported by the Center for International and Security Studies at Maryland (CISSM), as well as fellowships from the Graduate School at University of Maryland. That support was gratefully received and is gratefully acknowledged.

Table of Contents

ہے گرمیِ آدم سے ہنگامۂ عالم گرم
سورج بھی تماشائی، تارے بھی تماشائی

Activity of man has the universe's fevered pulse racing
With sun and stars for the audience

Muhammad Iqbal (1935, p. 164): *Bal-e-Jibril*
Translation: Victor G. Kiernan

Chapter 1: Introduction

Fears that climate change will destabilize countries and regions to the extent of stoking and (or) exacerbating violent conflict have concerned policymakers and academics for some time. Climate change has been referred to by the security community as a “threat multiplier” (Catarious Jr., Filadelfo, Gaffney, Maybee, & Morehouse, 2007) and a “catalyst of conflict” (Goff, Atkin, Malone, & McCutcheon, 2014). Changes in the natural system and their concomitant effects on societies around the world indicate that these fears are not without merit. In recent years, climate change has been attributed, at least partially, to be at the root of food riots in Haiti (Collier, 2008), popular uprising in Egypt (Rizk, 2011), and a series of farmer suicides in India (Carleton, 2017). Some accounts of the early waves of protests in Syria point to an extended drought in the Fertile Crescent as a major cause, if not the sole reason of one of the deadliest protracted conflicts in modern history (Gleick, 2014; Kelley, Mohtadi, Cane, Seager, & Kushnir, 2015; Leenders, 2013). Moreover, recent years have seen an uptick in the frequency and severity of extreme climate events, some of which have resulted in massive destruction of life and property, and displacement of hundreds of thousands of people both within and without countries around the world. Steinbruner et al. (2013) warn that we can expect to see more of such climate events that “will produce consequences that exceed the capacity of the affected societies or global system to manage and that have global security implications serious enough to compel international response” (p. 5). There is an increasing concern in the US defense community that “in addition to the changing environmental conditions that will contribute to a changing security environment, climate change will likely also result in social, political, and market pressures that may profoundly affect the Army's (and DoD's) activities" (Brosig et al., 2019, p. 2).

Concerns about the potential of climate change to impose burdens on local and international security have not remained strictly within the policy domain. The worry seems to have galvanized the academic community as well, particularly those involved with the study of onset and dynamics of civil conflict. In the past couple of decades, there have been numerous studies, books, monographs, and refereed journal articles published on the topic. However, despite a broad agreement about climate's potential to impose social and political burdens, and to threaten human security (Adger et al., 2014b), scholars are bitterly divided over whether climatic changes can lead to civil conflict all on their own (Salehyan, 2008; Solow, 2013). Those who argue in favor of such an association (between climate change and conflict) are faced with an even bigger challenge of disentangling (isolating), from confounding factors, the role of climate change in inducing conflict (Buhaug, 2015; Hendrix, 2017; Hsiang & Burke, 2014; Selby, 2014; Selby, Dahi, Fröhlich, & Hulme, 2017; Theisen, 2018). This is a daunting task because, in addition to methodological challenges, it has implications on local and global security imperatives.

This dissertation proposes a theoretical framework with the aim to carry out a systematic analysis of the climate-security phenomenon. The framework is based on the realization that establishing whether climate change causes civil conflict, or any of the varied manifestations of contention, requires an understanding of how climate change unfolds and interacts with a society's political economy, elicits responses from vulnerable populations, and ultimately imposes burdens on them. These burdens or grievances, upon interaction with the society's political, cultural, and historical contexts may trigger mechanisms of political mobilization, social movement, or even conflict. I apply this framework on a case study of Pakistan where the "press and pulse" of climate change (Harris et al., 2018) is imposing significant burdens on vulnerable populations, such that a farmers' (social) movement, attributable directly to effects of climate change, is fast taking roots.

This chapter is organized as follows: Section 1 makes the case for a new conceptualization of the climate-conflict problem, as well as briefly discusses methodological constraints in the extant approaches. Section 2 provides a short summary of the climate-conflict literature. Section 3 outlines basic contours of the framework proposed in this dissertation. Section 4 introduces the nature of the climate stressor, its interaction with Pakistan's agricultural system and broader political economy, and the social and political burdens it is imposing on the society.

Zeroing in on the problem:

In recent years, there has been an emerging consensus among climate-conflict scholars that due to its interactive and indirect nature, establishing a direct link between climate change and conflict may not be possible, and that a more nuanced mechanism-based investigation is in order. Theisen argues:

> [The] reasons for nonconvergence could be more effectively addressed if we turned from testing very general and direct connections between environmental

> change and civil conflict outbreak, into investing more in understanding possible (as well as eventually less plausible) intermediate mechanisms linking environmental change to civil war. With statistical studies in the environment-conflict tradition often having a weak spot on theory, there should be a strong case for investigating intermediate mechanisms. (Theisen, 2018)

Buhaug (2015) makes a similar case in support of developing a mechanism-based understanding of the phenomenon. This evolution in thinking, although laudable, traces the source of the problem to epistemological approaches (mechanics for explaining reality) as compared to ontology (how reality is perceived). This is a nontrivial oversight and may very well lead to yet another impasse in research on the topic.

The call to shift from variable-based explanatory strategy to a mechanism-based approach presupposes important ontological details about what climate change entails; at what level of abstraction coherent social entities exist that may interact with it; and what role variability and change in the earth's climate play in inducing or exacerbating social unrest. As Jackson (2010) points out, one's perception of how reality is structured is a function of one's philosophical predisposition or the "philosophical basis on which claims about the world are formulated in the first place" (p. 28). This philosophical basis does not affect reality, which exists independent of one's knowledge of it, just as the philosophical notion of a flat earth did not affect the physical nature of the earth itself. However, it has lasting effects on the agenda and boundaries of the entire intellectual exercise, e.g. unit of analysis, level of abstraction for data collection, hypotheses to be tested, explanatory strategies, etc.

But what is the “reality” of climate change? Looking through academic and policy literature generated on the topic, two popular and complementary definitions emerge: 1) climate change is the increase in frequency and severity of extreme climate events; and 2) climate change is the deviation of inter-annual trends of climate variables from their respective long-term means. Both these definitions have become widely popular measures of climate change in scholarship and media accounts about the most dangerous of threats of our time.

Whereas aggregation and simplification of complex climate processes by climate scientists has been extremely useful for research as well as for conveying the message to the general public and policymakers, the same cannot be said about abstraction of climate-society interaction that social scientists have put forth. The level of abstraction of most of the aggregate datasets used in climate-conflict studies, for example, is country-year. In addition to disregarding the likelihood of more than one ecological system within a country,[1] the level of data resolution implies that to become visible on the radar, the annual average value of a climate variable must be large enough to deviate from the long-term trend line, or risk being dismissed as a nonevent. Although long-term time series of climate trends are extremely important for analysis, the concern lies with over-aggregation and a rather misplaced emphasis on variables instead of the *process* of

[1] The United Nations’ Food and Agricultural Organization (FAO) divides agricultural lands within and across societies in terms of Agro-Ecological Zones (AEZ), or areas of land with “similar characteristics related to land suitability, potential production and environmental impact” (FAO, 1996). Changes in weather and climate trends may vary within and across societies based on the ecological zones they are comprised of. These differences are also reflected in their respective agricultural practices and broader political economies. An AEZ with its local political economy built around hot and dry conditions, for example, may be affected more adversely by a downward trend in its summer temperatures as compared to regions where moderate summer temperatures are a norm. Similarly, shifting of rainfall by a few weeks or months may have varied impacts on different AEZs and their populations. The fact that more than one ecological zone, each with different climate patterns, may exist within a single country turns the country-year approach, around which most aggregate climate-conflict datasets are developed, on its head.

climate change (Hulme, 2008; Taylor, 2014). Annual average values mask many, and arguably much more important sub-annual and sub-seasonal trends with regard to their effects on social systems. Conflicting trends, for example hotter than average summers followed by colder than average autumns and winters may cancel each other out, yet they leave no trace in time series of deviation from the average. Similarly, intra-annual changes such as shifting of meteorological calendars without affecting the overall annual average values of climate variables may never get reported, yet force significant changes in the lifestyles of vulnerable populations.

This oversimplification of the climate change process has also, and considerably, affected the research on security implications of climate change. The notion that deviation of climate variables from their respective long-term means can act as a good predictor of human behavior has captivated attention of scholars working on the topic. The concept of climate-induced scarcity has been used frequently to deduce the conflict potential of climate change (Homer-Dixon, 1991, 1999; Kahl, 2006), although the evidence of such a connection remains elusive (Salehyan, 2008; Solow, 2013).

It is within this rich intellectual terrain that this dissertation makes two distinct contributions:

1: The first concerns the conceptualization of the problem by proposing an alternative ontological basis regarding the process of climate change; its interaction with a society's preexisting social, political, and economic processes; and finally, the imposition of social and political stresses traceable to the original stressor. I make the case that climate change is a complex and emergent process, and its effects on social and political systems manifest in a varied and interactive manner. The fact that global climate change is a result of local climate and weather trends (Lorenz, 1963; Rind, 1999), which are not just non-uniform but also interact with each other to exhibit emergent behavior (Santer et al., 2018; Trenberth, Cheng, Jacobs, Zhang, & Fasullo, 2018), points to the complexity of the problem. It also raises concerns about the applicability and usefulness of statistical models and aggregate datasets that lack the capability to handle complexity and dynamism inherent in the phenomenon under consideration.

Social and ecological systems are intertwined and interdependent on each other (F. Berkes, Folke, & Colding, 2000; Liu, Dietz, Carpenter, Folke, et al., 2007). Human beings rely on nature for livelihoods, and human actions have consequences for nature. Similarly, changes in the natural system impose burdens on vulnerable populations and tend to elicit responses from them in real time. These impromptu adaptation responses, uncoordinated and bounded-rational by nature, are prone to introduce maladaptation as well as system effects that in turn may interact with social, political, and economic processes in a society.

This line of reasoning shifts the focus from investigating whether a link exists between climate change and contention to the more important question of *how* the former introduces instability in a society. It also calls into question the assumption of rationality and efficiency that undergirds the adaptation framework. It follows that instability may arise because of both, i.e. direct climate stresses as well as indirect system effects produced due to maladaptive coping responses. Contention may follow later and will be harder to reverse, as by then the original stressor (climate change) may have spawned several new stressors through interaction with antecedent (social, political, and economic) processes of society, thereby losing the original causal chain in a host of confounding factors and mechanisms.

I also diverge from a narrow focus on civil conflict as a potential outcome of climate-induced instability. I follow the lead of other scholars who have argued much earlier that civil conflict does not erupt overnight. Rather, it is a result of a tortuous path through which a society must pass before individual grievances and uncoordinated expressions of unrest coalesce into organized and sustained episodes of social and political contention and violent conflict (J. Goldstone, 1998b; McAdam, Tarrow, & Tilly, 1996; Petersen, 2001). As early signs of unrest traceable to climate change are being reported in media accounts from around the world, a systematic understanding of this complex process is warranted. A deeper understanding of the phenomenon will be helpful in not just tracking the progress of budding social unrest, it may invite effective policy measures aimed at curtailing or even preempting episodes of contention.

2: The second contribution concerns distinguishing method from methodology. Whereas the former is about techniques of gathering and analyzing bits of data, the latter has to do with the logical structure of the intellectual exercise (Sartori, 1970, p. 1033). I contend that the fundamental problem with the current analytical approach has more to do with ontological assumptions than explanatory approaches (qualitative vs. quantitative). Given the complexity and emergence inherent in the phenomenon under consideration, I concur with Selby (2014) that the positivist ontology lacks the capacity to reveal causal pathways linking climate change with predictors of social and political instability and conflict. In this dissertation, I build a case for a critical realist perspective as an alternative and more suitable ontological basis for analyzing the problem.

Once a lens to view the world has been chosen, the next step is selecting an appropriate explanatory strategy "relative to the subject of inquiry" (Wight, 2006, p. 259). A dominant explanatory strategy employed in political science in general, and climate-conflict research in particular, has to do with the belief that the causal effect at the root of political processes is identifiable only if the corresponding independent and dependent variables exhibit correlated variation (King, Keohane, & Verba, 1994, p. 82). According to this approach, causal mechanisms are nothing more than a chain of intervening variables that connect posited cause and the ultimate effect (ibid, p. 87).

As Tilly & Goodin (2006) argue, this is an overly simplistic view of reality and "assimilates scientific inference to the world-view contained in statistics based on general linear model" (p. 8). Given the fact that complexity pervades all aspects of social life, this approach has limitations when applied to social and political processes. Its applicability becomes even more suspect in the case of climate-induced contention due to the complexity and emergence inherent in the stressor itself.

A critical realist perspective, on the other hand, argues that a causal chain consists of mechanisms instead of variables. Unlike variables, mechanisms are generalizable "bits of theory" (Stinchcombe, 1991), and generate the same or similar effect in other episodes or situations (Hedstrom & Swedberg, 1998; McAdam, Tarrow, & Tilly, 2001). Also, unlike intervening variables, their role is not merely supportive; instead they have internal structure and self-sustaining logic (Sayer, 2000), and produce independent effects on the outcome (Hedstrom & Swedberg, 1998; McAdam et al., 2001).

In a nutshell, an alternative analytical approach is proposed in this research that not only uses mechanisms as bases of explanation, but also emphasizes their distinct ontological status. Rather than fishing for Hempelian covering laws (Hempel, 1942) of the form “climate change leads to conflict (peace)”, a mechanism-based explanation aims at identifying smaller generalizable chunks, which when concatenated will provide explanations of salient features of a causal chain (Gambetta, 1998). Climate change is a dynamic phenomenon, as are coping responses, social movements, rebellions, and civil conflicts. Developing a dynamic understanding of their interaction requires a change of perspective in how they unfold, and how, if ever, one paves the way for the other.

Most importantly, instead of providing yet another hardwired theory on the topic, the goal of this research is to propose a theoretical framework on which robust mechanisms of each of the processes identified may combine in varying sequences to produce outcomes of varying nature and severity, ranging from impromptu expressions of unrest, to mass mobilization, to morphing of disparate groups of disgruntled populations into social movements or even conflicts. The framework can be likened to an electrical breadboard - a platform where basic electrical circuits concatenate in varying combinations to produce complex circuits. In place of electrical circuits, the platform proposed in this dissertation would allow mechanisms of varying nature to concatenate and produce macro social outcomes. As mentioned above, the types of individual mechanisms, as well as combinations and sequences in which they concatenate will determine the trajectory of the causal chain and the nature and severity of the final outcome. Not only does this approach capture the dynamism inherent in the phenomenon, but it may also explain the paradox of why climate change may cause instability in some societies and not in others.

Extant literature and its discontents:

The body of work produced on the topic is prolific and discordant. Much of the climate-conflict literature is generally aligned along two major conceptualizations - neo-Malthusian and Cornucopian. In the former group are those who hypothesize that climate change causes scarcity of natural resources, particularly renewable resources such as fresh water, rainfall, aquifer, etc. Scarcity, thus produced, is expected to trigger resource-capture competition among vulnerable populations that may escalate to violence and ultimately civil conflict. Additionally, reduced water availability and increased temperatures may translate into depressed agricultural production and economic activity; which, in turn, may result in clashes over natural resource distribution, food riots, cattle raiding, farmer-herder clashes, etc. Cornucopians, on the other hand, adopt an opposite stance to the scarcity approach and make the case that just as human ingenuity has overcome threats of resource scarcity in the past, climate-induced scarcity too, may propel vulnerable populations towards finding efficient adaptation solutions. Human ingenuity and ability to adapt, or lack thereof, serves as the foundational argument in concepts such as adaptive capacity, resilience, as well as vulnerability and human security.

The other important distinction often employed for sorting through knowledge generated on the topic is that of the analytical and methodological approaches employed by researchers to marshal evidence to assess whether a relationship exists between climate change and onset of conflict. The age-old "qual vs. quant" debate seems to have intensified in this field of study. Whereas the "quants" tend to look for correlations between climate variables and predictors of civil conflict across a large array of cases, the "quals" argue in favor of detailed case studies, sometimes conducting paired comparisons between structurally similar cases behaving differently under the same (or similar) stress. Although there has been some success in both camps in demonstrating links between indicators of climate change and conflict, a consensus among the wider academic community remains elusive (Salehyan, 2008). No generalizable insights have emerged yet that may explain the phenomenon in reasonable detail. Given the enormity and urgency of the problem, there have been calls that both camps set aside their methodological differences and devise a composite approach that may complement each other's weaknesses and blind spots (Solow, 2013).

The two categorizations, i.e. qual/quant and neo-Malthusian/Cornucopian, are not mutually exclusive, and usually overlap in most studies. For example, generalized linear models designed to test correlations between variables of climate change and conflict are as prevalent in the literature as qualitative case studies exploring causal pathways linking resource scarcity to societal fragmentation and violent conflict. Similarly, studies about climate adaptation and resilience are conducted using both qualitative and quantitative approaches. The one common denominator in all these framings is their emphasis, often unstated, that structural variables constitute the fundamental causes of political processes.

Statistically significant correlations or "constant conjunctions between events" are considered a gold standard that most studies use to investigate whether a relationship exists between climate variables and the onset of civil conflict. This Humean explanatory approach is observed even in qualitative studies where structural characteristics of different cases such as size, terrain, resources, demographics, GDP, political institutions, etc. are used to select structurally similar cases to perform paired comparisons. Civil conflict, treated as a binary phenomenon, is assumed to commence only after the body-count variable (in battle related deaths) has reached a specific threshold, thus dismissing all the instability and drama (mobilization, resentment formation, protests, violence short of conflict, etc.) that may have led up to it.

An Alternative framing / Towards a mechanism-based framework:

Opening the black box of correlation, and using "causal-process observations" instead of "data-set observations" (Mahoney, 2010) imparts much needed explanatory power and a dynamic understanding of the phenomenon. However, merely breaking the causal chain into smaller pieces is not enough. As Jackson (2010) argues, it is the philosophical differences, not different analysis techniques that are at the root of bitter ideological debates in social sciences. Also, without a meaningful difference in philosophy, it would barely matter if the mode of explanation were quantitative or qualitative. A mechanism based approach is fundamentally different from the co-variational analytical approach, and not stating clearly the philosophical differences can result in misrepresentation of the concept, with a search for mechanisms turning into a search for smaller covering laws.

To that end, I note below two key ways in which the proposed formulation and its philosophical underpinnings differ from the extant conceptualization.

Ontology: Stratified reality and critical realism

Ontology in social sciences has to do with two cardinal questions: a) what constitutes reality; and b) at what level of abstraction coherent social action takes place. Although both questions may appear abstract, they have implications on how we theorize. As Wight (2006) argues, “all theories presuppose a basic ontology from which all other considerations follow. No ontology, no theory.” (p. 2). The basic ontology in the extant approach is influenced by the positivist account of science. Reality, according to this ontological belief consists of only that which is observable and measurable. In other words, that which cannot be measured or is unobservable because its potential lies latent either does not exist, or can be dismissed as “context” unsuitable for systematic exploration and elaboration. This leaves no room for complexity and emergence to be incorporated in the research design under the prevalent ontological regime.

Climate change, as discussed above, is both complex and emergent; complex, because it is a result of interconnected and interdependent local climate and ecological systems; and emergent, because the final outcome is irreducible to the components of which it is composed (Donner, Barbosa, Kurths, & Marwan, 2009; Rind, 1999; Zscheischler et al., 2018). Complexity and emergence are the running themes in the social world too. Almost all social phenomena, including contention, are often a result of interaction among an array of factors, and the final outcome is more than the sum of individual effects of constituent parts. The interaction of social and ecological systems adds even more complexity to the mix, thus rendering the currently employed co-variational approach ineffective, and its insights either marginal or misleading. In fact, the current malaise that has engulfed research on the subject can be directly traced to the ontology that does not accurately model the reality of climate change and its interaction with society.

A more effective way to explain the complexity involved in climate change and its interaction with society is through the rich concept of social-ecological system (SES). The concept, widely used in geography, is useful as it demystifies the phenomenon by identifying mechanisms and processes through which the two systems interact with each other. Ostrom provides a comprehensive definition of SESs as follows:

> SESs are composed of multiple subsystems and internal variables within these subsystems at multiple levels analogous to organisms composed of organs, organs of tissues, tissues of cells, cells of proteins, etc. In a complex SES, subsystems such as a resource system (e.g., a coastal fishery), resource units (lobsters), users (fishers), and governance systems (organizations and rules that govern fishing on that coast) are relatively separable but interact to produce outcomes at the SES level, which in turn feed back to affect these subsystems and their components, as well other larger or smaller SESs. (Ostrom, 2009, p. 419)

Environmental historian and sociologist Jason Moore argues:

> Try drawing a line around the "social" and the "natural" in the cultivation and consumption of food. In a rice paddy or a wheat field, in a cattle feedlot or on our

> dinner table, where does the natural process end, and the social process begin? The question itself speaks to the tenuous purchase of our Cartesian vocabulary on the everyday realities that we live, and seek to analyze. (Moore 2013:9 quoted in Taylor 2014, p. 12)

As an alternative to the positivist ontology, critical realism provides a suitable philosophical basis to cater for the complex and stratified view of reality, and is used as the philosophical basis for this research. Reality, for critical realists, is deeper than what happens at the level of events. The complete reality is composed of the "real", the "actual", and the "empirical" (Bhaskar, 1975). The "real" is what is out there, and whose complete knowledge we strive to achieve. Sayer (2000) defines:

> Real is the realm of objects, their structures and powers; whether they be physical like minerals or social like bureaucracies, they have certain structures and causal powers, that is capacities to behave in particular ways, and causal liabilities or passive powers, that is specific susceptibilities to certain kinds of changes. (p. 11)

Whereas the "real" is about objects, their structures, and the powers these objects may contain within themselves; the "actual" is the outcome of the activation of these powers (Sayer, 2000). In this research the "real" may entail varied manifestations of climate change; latent agency of vulnerable populations and state institutions; antecedent processes and a society's political economy, etc. The "actual" is these things in action. The interaction of climatic change with vulnerable individuals and groups through coping responses; the imposition of stresses on local economies; the interaction of antecedent processes with climate stresses, with the fallout of coping responses, etc. An important part of the “actual” is emergence and complexity. The interaction among components may create effects that otherwise could not have existed, and may be irreducible to the cumulative effects of constituent parts. As Sayer (2000) points out, “what has happened or been known to have happened does not exhaust what could happen or have happened” (p. 12)

Finally, the “empirical” is the part of reality that is observable, and is therefore measurable. As the research on climate-conflict has shown, the “empirical” or the observable is often not the entire reality, and at least some portion of the “actual” is either not readily observable or quantifiable or both.

The scholarly community engaged with conducting research on various aspects of climate change is waking up to the sobering realization that we know very little about the actual and the real of climate change, how it unfolds and interacts with societies, and what stresses it may impose that may destabilize local and global systems (Oppenheimer, 2013). Compound climate events, interaction of climate stresses with global processes such as international trade, seamless movement (or transferring) of vulnerability within and across societies, limits of adaptation, social-ecological traps, etc. attest to the fact that the convenience of conflating the “empirical” with the “real” and the “actual” is bound to result in incomplete or even misleading analysis.

But how does one tap into the unobservable and the invisible? The concept is not as contrived as it may appear. Scientists are familiar and comfortable with using the unobservable in their explanations of the physical phenomena. Some examples in modern physics include, “ ‘de-localized’ fundamental particles, entangled quantum states, vibrating strings existing in part in higher-order dimensions, and so on" (Jackson, 2010, p. 79). In social sciences, the concept of the "invisible hand" of the market is used so widely that it has become self-evident to economists and non-economists alike. In climate-society interaction, Leichenko & O'Brien (2008) identify "double exposure", an otherwise invisible mechanism which is invoked only when vulnerable populations are exposed to pressures imposed by climate change and international trade simultaneously. Similarly, the outcome of coping response(s), as well as their interaction with antecedent processes in a society is emergent as it may not be reducible to their original components. The same is true of mechanisms and processes in contentious politics. Some of the mechanisms such as "brokerage" do not exist until they are invoked. The effects they produce – e.g. coalition formation, identity shift, broadening of the framing of the demands, etc. – are not reducible to individual components that interact to produce the phenomenon (McAdam et al., 2001).

With this ontological worldview in mind, what follows are three theoretical constructs used by this dissertation to conceptualize the climate-security phenomenon:

1. Climate impact

It entails changes in the natural system, their nature and severity, and the extent and kind of direct and indirect stresses they impose. In addition to extreme climate events, the effects of climate impact include disruption in local weather patterns as well as changes in the long-term intra-annual and intra-seasonal trends of climate processes. The focus here is on local manifestations that are much more varied than is depicted in aggregate datasets. Local and global trends are, of course, related, and in fact the former is directly traceable to the latter; however, focusing on local climate trends may be more helpful in establishing a causal link between the climate stressor and its effects in a society. Field reports from around the world show that climate trends are spatially non-uniform, and are not limited to temperature increase or rainfall variability alone (Savo et al., 2016). The shifting of meteorological calendars, duration and schedule of seasons, and changes in the long-term intra-annual and intra-seasonal trends of snowfall, stream flows, winds, hail storms, diurnal temperatures, cold snaps, heat waves, etc. also constitute climate change (Holdren, 2017b), and have devastating effects on the livelihoods of vulnerable populations.

Direct stresses imposed by climate change may include crop failure, destruction of life and property, water scarcity, energy shortage, etc. As destabilizing as these may be, so far there is no evidence of direct stresses turning individual grievances into sustained political unrest and contention. Unlike what is hypothesized in most studies conducted on the topic, just like any other external process, stresses imposed by climate change interact with a society's social, economic, and political processes. Additionally, gradual and long-term changes in the natural system interact with vulnerable populations across scales and elicit responses from them.

The translation of climatic changes, be they short or long-term and extreme events or gradual changes, into social and political stresses is not as straightforward as the current framing of the problem suggests. As McAdam et al. (2001) argue, environmental factors or "externally generated influences on conditions affecting social life" (p. 25) do not readily result into macro level phenomena such as movements and revolutions. Rather, the path to such phenomena is "located in the collective interpretations and resulting actions that people fashion to perceived environmental conditions" (McAdam, 2001, p. 223). This is not to discount the critical role broad macro processes, in this case climate change, play in imposing burdens on society. On the contrary, the purpose is to highlight the macro-micro link (J. C. Alexander, Giesen, Munch, & Smelser, 1987; J. S. Coleman, 1986; T. C. Schelling, 1978), which is discussed next.

2. Society's adjustment to the impact

The discursive separation in the extant scholarship between the "social" and the "natural" gives the notion that climate change is an external force destabilizing an otherwise well-ordered society, and that this instability can be countered through "efficient" and "effective" adaptation schemes (Kaiser, Riha, Wilks, Rossiter, & Sampath, 1993; Mendelsohn, 2000). The United Nations Framework Convention on Climate Change defines adaptation as follows (emphasis added):

> Adaptation is a process through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails taking the *right* measures to reduce the negative effects of climate change (or exploit the positive ones) by making *appropriate* adjustments and changes. . . . Future vulnerability depends not only on climate change but also on the type of development path that is pursued. Thus adaptation should be implemented *in the context of national and global sustainable development efforts*.(UNFCCC, 2007, p. 10).

Not only does this framing actively separate the natural system from society, it downplays the complexity already present in social systems, let alone that which may be added upon interaction of the two complex systems. In addition, it appeals to a utilitarian rationality in vulnerable populations by assuming that they can take measures that are not only optimal with reference to climate conditions to which they are exposed, but are also in line with national and global sustainable development goals. Taylor (2014) argues that this is an unrealistic assumption, as "humans do not stand outside of their environment but are active protagonists in their ongoing production" (2014, p. xiii). After all, climate change itself is a result of human influence on the natural system in the first place. Moreover, not all adaptive measures may be "right" or "appropriate", and may lack the foresight to accommodate sustainability goals (Adger, Dessai, et al., 2009; Barnett & O'Neill, 2010; Carpenter & Brock, 2008; Cinner, 2011; Cumming, 2018; Dow, Berkhout, & Preston, 2013; Evans et al., 2015; Inderberg & Eikeland, 2009). In fact, most adaptation measures, especially those taken at individual level, are taken in real time, with a less-than-perfect understanding of the nature and extent of the stress itself, and with a narrow goal of ameliorating immediate local conditions. Spatial and temporal maladaptation means that what is considered successful adaptation at one time and place may increase vulnerability at another location or at the same location at another time (Magnan et al., 2016).

The climate-society interaction conceptualized in this research entails coping strategies employed at multiple levels of society; interaction of climate stresses and coping responses with a society's political economy, social and political processes; knock-on effects on businesses, livelihoods, etc. Unlike what is broadly assumed of adaptation measures, most coping responses are not "efficient" and "optimal", and take place, often in an extemporaneous manner, at micro and meso levels. Uncertainty imposed by climate change elicits, in real time, impromptu responses from vulnerable populations who often lack both timely information about the nature and severity of the climate stressor as well as computational resources needed for calculating efficient and optimal coping responses. As Adger & Kelly (1999) argue, stresses imposed by climate change are distributed disproportionately depending on a society's preexisting "architecture of entitlements". Lack of access to resources necessary for successful adaptation will beget inefficient and shortsighted coping responses.

Recognizing emergence and uncertainty unleashed by climate change, the framework proposed in this research assumes vulnerable populations practice decision-making under uncertainty. Steinbruner (1974) argues that the human mind, when faced with uncertainty, stops taking in new information, suspends rational cost-benefit analysis, and narrowly focuses on resolving uncertainty to alleviate immediate conditions. This "uncertainty resolution" is often suboptimal and shortsighted, and may lead to system effects and emergent behavior in the system. Similar argument has been made by Mullainathan & Shafir (2013) that the perceived sense of deprivation creates a "tunnel vision" for vulnerable populations, thereby narrowing their horizons and resulting in suboptimal coping responses. Burgeoning literature and reports from around the world about maladaptation, social-ecological traps, limits of adaptation, and backdraft echo this observation (Barrett, 2008; Carpenter & Brock, 2008; Cinner, 2011; Dabelko, Herzer, Null, Parker, & Sticklor, 2013; Dow, Berkhout, & Preston, 2013; Magnan et al., 2016).

Direct stresses imposed by climate change, as well as indirect stresses resulting from maladaptation or failed adaptation, introduce in a society a panoply of stresses ranging from commodity market destabilization to financial burdens caused by increase in agricultural inputs (water, energy, pesticides, etc.), etc., and create a sense of deprivation and hopelessness among vulnerable populations in particular and wider society in general. Failed crops may push some farmers out of business. Those who may survive may succumb to commodity market volatility attributable to weather and climatic changes, as well as haphazard adaptation and "double exposure" to climate change and international trade, etc. Knock-on effects on related businesses may result in unemployment, price hikes, etc. thereby setting in motion social and political unrest on a much wider scale.

The role of political processes in a society is of particular importance, and may play a major role in determining coping responses at the meso level. The burdens of climate change may shift in a society depending on how the latter is structured and what governs its political economy. A government composed of agriculturists, for example, by way of giving preferential treatment to its agriculture sector may shift vulnerability elsewhere in the society. Similarly, the interaction of climate change and political processes may be observable in a wide range of coping decisions ranging from deciding whether to protect urban centers or rural areas while diverting flood waters, to rationing stream-flow for irrigation or hydroelectric power generation, to subsidizing agricultural inputs for areas suffering from reduced rainfall or increased temperature, etc. A society's preexisting ethnic, social, political, religious fault lines may further compound the stresses imposed by climate change.

3. Contention attributable to climate change

Just like any other macro social phenomenon, the origins of protest cycles, social movements, and revolutions lie in the interpretations of threats and responses at the micro level. The mechanisms of mobilization are triggered based on wider perceptions of threats to lifestyles, identities, or a general sense of injustice, rather than a clearly (and narrowly) defined source of stress (Aminzade & McAdam, 2001; McAdam, 1982). As climatic changes, by way of imposing direct and indirect stresses, knock a society off-course and away from its "basin of attraction" (Walker, Holling, Carpenter, & Kinzig, 2004), individual grievances may coalesce, and give birth to collective expressions of unrest and contention. Scholars of contentious politics have already argued that protests, social movements, rebellions, civil conflicts all begin from the same mechanisms of mobilization. Once begun, they take a life of their own, often resulting in varying outcomes depending on which mechanisms are invoked, as well as their sequence and combinations (J. Goldstone, 1998b; McAdam et al., 1996; Petersen, 2001). The connective tissue between stresses imposed by climate change and expressions of unrest is often financial downturn, but it is also perceived deprivation, absolute or relative, that may induce individuals and groups to mobilize and express their frustrations in public, first extemporaneously and then in a coordinated and organized fashion. Identifying mechanism(s) connecting the original stressor and the onset of contention may provide insights as to which micro and meso level grievances gave rise to mobilization and kick-started the process of contention in the first place.

Epistemology: Mechanisms as building blocks of explanation

After clearly stating how one is hooked up to the world (Jackson, 2010), the next task is devising an explanatory strategy that may allow parsing reality as accurately and as systematically as possible. The currently used explanatory approach, under the influence of positivist ontology, is based on the assumption that social phenomena can be explained by a finite number of abstract law-like statements. Models for explaining social phenomena in such accounts are invariant under all conditions. For example, democratization would take place in the same manner everywhere; or climate change would impose burdens always using the same causal pathway, e.g. scarcity, in all societies, etc. Mechanisms in such an approach have almost no explanatory power. Their role is merely supportive, and they are nothing more than intervening variables that connect the dots between dependent and independent variables. In other words, mechanisms in the extant explanatory approach, although make intuitive sense, they have no separate ontological status (King et al., 1994).

The alternative epistemological approach employed in this dissertation, on the other hand, follows the lead of McAdam et al. (2001) who question the very logic of covering laws, and argue that "big structures and sequences never repeat themselves, but result from differing combinations and sequences of mechanisms with very general scope" (p. 30). Mechanisms in this epistemological approach are not merely intervening variables interspersed on a deterministic causal pathway connecting a cause with perceived effect(s). On the contrary, they are generalizable "bits of theory" (Stinchcombe, 1991, p. 367), or "social cogs and wheels" (Elster, 1989, p. 3) with internal structure and self-sustaining logic (Sayer, 2000); and upon invocation result in "designated consequences for designated parts of the social structure" (Merton, 1949/2012, p. 451).

This approach is remarkably different from the extant epistemology as it not only breaks the causal chain into smaller components of wider applicability, but also replaces determinism with contingency and emergence. A perceived cause may produce a particular effect *only if* specific constituent mechanisms combine in a certain sequence. In other words, climate change may or may not cause conflict depending on which mechanisms are invoked, and in what sequence or combinations they concatenate to create a causal chain. Concatenation of mechanisms (Gambetta, 1998) in a different order and combination may result in a different outcome altogether (J. S. Coleman, 1987). Whereas the final outcome of climate change in some cases may be a social movement, or non-violent social collective action, in others people may resort to violence and launch a sustained violent campaign against the government or against opposite groups. Yet in other cases, climate-induced stresses may result in bringing people together to devise joint strategies to fight climate change, and so forth.

Another important difference that this explanatory strategy introduces is the recognition of the fact that macro social phenomena such as conflicts, movements, rebellions, etc. are not born at the macro level. As Coleman (1987) argues, proper explanation of collective social action is possible only if one traces the effects produced by macro level conditions, such as climate change in this case, at the micro or individual level because this is where data are collected. The model is termed as macro-micro-macro model and is based on a 3-step logic. Macro level events influence behavior at individual level (step 1); change in individual behavior results in invocation of actions at the micro level (step 2); and combined effect of actions by multiple individuals generates macro level outcome (step 3) (J. S. Coleman, 1987; Hedstrom & Swedberg, 1998). Since the assumption of rationality is suspended, the combined effect of actions is not the additive sum of actions taken by all individuals. Rather, it is the interaction among these individuals that may invoke mechanisms of social (and political) collective action (Tilly & Goodin, 2006).

In the climate-conflict problem, one can easily imagine macro-level climate change invoking micro-level mechanisms by interacting with vulnerable individuals. Mechanisms such as “uncertainty resolution” (Steinbruner, 1974) may be triggered as struggling individuals hurriedly try to cope with the changing climate and weather conditions. The mechanism of “rational imitation” may cause other individuals such as neighbors, etc. to copy an apparently successful coping mechanism (Hedström, 1998a), thereby resulting in its widespread adoption through the mechanism of “belief formation” (Hedstrom & Swedberg, 1998), and so on. Successful coping responses may lead to lessening of burdens imposed by climate change; failed responses, on the other hand, may aggravate the situation, and may in turn trigger mechanisms of contentious politics, such as resentment formation, social mobilization, diffusion, brokerage, radicalization, etc.

Mechanism-based framework

The emphasis placed on mechanisms does not mean that the final product of this research is yet another hardwired, albeit mechanism-based, theory. The problem of climate-induced instability in a society, this research contends, is too complex and dynamic to allow a single theory to capture all of its nuances and contingencies across time and space. Therefore, this dissertation adopts a novel approach and proposes a framework or a dashboard, using which mechanisms of constituent social-ecological phenomena may be identified. The mechanisms, of course, need to be of some general scope and will have to have wider applicability across episodes and cases. That is, they will produce the same or similar outcome when invoked across different situations and contexts.

As scholars of civil conflict, rebellions, revolutions, and social movements know well, no two occurrences of a contentious politics phenomenon unfold in the same way or have the same outcome. Individual grievances attributable to climate change may or may not turn into organized and sustained campaigns of contention depending on state's handling of these grievances; the leadership available to lead social and political mobilization leading to a sustained political campaign; climate of political opportunity or threat in a society at a given time; discipline and organization of aggrieved groups of people; presence or absence of cross-class coalitions, etc. The preexisting ethnic, political, and religious fault lines may vary from one society to the next and may affect the trajectory and severity of the final outcome.

The epistemological approach behind this framework has deep roots in sociology, and can be traced back to Merton's "middle range theories" (Merton, 1949/2012). Merton firmly rejected the idea of general systems of social theory, and argued instead that the fundamental job of sociologists is to identify mechanisms of general scope, and conditions under which they come into being, fail to operate, etc. The mechanisms, he argued, should offer a middle ground between the "nomothetic and idiothetic, between the general and the altogether particular, between generalizing sociological theory and historicism" (ibid, p. 452).

This approach is immensely powerful not just because it is based on sound sociological and philosophical bases, but also because it helps solve the paradoxes raised by the covering law models, e.g. why climate change causes instability in some societies but not in others, etc. Moreover, by way of opening the black box, it may help develop pointed policy interventions – something that covering law models are inherently incapable of.

I test this framework on the case study of Pakistan, and identify mechanisms of climate change, those of climate-society interactions, and finally, mechanisms of emerging contention attributable to climate change. The list of mechanisms identified is not exhaustive, but it may provide useful insights about salient features of the social-ecological phenomena as they unfold in the country. The power of this framework lies in the fact that it can be used for other cases of wide variety, rather than limiting the analysis to paired comparisons of cases with similar structural characteristics. The mechanisms and their combinations may be different in other cases, and may produce different outcomes, but the net result will be a comprehensive and deeper understanding of climate change and its interaction with societies around the world. As the framework is used for more cases, more and new types of mechanisms may be identified and a repository of mechanisms enriched.

Social and political unrest attributable to climate change in Pakistan

The case study of Pakistan counters the overly simplistic conceptualization of climate change in extant scholarship that focuses either on increased frequency and intensity of extreme climate events or on deviation of annual average values of climate variables from their respective long-term means. By opening the black-box of country-year approach, it showcases the intra-annual changes in climate trends and their effects on the country's political economy.

The Global Climate Risk Index lists Pakistan among the top ten countries facing the risk of extreme climate events (Eckstein, Hutfils, & Winges, 2019). ND-Gain Country Index includes it among the countries with high vulnerability to climate change and low readiness to tackle its effects (Chen et al., 2015). The long-term hydro-meteorological data analyzed in this dissertation showcases the domain and range of climate change and its effects, especially when looked at the sub-annual level. Whereas successive droughts, flash floods, hurricanes, etc. constitute the "pulse" of climate change, the intra-annual changes in climate trends, stream-flow variability, and shifting of meteorological calendars are the "press" that has been battering the society for some time, without having been picked up in aggregate datasets. Moreover, the fact that the country is composed of more than one agro-ecological zone, each undergoing change in its local climate trends, adds to complexity of the overall impact of environmental changes taking place in the society.

The research conducted on effects of climate change in Pakistan as well as its interaction with the country's society has been both scarce and limited in scope. For example, studies investigating the effect of climatic changes on the Indus stream-flows have remained restricted to analyzing the stream-flow trends in the Upper Indus Basin (Archer, 2003; D. Archer & H. Fowler, 2004; H. Fowler & D. Archer, 2006; Kenneth Hewitt, 2011; K Hewitt, Wake, Young, & David, 1989; Khattak, Babel, & Sharif, 2011; Sharif, Archer, Fowler, & Forsythe, 2013; Siddique & Hashmi, 2012). Similarly, although some work has been done to study changes in meteorological trends in parts of the country (Abbas, 2013; Abbas et al., 2014; M. Hanif, Khan, & Adnan, 2013; H.-u.-R. Khan, 1959; M Zahid & Rasul, 2011; Maida Zahid & Rasul, 2012), it remains limited to assessing variability of average annual values from respective long-term means. This dissertation contributes to scholarship in this field by conducting time-series analysis of long-term records of stream-flows for all three rivers, namely Indus, Jhelum, and Chenab, that comprise Pakistan's hydrology. Instead of using annual average values, I use total monthly stream-flow in each river for a high-resolution analysis of intra-annual and intra-seasonal trends. Additionally, I conduct trend analysis of long-term records of mean monthly minimum and maximum temperatures as well as rainfall patterns in three distinct agro-ecological zones in the country.

The other important oversight in the literature has been regarding the interaction of climatic changes with Pakistan's society, particularly its agro-based economy that is built around predictable weather patterns as well as timely and abundant supply of the Indus stream-flows. Although some work has been conducted on the effect of climate change on particular crops or sectors (Ahmad et al., 2015; Ahmed & Schmitz, 2011; U. Hanif, Syed, Ahmad, Malik, & Nasir, 2010; Hussain & Mudasser, 2007), a holistic analysis of climate-society interaction in lacking. More specifically, the role complexity and emergence of climate change play in eliciting coping responses in real time from vulnerable farmers, and effects of these coping responses on wider political economy is an area that remains under-researched. This dissertation contributes to this part of literature as well.

Temporal and spatial changes in climate trends

Located in the foothills of the Karakoram range of the Himalaya mountains, Pakistan's society relies on sustained and timely availability of the Indus stream-flows for its irrigation and power generation needs. Additionally, the country is divided in more than one agro-ecological zone, each with its own distinct weather pattern. Agricultural practices, as well as local commodity markets and related agro-based industries and businesses depend on both predictable weather trends as well as timely availability of the Indus waters. Analysis of long-term time series of hydro-meteorological data is conducted in this research, and shows spatial and temporal changes taking place in the country's climate trends at intra-annual and intra-seasonal levels. Two insights gleaned from the analysis are particularly important:

1: Long-term records (1922-2011) of stream-flows of rivers Indus, Jhelum, and Chenab, recorded at the rim-stations where the three river enter Pakistan's hydrological system, show a downward trend during the summer months but an upward trend during the winter months. However, since most of the stream-flow historically takes place during the summer season, the overall trend has been negative in recent years. Moreover, since the demand for water is the highest during the peak summer months for both irrigation as well as hydroelectric power generation, the shrinkage in the Indus waters has exposed distributional conflicts between the country's irrigation and hydroelectric power generation needs. Ethnic and political fault lines, particularly between the upper and lower riparian populations, also appear to be exacerbating over the issue of fair distribution of water shortages.

2: Long term records of climate variables in three sites,[2] each located in a distinct agro-ecological zone, show intra-annual changes in monthly minimum and maximum temperatures, as well as in average monthly rainfall amounts. Changes in the long-term temporal and spatial trends show that i) regions that were historically hot and dry during summer months are becoming cooler and wetter; ii) there is a general trend of warming during the winter months across the country, with cold snaps increasing in frequency; iii) summer season appears to be lengthening in duration, with rapid increase in temperature as early as in March in some parts of the country; iv) rainfall has become erratic, and there is a shift in meteorological calendar with rainfall schedule having shifted forward by as much as two months.

[2] Time-period for meteorological records varies from one location to the other. The longest time-series is available for Lahore (1951-2012), followed by Bahawalpur (1960-2012), and Hyderabad (1961-2013).

The fallout of the climate-society interaction on local farmers

The effects of climatic changes unfolding in the country are significant and far-reaching, with almost all sectors of society being affected by it either directly or indirectly. Two sectors in particular, namely agriculture and power generation, have taken a direct hit by these changes. Since Pakistan's manufacturing base consists primarily of agro-based industries, the knock-on effects have an even larger reach. However, the causal chain becomes so large, and confounding processes so numerous that establishing a direct link between climate change and its effects becomes difficult. That's why this research narrowly focuses on agriculture sector alone where effects of climate change are the direst and direct. Vulnerable farmers depend for their livelihoods on predictable weather trends and sustained water supply for timely cultivation and harvesting of crops.

Among the direct effects of climate change include water shortage, increased pest attacks (caused by changes in diurnal temperatures), and unpredictable rainstorm/hail/heatwave/cold snap, etc. that are resulting in crop failure at unprecedented scale. In addition, changes in intra-annual trends of climate variables have hampered yield as well as production of major and minor crops. Farmers are trying, to the best of their abilities and knowledge, to cope with the changing temperature and rainfall trends by switching to alternative crops, shifting cultivation patterns according to the changed weather trends, intensifying the use of agricultural inputs to resuscitate yields, and shifting cultivation windows in accordance with the changed meteorological and hydrological calendars. However, in the absence of complete information about climatic changes unfolding in their respective regions, as well as lack of access to long-term records of climate trends, their efforts remain uncoordinated and bounded rational.

These haphazard adaptation measures are generating system effects, and have culminated in massive disturbance in domestic commodity markets. Interaction of climatic stresses with coping responses of farmers, as well as with the wider political economy, has led to two notable effects that may help trace the causal chain linking climate change with general social unrest in the country:

1: Input intensification, aimed at stabilizing dwindling crop yields (attributable to climate change), has led to an increase in cost of agricultural production, thereby making Pakistan’s farmers uncompetitive. Local commodity traders, in order to meet the domestic demand, import cheaper agricultural products from elsewhere in the world. Since keeping food price low is also politically advantageous, traders are often encouraged by the state in doing so.

2: Direct effects of climate change, e.g. changing weather patterns, reduced water availability, extreme climate events, increased pest attacks, etc., have disrupted agricultural practices that had been in practices for decades if not centuries. Variability and change in weather trends has pushed farmers into the realm of uncertainty when it comes to choosing alternative crops to replace the ones that are no longer profitable. Since there are not many alternative (crops) to choose from in the first place, interviews with farmers revealed a bandwagon effect with regard to trying new crop patterns. Resultantly, crop gluts have become frequent, and led to price crash of wheat, cotton, rice, sugarcane, potatoes, maize, etc., multiple times in the past few years alone, often bankrupting small farmers. Increase in the cost of production, plummeting crop yields, and intermittent price crashes have pushed a lot of Pakistan's farmers deep in debt, with an increasing number abandoning commercial agriculture altogether.

Discussed in greater detail in chapter 5, three mechanisms are deduced from analyzing the climate-society interaction in Pakistan. The first is what Steinbruner (1974) calls "uncertainty resolution". Unaware of the complete picture of climate change taking place within the country, in addition to being neither equipped to nor keen on finding the most optimal and efficient adaptation measures, farmers are resorting to their common sense as they attempt to alleviate their immediate conditions and ward off uncertainty imposed by changes in their respective meteorological systems. Input intensification, chasing down the aquifer to make up for reduced surface water availability, etc., although resolve uncertainty in the short run, they are imposing additional burdens and generating system effects.

Similarly, "rational imitation" (Hedström, 1998a) - a non-verbal sociological mechanism in which an action taken by actor A is assumed to be rational and therefore adopted or imitated by actor B – can explain the bandwagon effect in Pakistan's farmers regarding choosing alternative crop patterns.

Finally, climatic changes are not exclusive to Pakistan's society; agricultural systems in countries around the world are also taking a thrashing by changes in temperature and rainfall patterns. Since domestic commodity markets are interconnected through international trade, stresses attributable to fluctuations in agricultural production are seamlessly transferred from one country to the other. The phenomenon, aptly termed as “double exposure” (Leichenko & O'Brien, 2008), has been at play in Pakistan for almost two decades. Its most notable manifestation came during the global food crises in 2008 and 2010, attributable in large part to historic drought in China and wildfire in Russia respectively. The massive gap in demand and supply of food items in the global market resulted in smuggling out of Pakistan’s staple commodities, at times causing food riots in the country. The obverse has happened quite a few times since then when oversupply of agricultural commodities such as sugar, rice, wheat, etc. in the global market depressed crop prices internationally, bankrupting local farmers overnight. As climatic changes pound agricultural systems with increasing frequency and severity, the phenomenon has become a regular occurrence in recent years, and has become a constant source of unrest for Pakistan’s already uncompetitive farmers.

Contention attributable to climate change in Pakistan

The natural progression of farmers’ unrest is manifesting in the form of their mobilization and organization as they struggle to maintain their livelihoods on account of falling farm incomes and failing agriculture. Political violence data retrieved from the Armed Conflict Location and Event Database (ACLED) shows a rapidly rising trend of Pakistan’s farmers organizing at grass-roots level and mobilizing for contentious collective action. In the past five years alone, farmers of Punjab and Sindh – two predominantly agricultural provinces of the country – have carried out over 700 protests, sit-ins, rallies, and marches across the country. Scores of farmers’ representative organizations have sprung up, organizing hundreds of thousands of tenant-farmers and small and medium landowners throughout the rural landscape of the country.

The analysis of farmers' (social) movement carried out in this dissertation is based on two sources of data, namely records of contentious collective action listed in ACLED, and over 1300 news reports, retrieved from LexisNexis, about public claim-making by leading farmers organizations in public meetings, press conferences, membership campaigns, rallies, etc.

One of the key insights from high-resolution reporting of protest events includes the traceability of farmers' unrest and contentious collective action to effects of climate change. Detailed accounts of protesting farmers report growers lamenting the shifting of weather patterns, increased pest attacks, water shortage, the necessity to pump water from the aquifer, etc. as leading causes of increase in their cost of production and the resultant uncompetitive-ness. Crop failures as well as price crash of major and minor crops bring them on the streets, demanding that the state cover their losses, provide them subsidies on agricultural inputs, and ensure purchase of their products at a floor price higher than the cost of production. In the case of depressed international prices of agricultural commodities, farmers demand that the state must protect them from international price fluctuations, etc. This is as straightforward a link between farmers' unrest and effects of climate change as it gets, given the interactive nature of the phenomenon, and puts in perspective the fragile balance between social and ecological systems on which agriculture system rests.

Whereas water shortage in the Indus river and its tributaries has laid bare inter-sectoral distributional conflicts (between irrigation and hydroelectric power generation), it has also exacerbated political tensions between upper and lower riparian populations of

Punjab and Sindh. The lower riparian farmers of Sindh blame the upper riparian Punjabi farmers of stealing their share of water. Even within Punjab, the lower riparian farmers in southern Punjab protest being denied their fair share of irrigation water. The issue has turned into a political, and even an ethnic fault-line, that has the potential to become active in no time. The sharpening of these fault lines holds or even exacerbates in times of excess as well, when flash floods originating on the upstream pass through villages and fields on the downstream, often destroying life and property.

In addition to ethnic and political conflicts flaring up over distribution of the Indus waters, identity work is underway between farmers and industrialists as well. Most of Pakistan's industrial base consists of agro-based industries such as sugar mills, flour mills, rice mills, textile mills, etc. As the cost of agricultural production has increased domestically, mill owners as well as commodity traders find it economically unviable to purchase expensive agricultural products produced domestically. Overproduction and crop glut, as well as price crash in international commodity markets sours relations between local farmers and manufacturers even further, as the latter insist on paying to farmers the prevailing market price, or import cheaper goods from the outside world.

In the last five years, contentious performances of struggling farmers have evolved – from non-violent localized protests to increasingly violent and large processions, sit-ins, and even civil disobedience campaigns. Farmers travel in large numbers from remote villages toward big cities, and choke national highways, railways tracks, and important city squares. The intensity of these expressions of unrest has particularly increased in recent years due to successive crop failures and/or price crashes that bankrupted a large number of small farmers. Thousands of protesting farmers, armed with sticks as well as farming implements such as sickles, reapers, axes, etc., bring with them piles of their produce and set it on fire as an expression of their desperation and anger.

In sum, a movement, led and organized by farmers in Pakistan is underway. From small towns to large cities, from groups to organized associations, farmers have coalesced around their cause. It is striking how ordinary farmers have carved out a separate space for themselves in the country's political landscape in a very short time, and without any support from mainstream political parties or elites. Their grievances of failing crops and financial ruin have shifted from the individual to the social and political realm. This is of grave concern in a multi-ethnic nation state where deep fault lines around identity and ethnicity crisscross the length and breadth of the country. It is these fault lines that have become activated on account of discontent directly attributable to climate change.

Although protests have not turned overly violent yet, they have grown in number, the framing of demands evolved over time to become political, and contentious performances refined. Often times, the focus on violence associated with protests or the number of protests misses this dynamism. Protests, in effect, are an expression situated in complicated, even unstable socio-political contexts. In other words, before a protest erupts, or is organized, social groups have become aligned along particular demands and grievances. Power geometries have been considered, and the threats and opportunities of coming out on the streets weighed.

It is this unrest that can be traced only through a mechanism-based approach. Deterministic accounts fail to capture this granular picture of a society. Insights from this case study, thus, are of import for other such cases where societies are at the receiving end of punishing effects of climate change.

An Overview of Chapters

The remaining dissertation is organized as follows. Chapter 2 takes stock of the sprawling literature generated on various aspects of the potential of climate change to induce conflict. Chapter 3 makes a comprehensive case for an alternative conceptualization of the problem, as well as proposes a theoretical framework for systematic research on the topic. Chapter 4 illustrates trends of climate change in the country by mapping long-term trends of hydro-meteorological data. Chapter 5 delves into the qualitative data collected from field interviews, as well as analyzes the social and political unrest data curated by Armed Conflict Location and Event Database (ACLED). Chapter 6 sums up the dissertation and suggests future directions.

Chapter 2: Literature Review

Introduction

The literature generated on the potential of climate change to stoke political violence and conflict is prolific and discordant. Leading scholars acknowledge a lack of consensus on the issue. Buhaug (2015, p. 269) for instance, admits that climate-conflict scholars have failed "to converge on a single robust association between climate and conflict, and several opposing and seemingly incompatible patterns have been reported." Solow (2013) calls for peace between "qual" and "quant" scholars, and pleads them to work together to figure out this puzzle. Selby (2014) argues that positivist ontology is not suitable to study the climate-conflict problem.

These conclusions, although valid, barely scratch the surface of the problem. This literature review delves deeper by looking through the underlying logic as well as assumptions made by some of the leading arguments developed on the subject. In reviewing this sprawling literature, three broad concerns and realizations emerge:

First and most obvious is that the climate-conflict literature is poorly linked to the resource scarcity argument. It is true that climate change may result in deterioration and degradation and ultimately scarcity of renewable natural resources. However, neither climate change nor scarcity occurs overnight and certainly not in isolation from coping responses of vulnerable populations. Climate change is a complex phenomenon with effects on all sectors of society, ranging from political economy, to social, political, and cultural processes, to international trade. Treating climate change primarily as a resource scarcity or degradation problem may, at best, result in a limited understanding of the problem. Any effort to study the adverse effects of climate change on societies may not be complete without incorporating mechanisms and processes operating at the interstices of natural and social systems in the analysis.

Second, the climate-conflict literature, for the most part, involves searching for structural variables that may be correlated with the onset of conflict; rather than finding causal pathway(s) through which variability and change in a society's (or region's) climate may induce social and political unrest. This misplaced emphasis on the "whether" rather than the "how" of climate-induced instability and contention has its roots in the conventional structural approach that dominates the civil conflict field (Sambanis, 2002), which treats civil conflict as a binary phenomenon (Chenoweth & Lawrence, 2010). As realization among scholars grows about political contention being a spectrum, ranging from nonviolent expressions of unrest on one end and full-blown violent conflict on the other (Petersen, 2001), the framing of the climate-conflict problem needs revisiting.

Third, the fact that elucidation of the climate change *process* is largely absent from the climate-conflict literature raises two interrelated concerns. One involves inferential problems such as direction of causality, spurious correlations, etc. The other has to do with the understanding about interaction of climate change and society. The extant analytical approach, particularly quantitative models, is not equipped to answer questions such as: how does climate change manifest; what kinds of stresses the interaction of social and natural systems may produce; at what level of society (e.g. micro, meso, or macro), and how, do vulnerable populations respond to such stresses, etc.

Then there are questions about external validity: given that climate change is non-uniform spatially, and its stresses are mediated by interaction with social, economic, political, and cultural processes of a given society, to what extent would macro-level correlations, e.g., rainfall growth and civil conflict, be generalizable to other societies?

With these broad concerns and questions in mind, in what follows, I summarize leading arguments that have shaped the climate-conflict debate over the years. Two important topics that are usually left out in most literature reviews generated on the subject are human security and adaptation. Whereas the former is quickly gaining prominence among policymakers as a replacement of the climate-conflict argument (Adger et al., 2014a), the latter is considered a logical policy response to curtail or reverse the destabilizing effects of environmental changes on countries and regions around the world. This literature review would be incomplete without including these debates in the discussion.

This chapter first takes stock of two key arguments referred to in the climate-conflict literature as neo-Malthusian and cornucopian, respectively. Whereas the former warns of climate-induced scarcity as a growing cause of conflict, the latter provides reassurance by citing human ingenuity and (latent) genetic ability of mankind to adapt to changes in the natural system. A brief summary of the human security argument follows these debates. The conclusion sums up the state of the literature, identifies room for contribution, and proposes a way forward for an alternative framing of the problem.

The neo-Malthusian Argument:

Resource scarcity, whether caused by population growth or climate change, has been a cause of concern for academics and policymakers alike. The most notable mention of resource scarcity and deprivation as a threat to humanity is usually traced back to Thomas Malthus's famous treatise titled, '*An essay on the principles of population'* in which he argued that rapid population growth will ultimately outpace the generation of resources essential to sustain life (Malthus, 1798/1998). More recently, ecologist Garret Hardin revived the argument in his influential essay titled "The tragedy of the commons", and argued that uncontrolled population increase would result in tragic overuse of natural commons and leave the planet uninhabitable (Hardin, 1968).

Thanks to human ingenuity and advances in food production technology, Malthus's theory was refuted long ago. In aggregate terms, in the last fifty years alone, global food production has almost tripled despite limited availability and increase in the cost of land (Pingali, 2012). In response to Hardin's theory, Elinor Ostrom argued that the fear of destruction of natural commons is unfounded because human beings have the capability to work together and protect shared natural resources by creating and imposing rules of resource sharing (Ostrom, 1998, 1999, 2000; Ostrom, Walker, & Gardner, 1992).

As current and future projections of the effects of climate change become more severe, and nations struggle to curtail carbon emissions, a resurgence of the Malthusian argument is observed. Scholars of resource scarcity, commonly referred to in the literature as neo-Malthusians, point to depletion and degradation of renewable resources (fresh water, cropland, forests, etc.) as observable effects of climate change, and warn of impending social and political stresses and violence. The neo-Malthusian argument, in its strongest form, claims that climate-related depletion and degradation of renewable resources, as well as changes in rainfall, and temperature patterns will result in stunted agricultural production and economic activity, and may lead to food scarcity, unemployment, and poverty. Social and political stresses faced by vulnerable populations may incite violence and destabilize societies and regions.

Based on the causal pathways proposed by scholars from varying disciplines, the neo-Malthusian theory of climate-conflict can be further divided in three logical strands, namely: 1) environmental scarcity and deprivation argument, 2) state failure and civil conflict argument, 3) and state-exploitation argument.

Environmental scarcity and deprivation:

Resource scarcity, especially in the context of climate change's potential to degrade and deplete renewable natural resources is increasingly perceived as a security risk. The argument involves three steps: 1) environmental scarcity and degradation results in depletion or deterioration of renewable natural resources; 2) competition to capture dwindling resources ensues as vulnerable populations descend into poverty; 3) the resulting inequality and increased food prices lead to social and political unrest (Bellemare, 2015; Berazneva & Lee, 2013; Bush, 2010; Collier, 2008; Homer-Dixon, 1991, 1994, 1999; Kahl, 2006; Schneider, 2008). The third step in the argument, i.e. social and political unrest attributable to climate change, is usually joined with the established theories of conflict where overall reduction in local wealth, as well as absolute or perceived deprivation usually result in populations rioting against the state and/or mounting insurgencies or rebellions (Collier & Hoeffler, 1998, 2004; Fearon &

Laitin, 1999; Gurr, 1970; Hauge & Ellingsen, 1998; Homer-Dixon, 1991, 1994; Kahl, 2006).

Homer-Dixon, one of the early proponents of the environmental scarcity argument, differentiated among various types of scarcities, their origins, and respective effects on society. According to a typology he developed, "demand-induced scarcity" is caused by increase in population and/or consumption patterns. "Supply-induced scarcity" can be attributed to degradation or depletion of natural resources. "Structural scarcity" may be caused by unequal access to natural resources in a society making them scarce for large segments of society (Homer-Dixon, 1999). He argued that a renewable resource's degradation and depletion, in the presence of permissive contextual conditions such as weak government and institutions might cause deprivation and economic marginalization. Fear of disadvantage (absolute or relative deprivation) may lead individuals and groups to resort to resource capture, setting off fierce competition and violence (ibid).

Kahl (2006) emphasized that in the face of demographic and environmental stresses, preexisting fault lines (e.g. social, political, ethnic, religious, etc.) in a society in general ("groupness"), and in state institutions in particular ("institutional inclusivity"), may create or worsen inequity in resource distribution. He argued that a state and its institutions are not monolithic entities; they are composed of individuals (state elites and officials). These individuals may feel insecure by the looming specter of resource scarcity, and try to tip resource distribution in their own favor or that of individuals or groups of their preference. The resulting resource capture competition and frustration may ultimately lead a society into violent conflict (Kahl, 2006, pp. 52-55).

Recently, as climate variability and calamitous natural disasters have increased in frequency and severity, more policy makers and analysts have begun using the deprivation argument to argue that climate change is responsible for food crises that have led to violence, even though academics still dispute the validity of this causal mechanism. Since the turn of the century, the world has witnessed two major food crises, both of which resulted in food riots in countries around the world. The first one was in 2007-2008 in which food prices shot up by 51 percent between January 2007 and March 2008 (Bellemare, 2015). Food riots broke out in several countries across Asia, Africa, Americas, and the Middle East (Berazneva & Lee, 2013; Bush, 2010; Schneider, 2008). In Haiti, social unrest caused by spikes in food price forced the Haitian prime minister Jacque-Edouard Alexis to resign (Collier, 2008). The second food crisis came in 2010 and resulted in famine in the Horn of Africa (Bellemare, 2015). Rioters in Egypt famously chanted “Bread, freedom, and social justice” (Rizk, 2011), and set off a series of protests that led to President Hosni Mubarak’s resignation.

State failure and civil conflict:

The state failure argument asserts that environmental stresses (droughts, floods, variable rainfall and temperature patterns, etc.) not only impose burdens on vulnerable populations, they also weaken a state’s authority and coercive capacity. Depressed tax collection and reduced government revenues, attributable at least in part to reduced economic activity due to climate change, impair a government’s ability to provide relief to vulnerable populations, or even to maintain or restore peace as individuals and groups compete over depleted resources. People suffering from climate-induced stresses usually look to state for help, e.g. for subsidies for agricultural inputs, disaster relief after extreme climate events, new reservoirs for water storage or flood mitigation, protection from price fluctuations in local and international commodity markets, etc. Therefore, a state's inability to provide for its citizens may result in erosion of its legitimacy, which further weakens its authority (Hayward & O'Brien, 2010; Ignatieff 2005; O'Brien, Hayward, & Berkes, 2009). Della Porta (2015) makes the same argument for social and political unrest attributable to economic recession in general.

This argument is based on the premise that some of the direct and most adverse effects of climate change may be visible in agriculture sector before they appear elsewhere in a society. An increase in temperature and rainfall patterns is shown to adversely affect crop yield (Lobell & Field, 2007; Lobell & Gourdji, 2012; Lobell, Schlenker, & Costa-Roberts, 2011), and may result in reduced agricultural production (Hertel, Burke, & Lobell, 2010; Miguel, Satyanath, & Sergenti, 2004). Since agriculture remains one of the chief sources of employment as well as national income in the developing world (Alston & Pardey, 2014), recession may spread to the rest of the economy, thereby causing widespread frustration and chaos. Economic stresses as well as state's weakened capacity may provide conducive environment for political violence or even full-blown conflict (J. Goldstone, 1991, 2001; Homer-Dixon, 1999).

Busby et al. (2013) point to potential international security threats in societies where climatic changes, especially extreme climate events, may significantly weaken a state's capacity. While mapping climate hotspots in Africa, they argue that increased frequency and intensity of climate change, when coupled with state's weakened capacity, can result in security challenges with ramifications for domestic as well as international security.

> In the absence of effective delivery of relief supplies, the destruction of infrastructure and interruption of services could potentially contribute to such desperation that the populace will steal or riot to secure necessities. In such circumstances these risks to state control are compounded if others take advantage of the absence of a security presence to loot for personal gain. Moreover, disasters may provide focal points around which citizens with grievances against the regime may rally. (J. W. Busby et al., 2013, p. 140)

Questions about plausibility (falsifiability) of the argument that agricultural and economic recession may weaken state capacity and pave the way for political violence led to a series of studies conducted on the topic. Using economic and agricultural growth as predictors of deprivation and social grievances, a number of large-N studies sought to analyze the relationship between climate change and conflict. In an influential study, Miguel et al. (2004) used year-on-year rainfall growth as an instrumental variable for economic growth, and claimed that rainfall shocks adversely affect economic growth and increase the likelihood of civil war. These results opened the floodgates for similar studies exploring correlations between a vast array of climate variables and conflict. Burke et al. (2009) showed a statistically significant correlation between temperature increase and civil war in Africa. Hsiang et al. (2011) studied the effect of global climate change on civil conflict incidence for the period 1950-2004, and concluded that the "probability of new civil conflicts arising through the tropics doubles during El Nino years relative to La Nina years" (p. 438). Johnstone & Mazo (2011), and Sternberg (2012) connected the link between drought, agriculture failure, and the Arab Spring. Similarly, Kelley et al. (2015) and Gleick (2014) attributed the extended drought in the

Fertile Crescent to widespread crop failure, mass migration of failed farmers to urban centers, and subsequent civil war in Syria.

State exploitation and civil conflict:

Kahl (2006) argues that climatic changes may provide some states greater capability to use resource distribution as a political tool, especially in times of scarcity and unrest. Tipping resource distribution in favor of supporters, and economically marginalizing political opponents, may create zero-sum distributional conflicts. He showed this phenomenon at play in Kenya during the 1991-1993 riots where demographic pressures and scarce land provided state elites with an opportunity to trigger ethnic riots, resulting in the killing of 1500 Kenyans, and internally displacing 300,000.

Although the state exploitation argument has not gained much popularity in the literature yet, distributional conflicts over the use of scarce water for agriculture or hydroelectric power generation are being reported from around the world (Zeng, Cai, Ringler, & Zhu, 2017). Such conflicts, if aligned with ethnic or political fault lines, have the potential to at least provide the initial push for political contention, particularly in developing societies that may happen to be fragmented along those lines.

Criticisms:

The neo-Malthusian argument has drawn considerable criticism due to its deterministic logic as well as the research methodology employed by its proponents. Gleditsch (1998), for example, argued that being based almost exclusively on qualitative case studies, the neo-Malthusian literature violates the rules of quasi-experimental methodology, and therefore fails to qualify as systematic research (1998, p. 387).

Concerns have been raised about the broad strokes approach of the deprivation argument, and it being overly deterministic (De Soysa, 2002a, 2002b; Diehl, 1998; Gleditsch, 1998; Koubi, Bernauer, Kalbhenn, & Spilker, 2012; Salehyan, 2008). Deudney (1990) argued that since many resource-poor countries, such as Japan, are very wealthy while resource-abundant countries are poor, there is no clear and direct relationship between abundant resource availability and national wealth.

Gleditsch's critique triggered a series of quantitative large-N studies confuting the link between climate change, deprivation, and conflict. Miguel et al.'s work, in particular, drew considerable reaction from a large array of studies that found no correlational evidence for scarcity-conflict hypothesis (Buhaug, 2010; Ciccone, 2011; Koubi et al., 2012; Raleigh & Urdal, 2007; Theisen, 2012). Another line of reasoning claimed that it is not scarcity, but abundance, that may lead members of societies into conflict (Adano, Dietz, Witsenburg, & Zaal, 2012; Meier, Bond, & Bond, 2007; Ross, 2004).

Adano et al. (2012), based on interviews of pastoralists in Kenya's drylands, observed:

> When a drought is expected, warring pastoralists usually reconcile in order to use water and pasture together. Violent livestock raiding is mostly carried out during the wet season. The animals are stronger and fatter then, and the vegetation and surface water are more readily available, which is necessary during a long trek away from the area where raid took place. (p. 71)

De Soysa (2002a) found that "greed rather than grievance (at least in terms of the availability of natural resources) is likelier to generate armed violence" (p. 29). Bergholt & Lujala (2012) argued that although climate-related natural disasters have considerable negative effect on economic growth, they do not increase the risk of armed conflict. Ciccone (2011) used the same data as used by Miguel et al. (2004) and found their results to be sensitive to changes in the independent variable. He showed that using rainfall values, as compared to year-on-year rainfall growth that Miguel et al. had used, reversed the sign of the relationship. Similarly, Koubi et al. (2012), did not find any correlation between temperature and precipitation variability and reduced economic growth. Deschenes & Greenstone (2007) claimed that climate change on US agricultural land will, in fact, "increase annual profits by $1.3 billion in 2002 dollars (2002$) or 4 percent" (p. 354).

Adaptation as a response to neo-Malthusian argument

The history of adaptation to changing climate and weather conditions is as old as humanity itself. Hetherington & Reid (2010) trace the interaction of homo-sapiens and climatic changes over a period of 135,000 years through the Pleistocene-Holocene boundary. Using archival data as well as simulations, they explain the human response to climate change that occurred during the last glacial cycle (LGC) as follows:

> It was a time of significant global climatic change. The strength of the thermohaline circulation in the oceans, which directly influences the climate of the northern hemisphere, was highly variable. Global sea level rose and fell. Continental shelves were exposed for hundreds of kilometres in some areas and were submerged in others. Vegetation and animal distribution changed rapidly, sometimes decreasing biomass and sometimes increasing food resources for humans. Yet despite the variable climate and their prehistoric culture and

> technology, humans not only persisted but also spread throughout the world. At the height of the last ice age, Homo sapiens had migrated out of Africa, colonized Asia and Australia, and begun moving towards the Americas. (Hetherington & Reid, 2010, p. 5)

Confident of human ingenuity and adaptability based on such arguments, proponents of adaptation argument, commonly referred to as "cornucopians", argue that human societies, governments, institutions, social norms and practices will change in response to resource scarcity. For example, markets will respond to resource depletion or degradation by adjusting prices, thus nudging societies to adapt either by using resources more efficiently, or finding substitutes, or both. Bjørn Lomborg argued:

> There is often a general tendency throughout this discussion [of scarcity-induced] conflict to presume that environmental scarcity indeed sets in more and more often . . . As should be abundantly clear [from the evidence], we are far from exhausting our raw material resources . . . We continuously find new resources, use them more efficiently, recycle them, and substitute them. . . . Consequently, although the discussion of environmental stresses and their connection to conflict is clearly an important area of research, it is important to realize that, on the main issue areas, resources have not been becoming increasingly scarce but rather more abundant. (Bjørn Lomborg (2001) as cited in Kahl (2006, p. 14))

Gleditsch (2003) argued that if scarcities developed at a local level, nations and sub-national groups will engage in cooperative ventures and resolve violent conflict over resource use. Wolf (1999) claimed that there is more evidence of cooperation than conflict over shared water resources. Scouring through conflict databases, he found only seven minor skirmishes between countries in the twentieth century, and no record of any war having been fought over water. In contrast, upper and lower riparian countries signed 149 water-related treaties in the same period (ibid, p. 251). Simon (1989) anticipated that impending resource scarcity may encourage devising ways to mitigate the shortages, and result in cooperation rather than conflict. Gleditsch & Sverdrup (2002) argued that since democratic societies have more respect for human life, can encourage ingenuity by allowing more trial and error policies, and are open to international cooperation and trade, they may be able to resolve conflicts in case environmental degradation led to scarcities at the local level.

<u>Adaptation as a rational choice:</u>

The adaptation argument gained even more steam from the research of environmental economists who predicted that when faced with climatic changes, individuals, firms, and governments would act as rational economic agents and adapt to changes in the natural system. Mendelsohn (2000) qualified that "efficient adaptation" – i.e. when the cost of making the effort is less than the resulting benefits – will reduce costs imposed by climate change. The concept of efficient adaptation is echoed in the results of several other economists (Adams, Glyer, & McCarl, 1989; Easterling III et al., 1993; Fankhauser, Smith, & Tol, 1999). Using models of relevant economic, agricultural, and climate processes, Kaiser et al. (1993) argued:

> [G]rain farmers in southern Minnesota can effectively adapt to a gradually changing climate (warmer and either wetter or drier) by adopting later maturing cultivars, changing crop mix, and altering the timing of field operations to take advantage of a longer growing season resulting from climate warming. (p. 387)

Krishna Kumar et al. (2004) and Sanghi et al. (1998) showed effectiveness of efficient adaptation on agriculture in response to climate change in India. Goklany (2009) argued:

> [F]ocused adaptation can combat climate change and advance global well-being, particularly of the world's most vulnerable populations, more effectively than aggressive GHG reductions. (p. 179).

Clearly at work in this conceptualization is Adam Smith's argument that the invisible hand of competition may promote efficiency, minimize externality, and reduce overall costs imposed by climate change as well as adaptation. Differentiating between individual or private and collective adaptations, Mendelsohn (2000) argued that "self-interest will motivate most actors to engage in efficient private adaptation" (p. 585).

Just like the scarcity argument, literature generated on the adaptation argument is diverse, but the body of work is bound together by the underlying assumption that although climate mitigation requires international cooperation and consensus, adaptation is a low hanging fruit, a goal that every nation can aim for on its own. Calls such as "Adaptation now!" (Adger, Lorenzoni, & O'Brien, 2009) have gained attention of academics and policymakers alike. Taylor (2014) comments that "the idea of adaptation has become a touchstone concept that provides both a normative goal and a framework within which practical interventions are planned, organised and legitimized" (p. xi).

<u>Limits of adaptation, maladaptation, and social-ecological traps:</u>

Although, the assumption of economistic rationality in adaptation measures has gained widespread appeal across disciplines, there are some who have raised concerns that conditions generated by climate change as well as the human response to it may be more complex than imagined by resource optimists. Efficient adaptation requires complete information about the stressor, access to resources necessary for successful adaptation, as well as an assessment of all the possible alternative scenarios available to vulnerable individuals or groups, before any decision (for adaptation) is made.

Hanemann (2000) argues:

> In general, what is optimal depends on a variety of considerations: What you think the choice is about; what you see as the alternative courses of action (the choice set); what are your objectives; what you perceive to be the link between the alternatives and your objectives (perceived attributes, perceived costs, etc.); and what are your constraints. It is a mistake to assume that these are readily knowable based just on external observation. They are likely to vary with individuals and, for a given individual, to vary with circumstances. (p. 573)

Concerns about "limits of adaptation" are echoed in the literature on adaptation analysis, and point to physical and ecological, social, economic, and technological limits to adaptation (Dow, Berkhout, Preston, et al., 2013; Evans et al., 2015; Smit, Burton, Klein, & Street, 1999; Smit, Burton, Klein, & Wandel, 2000; Smithers & Smit, 1997). Even when successful, a particular adaptation measure may impose externalities and spillovers elsewhere in a society, or in other societies (Adger, Arnell, & Tompkins, 2005; Barnett & O'Neill, 2010).

As effects of climate change become visible in the form of variability in weather patterns as well as increased frequency and severity of extreme climate events, limits of the adaptation framework are becoming evident. In fact, there is a growing realization among scholars that some adaptation measures may increase vulnerability instead of decreasing it (Barnett & O'Neill, 2010; Magnan et al., 2016). What may be considered a successful adaptation strategy in the short term may have deleterious effects in the long run. The success of an adaptation measure, therefore, cannot be determined only by the stated objectives of adapters. In fact, for a coping mechanism to be considered successful, its consequences have to be assessed across temporal and spatial scales (Adger et al., 2005, p. 80).

Dow et al. (2013) point to limits of social systems' ability to adapt. They argue that opportunities and resources to adapt may be finite, and "breaching adaptation limits may result in escalating losses or require transformational change" (p. 305).

The concept of maladaptation has recently gained prominence among scholars, although there is little clarity on what it means in practice. The IPCC defines maladaptation in the Fifth Assessment Report as "actions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future" (IPCC, 2014). This definition is vague at best, as it fails to identify whether maladaptation is a case of planned adaptation that did not work (unsuccessful adaptation) or a spontaneous response that jeopardized the stability of the system. Also, there is no clarity as to what kinds of actions are included in the definition, adaptive or development related, or something else.

Barnett and O'Neill (2010) term only that action to be maladaptive that is taken "ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of *other* (emphasis added) systems, sectors, or social groups" (p. 211). This definition is clearer than the one adopted by the IPCC in two ways.

First, it considers only those actions as maladaptive that are taken with the forethought of adaptation to climate change. Second, it qualifies that an increase in vulnerability, in the case of maladaptive action, is to be expected in some other system. However, it still leaves out adaptive actions that may have self-inflicted detrimental effects on populations which conducted them in the first place. For example, pumping the aquifer to make up for reduced surface water availability or less rainfall may deplete the underground water reserves and increase vulnerability rather than reducing it. Chasing the cultivation window (that may have shifted or become variable due to climate variability and change) instead of switching to a different, more resilient crop that may be suitable for the changed environment, may result in increase in vulnerability, e.g. reduced yield, price fluctuation due to the imposed change in commodity markets. Similarly, burning of dry dung fuel to temporarily raise local temperature in a field to protect crops from frostbite may result in further polluting the environment, etc.

Complexity and uncertainty that come with climate change, as well as human responses to it, become pronounced in developing countries where there are hardly any adaptation plans devised at the government level. Boonstra & Hanh (2015) use the concept of "social-ecological traps" to point out that the sub-optimal behavior of vulnerable populations may result in negative or undesirable outcome from a sustainability perspective. Some such suboptimal coping responses may be path dependent, thereby pulling vulnerable populations in "traps" from which they may not easily escape.

The human security argument:

The human security argument is based on the twin concepts of resilience and vulnerability. Resilience is the magnitude of disturbance that a system can absorb, self organize, and adapt before losing its structure and transforming to a radically different state (F. C. Berkes, Johan Folke, Carl, 2008; Folke, 2006; Walker et al., 2004). Vulnerability is the "degree to which a system is susceptible to and is unable to cope with adverse effects of climate change" (Adger, 2006b). The main argument is that the effects of climate change will vary within and across societies depending on the resilience and vulnerability of populations exposed to changes in the natural system. Those individuals and groups with "architecture of entitlements" stacked in their favor will be comparatively less vulnerable and therefore more resilient and better positioned to adapt to the adverse effects of climate change. In essence, the framing traces the source of climate-induced instability in a society's preexisting social, political, and economic structures. It argues that the distribution of climate-induced stresses is a function of how a society is structured, how equitably (or otherwise) entitlements are distributed among its populations, and how accessible resources necessary for adaptation are to individuals and groups exposed to climate change (Adger, 2010; Adger & Kelly, 1999; Matthew, Barnett, McDonald, & O'Brien, 2010; O'Brien, Eriksen, Nygaard, & Schjolden, 2007; Ribot, 2010). As climate change threatens human security and well-being of individuals, populations, and the security of states, it may result in undermining "access to, and the quality of, natural resources that are important to sustain livelihoods" (Barnett & Adger, 2007, p. 639).

Proponents of the human security argument take issue with the narrow framing of climate change as a source of civil conflict, and particularly as a national security issue, as it may lead to securitization (Barnett, 2009; Brzoska, 2009; Trombetta, 2008) and militarization of climate change (Hartmann, 2009). Fears are raised that instead of taking substantive action regarding limiting carbon emissions and climate mitigation, narrow focus on national security may result in either more inward looking approach by states to protect their resources, borders and national interests, or provide a rationale for international intervention in failed and ungoverned spaces (Hartmann, 2009). Adger (2010) warns that traditional security framing of climate change has inherent risks because "it privileges those impacts of climate change that are important to states, often under-emphasising ecological and cultural risks" (2010, p. 281).

Instead of nation-state, the focus of human security argument is individual, whose well-being, health, and access to clean environment is threatened by changes in the natural system as well as their interaction with the preexisting social, political, and economic processes. From this perspective, the central issue is not just the exposure to changes in the biophysical system, but also a society's preexisting structure that may determine the resilience of vulnerable individuals as well as communities, and their ability to adapt to these changes. This conceptualization treats climate change as "a social problem with environmental characteristics, rather than an abstract scientific problem that can be disarticulated from social processes" (O'Brien & Barnett, 2013, p. 375).

The concept of human security is not new. It already has applications in geography, sociology, political science, development, international relations, etc. In the context of climate change, the argument is threefold:

1) Climate change is a global process, in that its effects are ubiquitous. Also, that the causes and effects of climate change are often located in different parts of the world (Adger, 2010; O'Brien & Barnett, 2013). Since most local social-ecological systems are interconnected, climate-induced stresses are readily transferable to distant locations and communities (Adger, Eakin, & Winkels, 2009; Leichenko & O'Brien, 2008);

2) Global processes such as climate change and globalization interact with local power structures and social, cultural, and economic processes of a society to impose burdens on vulnerable populations. In this way, although climate change is an exogenous factor, vulnerability to its effects is endogenous to societies (Adger, 2000, 2006a; Adger & Kelly, 1999; Barnett & Adger, 2007; Gemenne, Barnett, Adger, & Dabelko, 2014; Turner et al., 2003).

3) Human insecurity for vulnerable individuals and communities comes from their failure to respond "to threats to their human, environmental and social well-being imposed by climate change" (Adger, 2010, p. 281), and is owed in large part to a society's preexisting structural inequities and access to resources necessary for successful adaptation.

What makes this argument an important contribution to climate-security debate is the acknowledgement that climate change does not undermine human security directly. In fact, it interacts with local processes such as preexisting vulnerability from poverty, power structures, social cohesion, and related social economic, political, and cultural processes. Adger and Kelly (1999) refer to a society's preexisting structure as "architecture of entitlements" – i.e. "availability and distribution of entitlements, the means by which entitlements are defined, contested and, therefore, change over time, and the wider political economy of distribution and formation of entitlements" (p. 256).

Another important contribution of the human security argument is recognition of the role interconnectedness and interdependence of human socieities across the globe, especially global commodity markets, play in proliferation of climate-induced risks at the global level (Adger, Eakin, et al., 2009; Eriksen & Silva, 2009; Leichenko & O'Brien, 2008; O'Brien et al., 2004; Silva, Eriksen, & Ombe, 2010). The effects that droughts in China, Russia, and Ukraine, along with a drastic reduction in wheat production in the United States, had on global food prices are just a few examples of how large processes of climate change, trade, and economic choices in one part of the world can have unintended consequences across the globe. The phenomenon, aptly termed as "globalization of hazard" (Sternberg, 2013b), points to the fact that human security is a function of multiple processes operating across temporal and spatial scales, and climate change can certainly threaten it.

Although the proponents of human security argument discourage proposing "automatic, simplistic linkages" (Peluso & Watts, 2001, p. 5) between environmental change and national security, they warn that "diect and indirect impacts of climate change on human security may in turn increase the likelihood of violent conflict" (Barnett & Adger, 2007, p. 639). O'Brien et al. (2009) argue that as climate change threatens livelihoods of populations, it may erode governments' moral authority and ability to govern. Vulnerable populations may call into question existing social-contracts and demand new ones that ensure protection of their well-being and means of survival.

Conclusion

As can be gleaned from the summary of three leading debates generated on the topic, the literature on the effects of climate change on society, particularly its potential to stoke social and political unrest and contention, appears to be stuck. Bitter debates among scholars show that there is no consensus as to how the phenomenon interacts with vulnerable populations and societies, and what can be done to mitigate its effects without exacerbating or inducing vulnerability elsewhere across time and space.

Of late, there have been calls from scholars, most notable among them quantitative oriented social scientists, to shift away from large-N approach that has dominated the climate-conflict research for some time, and develop a mechanism-based understanding of climate-society interaction (Buhaug, 2015; Hendrix, 2017; Theisen, 2018). Anthropologists and sociologists have already argued in favor of developing a more high-resolution understanding of the phenomenon at the local level (Barnes et al., 2013; Crate et al., 2008; Hulme, 2010; Szerszynski & Urry, 2010). Climate scientists concerned with our limited understanding of climate-society interaction also warn that extant analytical approaches "are unable to estimate the full interaction among individuals, social-economic systems, and the climate" (Oppenheimer, 2013, p. 445).

This dissertation argues that the root cause of the problem goes much deeper than merely explanatory strategies. It is not only the lack of high-resolution data, but also the inability of current research approaches to incorporate complexity and emergence inherent in both climate change and society, that has led to an impoverished understanding of the phenomenon. The scarcity argument depicts society as a passive actor, limiting human agency to resource capture and contention at the first signs of scarcity. Moreover, it paints a rather static picture of climate change, reducing it to just a few variables behaving uniformly within and across societies around the world. The adaptation literature provides an engineering solution to the problem, focusing predominantly on agriculture sector and analyzing the effects of human ingenuity in a delimited fashion. Although the human security argument casts a wider net and situates the problem in the social and political structures of society, it is wanting with regards to elucidation of climate change *process* and human response to it across scales.

The world's climate is a complex and emergent system, composed of scores of local climates, each of them interacting with and affecting others, and being affected in return. These local climates are non-uniform, and their long-term climate and weather trends are a function of their respective ecological zones instead of national borders. A society's climate may be a combination of more than one ecological zone, each with its own distinct climate and weather trends. Local political economies as well as cultures are built around their respective local climate and weather trends. This means that climatic changes in different parts of the same country may manifest differently based on the ecological zone they take place in, thereby causing non-uniform stresses, and eliciting varied responses from populations. The effect on agriculture may be diverse too, depending on which crops are grown in a particular part of a country, and the prevailing climate conditions.

The fact that agriculture is considered essential for domestic food security in most countries, and enjoys preferential treatment when it comes to resource distribution, casts aspersions on the validity of the scarcity argument even further. This is all the more true in times of climatic variability, especially shrinkage in rainfall or surface water availability. Resource distribution tradeoffs in such situations may shift the burden of climate change elsewhere in society depending on its political and socio-economic makeup, and its priorities regarding its political economy.

Adger and Kelly (1999) argue:

> Social and biophysical systems react to climate change through adaptation. In the case of social systems, these reactions may be involuntary, spontaneous responses or may be deliberate, adaptive strategies. … [I]t is meaningless to study the consequences of climate change without considering the range of adaptive responses that will substantially alter any initial impacts. (Adger & Kelly, 1999, p. 254)

Additionally, the current conceptualization of the deprivation argument does not take into account the impact that globalization, especially the integration of global commodity markets, has on a society's food security. As globalization weaves local economies with each other through international trade (both formal and informal), effects of climate change and (mal)adaptation are expected to traverse through the entire global economy like seismic waves. This means that a society can be vulnerable to effects of climate change without experiencing climate change directly; its political economy and food security can unravel due to climate events taking place elsewhere in the world.

The question regarding the potential of climate change to trigger violent conflict is where the charge of over-determinism becomes more evident. It is true that effects of climate change may create winners and losers and result in economic marginalization of vulnerable populations. However, in the absence of a clear aggressor as well as large costs and risks associated with challenging the state, it may be difficult for hurting individuals and groups to mobilize direct opposition against government authorities (Hendrix & Salehyan, 2012, p. 39).

More importantly, the fundamental problem with the current formulation of the conflict theory is "reifying the category of civil war and downplaying the relationship between insurgencies and 'lesser' forms of contention" (Tarrow, 2007, p. 589). The dominant emphasis on identifying direct causality between climate change and civil conflict, where actors take up arms against the state, leaves out intermediate stages of political and social instability that may culminate in violent political contention. As careful students of social movements note, any successful collective action is predicated on social connections, organization efforts, coalition building, sharpening of identities, mobilization etc. before it turns into a social movement, insurgency, or civil war (Aminzade & McAdam, 2001; J. Goldstone, 1994, 1998b, 2011; McAdam et al., 1996; McAdam et al., 2001; Polletta, 2009; Tarrow & Tilly, 2007). These political activities, alliances among disparate groups over mutual demands, activation of boundaries which pit one group of individuals against the other, could manifest effects of climate change on political stability. In some cases, such activities could result in organized social movements, in others, tenuous equilibria, or worse, civil conflict.

Embracing the complexity and emergence in climate change process, its interaction with society, and finally violent collective action or contentious politics requires not just reformulation of the problem, but also the philosophical structure on which current research designs are based.

I present such a formulation in the next chapter.

Chapter 3: Climate change and contention - A Mechanism based framework

Abstract:

This chapter outlines a framework to systematically analyze the potential of climate change to impose social and political stresses. I make two contributions in this research:

1) The first concerns the conceptualization of the problem by proposing an alternative ontological basis regarding the process of climate change; its interaction with a society's preexisting social, political, and economic processes; and finally, the imposition of social and political stresses traceable to the original stress. I make the case that climate change is a complex and emergent process and its effects on social and political systems manifest in a varied and interactive manner. The fact that global climate change is a result of local climate and weather trends, which are not just non-uniform but also interact with each other to exhibit emergent behavior, points to the complexity of the problem.

Given its interactive nature, most manifestations of climate change, with the exception of extreme climate events, interact with vulnerable populations by eliciting coping responses in real time. Without complete information about the nature of the stress, coping responses employed by local vulnerable populations are bound to be shortsighted and bounded-rational, and may even turn out to be maladaptive, and result in exacerbation of stresses. Moreover, interaction of climate stress as well as coping

responses with antecedent mechanisms and processes in a political economy may result in emergent and complex stresses.

I also diverge from a narrow focus on civil conflict as a potential outcome of climate-induced instability. I follow the lead of other scholars who have argued much earlier that civil conflict does not erupt overnight. In fact, it is the result of a tortuous path through which a society must pass before individual grievances and uncoordinated expressions of unrest coalesce into organized and sustained episodes of social and political contention and violent conflict (J. Goldstone, 1998a; McAdam et al., 1996; Petersen, 2001). As early signs of unrest traceable to climate change are being reported in media accounts from around the world, a systematic understanding of this complex process is warranted. A deeper understanding of the phenomenon will be helpful in not just tracking the progress of budding social unrest, it may invite effective policy measures aimed at preempting or even curtailing episodes of contention.

2) The second contribution concerns distinguishing method from methodology. Whereas the former is about techniques of gathering and analyzing bits of data, the latter has to do with the logical structure of the intellectual exercise (Sartori, 1970, p. 1033). I contend that the fundamental problem with the current analytical approach has more to do with the ontological assumptions, rather than explanatory approaches (qualitative vs. quantitative). Given the complexity and emergence inherent in the phenomenon under consideration, I concur with Selby (2014) that the positivist ontology lacks the capacity to reveal causal pathways linking climate change with predictors of social and political instability and conflict. In this dissertation, I build a case for a critical realist perspective as an alternative and more suitable ontological basis for analyzing the problem.

In a nutshell, an alternative analytical approach is proposed in this research that not only uses mechanisms as workhorses of explanation, but also emphasizes their distinct ontological status. Rather than fishing for Hempelian covering laws (Hempel, 1942) of the form “climate change leads to conflict (peace)”, a mechanism-based explanation aims at identifying smaller generalizable chunks, which when concatenated will provide explanations of salient features of a causal chain (Gambetta, 1998). Climate change is a dynamic phenomenon, as are coping responses, social movements, rebellions, and civil conflicts. Developing a dynamic understanding of their interaction requires a change of perspective in how they unfold, and how, if ever, one paves the way for the other.

Introduction:

When almost fifty years ago, in his influential essay “the tragedy of the commons” Hardin revived Malthus’s famous theory-cum-cautionary-tale, his concern was that tragic overuse and exploitation of resources by self-serving and benefit-maximizing rational beings would result in deterioration and destruction of commons (Hardin, 1968). Although he discussed in sufficient detail the causal pathways through which human action may lead to the destruction of natural resources, Hardin was circumspect in laying out the same for the converse. That is, how would degraded natural commons affect human populations? Will scarcity lead to famines, conflict, or both, and if yes, how? Would the consequences of degraded commons be local or global in their reach? He also disregarded the possibility that these adversities could lead to cooperation. Hardin's rekindling of the Malthusian argument prompted efforts from resource-optimists, most notable among them Elinor Ostrom, who claimed that human beings are capable of self-organizing and self-policing, and therefore able to keep the natural commons intact (Ostrom, 1998, 1999, 2000; Ostrom et al., 1992). Ostrom's work, although, successfully countered "the tragedy of the commons" as well as provided a solution to Olson's collective action problem (Olson, 1965), it too did not address the effect the changes in the natural system may have on human societies, should stakeholders fail to protect it. As concerns about the rising global temperatures and their potential to destabilize societies and stoke conflict have grown in recent decades, scholarly efforts to identify pathways of climate-induced-instability have accelerated. The question now is not if but *how* would climate change undermine (local and global) economies, impose burdens on vulnerable populations, and destabilize countries and regions (Steinbruner et al., 2013). The concern is much bigger for societies where governments and populations lack resources not only for adaptation but also for accurately measuring current and future variability and change in their local ecosystems. This chapter contributes to these debates.

As discussed in the literature review section, a large proportion of the efforts to theorize climate-society interaction has come from scholars collectively labeled as neo-Malthusians for their invocation of Malthus's (and Hardin's) imaginary in which pressures on the environment may result in scarcity and lead to destabilization of human populations. However, the hypothesis that climate change, by way of making renewable natural resources scarce, would pit groups and individuals against each other, so far, has not fared well when tested against the empirical evidence. This inability of social scientists to explain climate-society interaction is not a statement on the innocuousness of climate change. On the contrary, it is testament to the bafflingly complex phenomenon that has, by way of morphing into and metastasizing the preexisting stresses and fault-lines in a society, made the task of theorizing quite difficult. Then there is the human response to climate variability and change at multiple levels of society, ranging from unsuspecting individuals to local institutions to central governments, that shapes the path of this interaction if not necessarily determines the final outcome. Although several studies have demonstrated that a link between climate change and political violence exists, a systematic theoretical framework is required.

The inability of climate-conflict scholars to come up with a plausible theory to explain the phenomenon in the past one and half decade has not only brought research at an impasse; it has also raised serious concerns about the suitability of *methodology* (contrasted from method)[3] employed in the research so far. Two leading concerns continue to confound scholars studying the topic:

1. There is a growing realization among climate-conflict scholars that the literature is "weak on theory", and that correlations, without the accompanying causal mechanisms and contexts, have limited explanatory capacity, if at all (Hendrix, 2017; Selby, 2014). Buhaug (2015) reflects:

    > … [F]urther scientific progress in this field depends critically on our ability to specify plausible causal mechanisms, the conditions under which they are likely

[3] Sartori (1970) differentiates "methodology" from "method" by pointing out that method in social and behavioral sciences is about techniques for gathering and analyzing bits of data and social statistics; whereas methodology deals with "logical structure and procedure of scientific enquiry" (p. 1033).

to play out, the actors at play, and the range of possible outcomes in terms of conflictive (or cooperative) behavior. (Buhaug, 2015, p. 270)

Building on this insight, I argue that there is also a need to broaden the scope of the research field. The conflict potential of climate change cannot be explained without mapping antecedent processes and mechanisms that are invoked upon a society's interaction with the climate stressor. These include coping responses at multiple levels of society, interaction with political economy, preexisting social, political, economic, and historical contexts, and finally, with global commodity markets. In other words, there is no single causal mechanism that can explain the conflict potential of a phenomenon such as climate change that interacts with a society at multiple scales simultaneously, and generates feedback loops and system effects. It is the concatenation and combination of multiple distinct mechanisms that constitute the causal chain linking the external mechanism (climate change) with the final outcome (social and political instability). The final outcome may differ in structure and severity in different cases depending on which mechanisms are invoked and concatenated to constitute the causal chain, as well as varying initial conditions in each case.

On the dependent variable side, instead of using a binary delineation of conflict, i.e. absent or present, the outcome range needs to be broadened by using a richer suite of "contentious politics" ranging from non-violent expressions of unrest on one end of the spectrum to armed violent conflict on the other (McAdam et al., 1996; Petersen, 2001). I draw from the vast literature of contentious politics and social movements to elaborate dynamics of climate-induced social and political instability that may lead to violent forms of contention.

2. The other equally important debate raging in scholarly circles is about methodological approaches so far used in knowledge production on the subject. In what appears to be a reflection phase in the climate-conflict research, scholars with varied methodological persuasions have raised wide ranging questions from data collection and analysis approaches, to sampling bias, to spatial and temporal granularity, to a rare willingness to allow for varied (social) outcomes, etc. In addition to these analytical issues, deeper questions have also been raised about epistemological and ontological choices, and about scientific rigor. Selby (2014) for example, critiques the use of positivist epistemology in climate-conflict research by arguing that it is "not the use of quantitative methods per se, but rather underlying philosophical commitments that lie at the root of its shortcomings" (p. 831).

These two debates inform the structure of the framework that is proposed in this chapter. The sprawling literature generated on the subject, as discussed in the literature review chapter, has, although, improved our understanding of the ways climate change affects societies, but it seems to have overlooked the part where a society responds to these changes. I contend that in the face of climate change, society is not merely a passive observer. Human beings at all levels of society respond to climate change in their own ways; it is this interaction which determines the trajectory and shape of the causal pathway(s) linking climate change with either instability or resilience. Understanding this social-ecological interaction, therefore, is necessary both for scholarship and effective policy interventions.

This chapter addresses these questions and is organized in two sections, each of which is a discrete unit. The first section lays out philosophical debates surrounding knowledge production on the subject. The second section presents my framework.

Intellectual resources

Climate-conflict debate has far too often been portrayed as a classic tussle between "quants" and "quals" (Solow, 2013), with the former either claiming their approach to be more scientific and therefore more relevant for comparative analysis (Buhaug, 2018), or questioning the scientific rigor of the latter (Gleditsch, 1998). However, it is important to note that such polemics have not remained strictly between "quals" and "quants". In fact, as discussed in the literature review chapter, the most heated arguments have taken place within the quantitative camp over the issues of attribution, data used, sampling bias, selection of variables, etc. Regardless, such debates have by far revolved around the tactical issues pertaining to "method" or "techniques for gathering and analyzing bits of data" (Jackson, 2010, p. 25) instead of "methodology" or "logical structure and procedure of scientific enquiry" (Sartori, 1970, p. 1033). The fixation over finding statistical regularities between variables of interest has shifted the focus away from the foundational issues at the heart of knowledge production on the subject.

Hsiang & Burke (2014) point out that the state of knowledge in the climate-conflict debate is akin to the link between smoking tobacco and lung cancer in the 1930s. There is clear statistical evidence but the underlying mechanism is difficult to disentangle (p. 42). Selby (2014) argues that this is perhaps because the positivist approach, which has dominated the research on the topic for the past one and a half decade, is ill-suited to identify causal relations. If this is true, then the question arises as to what other approach of knowledge production may be suitable for solving this puzzle? Also, is the currently used ontology of mind-world dualism, which provides the philosophical foundation for the positivist approach, suitable for the job? I agree with Selby that merely the tools of choice (quant. vs. qual.) are not the reason for the lack of consensus among climate-conflict scholars; rather it is the philosophical assumptions underlying different approaches of knowledge production that scholars make, either knowingly or unknowingly, that result in ideological differences. Being indifferent to or unaware of these philosophical choices only perpetuates these differences. Also, success or failure of any future research effort will depend on addressing these philosophical concerns to some extent. Therefore, in what follows, I turn attention to the logic and philosophy of knowledge production on the subject.

<u>Knowledge production and the question of "scientific rigor":</u>

In their oft-cited book on research methods in social sciences, King et al. (1994) declare: "research designed to help us understand social reality can only succeed if it follows the logic of scientific inference" (p. 229). Implicit in this framing is the rhetorical use of the "scientific" approach that social scientists often do in order to elevate credibility of their work. The logic is as follows: since it is broadly accepted that research approach employed in science is rigorous and therefore its findings credible, it implies that (social scientific) studies that do not follow "the logic of scientific inference" in their research must not be deemed credible (Gleditsch, 1998). This begs the question: what are the rules of scientific inference? Is there a global consensus among philosophers of science on such rules? Even a cursory look at the philosophy of science literature may reveal that such consensus does not exist (Jackson, 2010; Kurki, 2008; Sayer, 2000, 2010).

An analyst's worldview is central to his comprehension of the world, and therefore would determine his vantage point (as an observer of reality), data to be collected, hypotheses to be tested, etc., thereby making it impossible to "verify" (Hempel, 1942) as to what "force" or "cause" is responsible for a particular effect. The result is apparently irresolvable disputes among scholars, surrounding the questions of sample selection, analytical coherence, statistical model, assumptions, etc. Jackson (2010) argues that unless research in social sciences is elevated beyond mechanics of data collection and analysis, into the realm of philosophical ontology or "ways of being connected to the world," it would be nearly impossible to resolve such empirical conflicts; because "any scholar can at almost any time retreat behind the safety of their particular view of the world" (p. 30).

Does it mean that objective and scientific analysis of climate impacts on society is not possible; and all one can aspire to achieve is a subjective and anecdotal understanding of the resulting social phenomena? The answer depends on as to what definition of science one espouses; which in turn depends on one's ontological assumptions or "hookup to the world" (Jackson 2010). The rationale for getting into the territory of philosophy of science can be explained by pointing out implications of its absence from the research design. As previously mentioned, data collection and analysis schemes are dependent on the epistemological approach (a.k.a. explanatory strategies) an analyst adheres to (e.g. covering law, interpretivism, propensity, systems approach, etc.), each of which in turn is based on a separate set of ontological assumptions or an analyst's understanding of how the world is ordered. An analyst unaware of the underlying ontological assumptions of his chosen epistemological approach, or "unconscious thinker" (Sartori 1970, 1033), would be unable to resolve or even identify logical inconsistencies in the knowledge produced, thereby giving rise to the polemics of the type that have essentially brought climate-conflict research to a halt. This demand on analysts to be cognizant of ontological and epistemological choices elevates the debate (of knowledge production) from empirical to the philosophical level, and from data analysis to logic of enquiry. Weber argues:

> A systematically correct scientific demonstration in the social sciences, if it wants to achieve its goal, must be recognized as correct even by a Chinese (or, more accurately, it must constantly *strive* to attain this goal, although it may not be completely reachable due to a dearth of documentation). Further, if the *logical* analysis of the content of an ideal and of its ultimate axioms, and the demonstration of the consequences that arise from pursuing it logically and practically, wants to be valid and successful, it must be valid for someone who lacks the "sense" of our ethical imperative and who would (and often will) refuse

our ideal and the concrete *valuations* that flow from it. None of these refusals come anywhere near the scientific value of the analysis. (Weber quoted in Jackson 2010, p. 22)

This broader Weberian definition of science does nothing more than making the case for internal validity of the *philosophical* logic employed in research design. The goal of knowledge production is not to fit data to a particular interpretation and analysis scheme, but to employ coherent (logical) concepts and rules to gain understanding of social phenomena. Since all approaches of scientific knowledge production are based on (ontological) assumptions, and no one set of assumptions (about how the world is ordered) is superior to others, adherents of one approach cannot use the "science" label to discredit other analyses and elevate their own (Jakcson 2010, p. 9). In fact the only way to demarcate sound analysis from an unsound one is by making sure that "given our assumptions, our conclusions follow rigorously from the evidence and logical argumentation that we provide" (ibid, p. 22).

Climate change is unlike any other problem tackled in social sciences for several reasons. To begin with, climate variability and change is too varied across temporal and spatial scales to allow for a single generalized model to find statistical regularities (Selby 2014). Secondly, most stresses brought about by climate change are not only unprecedented; they are also adaptive. Therefore, instead of developing new concepts and identifying new causal chains, scholars resort to what Sartori (1970) calls "concept stretching" or "concept straining"; that is, they tend to "broaden the meaning – and thereby the range of application – of conceptualizations at hand" (p. 1034). But analytical challenges aside, given that social-ecological systems (SES) are composed of complex subsystems at multiple levels (Ostrom, 2009), and are intertwined to such an extent that "delineation between social and natural systems is artificial and arbitrary" (F. C. Berkes, Johan Folke, Carl, 2008, p. 3), the task of unbiased and impersonal observation and measurement (of effects of climate change) is rendered difficult. This is a major epistemological challenge, as unlike natural processes where objective causal analysis can be conducted by dismissing context and subjective details in favor of generalizability, social-ecological interactions are highly dependent on local contexts as well as local populations' perceptions and interaction with changes in the natural system. As Selby (2014) argues, since causal linkages between climate and social and political instability may be multiple and contradictory across a large array of societies, they may cancel each other out resulting in relationships that are not statistically significant.

If it is established that there is no single definition of science or one way to attain "scientific rigor"; that different worldviews can result in starkly different understandings of the same phenomenon; and that interaction of social and ecological systems imposes fuzziness more powerfully than in other cases; then, instead of engaging in "disciplinary war of paradigms" (Klotz & Lynch, 2014, p. 5), a more productive approach would be to identify implications of different ontologies, and come up with a more inclusive methodological approach instead of perpetuating the differences. In what follows I lay out three important intellectual resources namely ontology, epistemology, and methodology, that if clearly specified, in that sequence, can help attain "methodological innovation and pluralism" (Wight, 2006) that not only may alleviate the differences that hound climate-conflict research, but also lead to effective policy proposals.

Ontology

Ontology pertains to "what there is" in the world, and how it fits together for us to make sense of the perceived reality. In social sciences, particularly in political science, ontology is referred to as "social entities whose coherent existence analysts can reasonably assume" (Tilly & Goodin, 2006, p. 10). But as Jackson (2010) points out, this is a rather limited view of ontology; what the world is made of often depends on how one is inclined to see it. Although the world or reality exists independently without our knowledge of it, knowledge production about it is a function of one's ontological belief, first and foremost. As Sayer (2010) points out, our belief of whether the earth is flat or round does not change physical reality of the earth itself, but it has serious implications on how we understand it (p. 26). Similarly in social sciences, once a lens to view the world is chosen, appropriate epistemology and methodology "relative to the object of inquiry" (Wight, 2006, p. 259) can be selected, and social phenomena explained.

Wight cautions that "methodologies are always, or at least should be, ontologically specific . . . [T]he attempt to assess validity of particular methods cannot be made in an ontological vacuum: the methods required to study atomic particles, for example, would be wholly inappropriate when applied to the study of social processes" (Wight, 2006, p. 259). Also that it is the ontological differences, and not different data analysis techniques, that are at the root of the heated debates in social sciences (Jackson, 2010, p. 67). With regard to the problem under discussion, for example, without difference in ontology, it would barely matter if one chooses to use quantitative or qualitative approach for data analysis. What matters is the analyst's worldview as to how climate change unfolds; at what level of society are its effects observable; what effects it may have at various levels (micro, meso, and macro); how those effects may traverse through society; and most importantly, whether or not it is possible to observe the phenomenon and its effects in an impersonal or disinterested manner, etc. This emphasis on ontology does not imply that epistemological or methodological standards alone are unfit to guide knowledge production, or that "anything goes" approach is in order. On the contrary, the goal here is to draw attention to the fact that ontological choice ultimately determines the trajectory of subsequent knowledge production activities, and therefore should be included in the analytical process to make theoretical debates more rigorous and constructive (Jackson, 2010; Kurki, 2008; Sayer, 2010; Wight, 2006).

Although ontology is important in all knowledge production, its significance in climate change research is heightened by the fact that most of the impacts of climate change on society are mediated through human interaction as well as interaction with preexisting processes in a society. Causal chains are often long and consist of arrays of mechanisms and processes, most of which although observable are not readily quantifiable, thus rendering the current variable-based approach moot.

Patomäki & Wight (2000) divide ontology in two distinct components: 1) scientific ontology, and 2) philosophical ontology. Whereas the former is concerned with what entities, beings, structures, or processes exist; the latter is about the philosophical and conceptual basis using which claims about the reality are formulated in the first place and social entities and their interaction explained.

Philosophical ontology

Philosophical ontology is the foundation on which all knowledge production rests (Jackson, 2010; Wight, 2006). More specifically, as compared to focusing on what the world is composed of – i.e. a bestiary of sorts, philosophical ontology is concerned with how we (analysts) are hooked up to the world. In simple words, are our minds capable of observing the world (and the social phenomena it contains) in a dispassionate manner as an alien from the outer space would if it visited our planet? And is it possible for us to be definitively certain that whatever is observable or measurable, is total and complete reality? Although apparently remote from the subject matter, somewhat detailed explication of philosophical ontology, especially dualism, is important because its wholehearted embrace by positivists has been absolutely decisive, and arguably at the root of the climate-conflict impasse.

Positivism and its embrace of mind-world dualism:

Mind-world dualism or Cartesian dualism[4] believes the world to exist independent of our knowledge of it. This view expects analysts to create knowledge about a society by observing it in a dispassionate or impersonal fashion, as if observing entities or elements

[4] Cartesian mind-world dualism or simply mind-world dualism is a philosophical assumption traced back most recently to the seventeenth century French philosopher René Descartes who argued that an objective understanding of the world is possible only by isolating the mind from the physical world, lest an ”evil genius” may deceive the analysts' senses and make things appear self-evidently true when in fact they are not (Descartes, 1637/1993). Descartes believed that although senses can be corrupted/deceived, mind couldn't be, and that "everything that I clearly and distinctly perceive is necessarily true" (ibid). Modern day positivism, although kept the assumption of mind-world dualism intact for the same reasons as imagined by Descartes, but, instead of relying on mind, it resorted to the Humean approach of looking for "constant conjunctions" (Hume, 1748/2016) or recurring patterns of events to explain causal relations between phenomena, processes, events, etc. For example if a regular sequence or "constant conjunction" of two events C and E is observed to occur in which event E followed event C, one can, out of natural instinct or custom, anticipate the sequence to continue in the future as well; although the observed conjunction is only contingent and cannot be considered to be causal (Sayer, 1984). For Hume, as well as many positivists, this instrumental knowledge of causality is all we can hope to know (Kurki, 2008, p. 35).

(and their interaction) in the natural world (Bevir & Kedar, 2008). Claims about reality are evaluated by testing falsifiable hypotheses on empirical observation and data. Invalid claims may be falsified (Popper, 1959), thus winnowing away false assertions such that only valid or not yet falsified claims survive.[5] The goal in this view of the world is to keep knowledge production as pure as possible of mistakes in observation, as well as perception and interpretation of social phenomena.

Most wholehearted embrace of the mind-independent world can be seen in the positivist tradition (Jackson, 2010). Strictly maintaining the mind-world gap, positivist is aware of the limitations of observation and cognition and tries to construct understanding of a phenomenon by observing "constant conjunctions" (Hume, 1748, 2016) or co-variation of variables, events, entities, etc. In what has become a standard text on research methods in social sciences, King et al. (1994) argue that this co-variation between two variables implies causation:

> The causal effect is the difference between the systematic component of observations made when the explanatory variable takes one value and the systematic component of comparable observations when the explanatory variable takes on another value. (King et al., 1994, p. 82)

As Tilly & Goodin (2006) point out, this claim assimilates "[social] scientific inference to the world-view contained in statistics based on the general linear model" (p. 8), and assumes structural variables to be the causes of political processes. According to

[5] Kuhn took issue with Popper's concept of "falsification" and argued that practicing scientists, instead of trying to falsify preexisting claims, take a lot of them for granted in their everyday research. When confronted with results that may appear to call into question those preexisting claims, they simply reinterpret their results rather than abandoning or even questioning the underlying paradigm (Kuhn, 1962).

this approach, the causal relationship between climate change and the explanatory variable of interest (civil conflict, social movement, etc.) may be deemed present only if the two variables vary together. This is where the explanatory capacity of this otherwise powerful research approach appears to be under stress.

In addition to its inability to see beyond "constant conjunctions of observable impressions" (Kurki, 2008), positivist approach is particularly limited in explaining climate-society interaction in the highly interwoven social and ecological systems. The fact that it assumes that fundamental causes of political processes consist of variables and not mechanisms (Tilly & Goodin, 2006) makes it vulnerable to several shortcomings. For example, it leaves out important antecedent processes that although observable may not be readily quantifiable. In the case of an adaptive and interactive process such as climate change, these antecedent processes may be different based on the nature of the climate stress, geographical and social makeup of a society, and most importantly human interaction (adaptive strategies) employed by the affected populations. Selby (2014) points out in his analysis of the "positivist climate conflict literature":

> Even if such causal links did exist, it is highly unlikely that they could ever be observable in the form of invariant statistical regularities, for two reasons. First, the linkages would be multiple and contradictory, effectively cancelling each other out: most obviously, in some contexts warmer weather decreases agricultural productivity, while in other contexts, chiefly at high latitudes and altitudes, it raises it. And second, countless other factors would variously

moderate or accentuate the causal effects of temperature on agriculture and in turn rebellion. (Selby, 2014, p. 839)

As Jackson (2010) points out, because of the marvelous strides science has taken in the last several decades, there has been a push in social sciences to emulate the positivist ontology in understanding social phenomena. Assuming variables instead of mechanisms to be at the root of social and political phenomena has become so prevalent in social sciences, especially in political science, that positivist ontology often goes undetected. So much so that qualitative case studies, which in principle take a philosophically different approach, are expected to be designed as quasi-experiments with control and treatment groups (Gleditsch, 1998, p. 391), or they risk being dismissed as anecdotal and therefore having little to no knowledge value. In climate-conflict research, the result is that scholars end up conducting case-study comparisons by matching "countries or localities on same criteria of physical exposure but different security outcomes" (J. Busby, 2018).

Just as mind-world dualism is of necessity concerned with maintaining the mind-world gap such that any knowledge-claim is backed by observable and measurable conjunction of variables; mind-world monism claims the absence of a clear line of demarcation between the mind and the world (Geertz, 1983). This worldview has the potential to fall into what has been referred to as idealism (only mind exists) or interpretivism (reality is a function of individual perceptions or states of mind) (Jackson, 2010). Similar to the positivist approach, monist ontology is too extreme to make sense of climate-society interaction. After all, some level of generalizability is needed in order to understand social phenomena and devise effective policy interventions. Critical realism provides a middle ground and is discussed next.

Critical realism:

Between the Cartesian mind-world dualism and the Geertzian postmodernism comes critical realism as a reconciler of the two. One of the basic tenets of critical realism is that reality exists regardless of our knowledge of it. But unlike positivism, more generally empiricism of late, which identifies real with the empirical, that is only that exists what we can measure, critical realism distinguishes between the real, the actual, and the empirical (Bhaskar, 1975). "Real" is whatever is out there in the world, be it natural or social; and our knowledge or ability to comprehend does not affect its existence in any way. Sayer (2000) gives the example of round earth to make the distinction. The fact that our theories shifted from that of a flat earth to a round one did not have any effect on the shape of the earth. "Empirical" is what we can experience or observe. Although observing a phenomenon makes one feel confident about its existence, it may or may not manifest complete reality. "Actual" is what may happen but is not in pure sight yet, quite possibly because its potential lies latent, and is not invoked yet. While observations may detail some objects and their structures, there may be objects and structures that are not observable in the traditional sense. Emergent phenomena are a case in point where the conjunction of observable objects gives rise to new phenomena which are irreducible to original constituents.

Thus, unlike other ontologies, critical realism offers a stratified approach to seeing the world. There are objects with structures that are observable through conventional means of measurement. Also, there are objects which are although unobservable, have structures that may become visible only when they get activated. This is where critical realism parts ways from positivism, although it maintains the original notion of mind-world duality. The concept of mechanisms is central to this ontological approach, as mechanisms are emergent phenomena that exist without our knowledge of them, latent in both the social and the natural worlds. It is only upon their activation that we are able to observe them, make sense of their triggers, conditions, and outcomes. McAdam et al. (2001), for example, give an example of brokerage – a causal mechanism in contentious politics - which joins two or more previously unconnected sites (groups) of contention by highlighting their commonalities. In itself, brokerage is not an object that can be observed until it is invoked. But it has structure, initial conditions that trigger it, and specific outcome(s) that can be expected of it. Also, the fact that it is irreducible to its constituents makes it emergent in character. Natural world is replete with examples of such emergent behavior. Atoms of different elements, for example, combine in order to produce new compounds with characteristics non-existent in any of their original components. Reductionist explanations which focus only on the observable are therefore inadequate (Bhaskar, 1975).

Causation in critical realism:

One of the most distinctive features of critical realism is its analysis of causation, which is otherwise missing in the Humean approach of recording succession of events. Unlike Hume, for whom the instrumental knowledge of constant co-occurrence of two events was not only sufficient for establishing causation, but that it was all one could hope to know anything about (Kurki, 2008, p. 151), critical realism by making distinction between the real and the actual, prepares ground for causal explanation of phenomena. This little piece of emergence is where the concept of causal mechanisms comes into play. Mechanism are invoked under certain conditions, and tracing them may be a key to answering questions such as why does drought lead to famines in some societies and not in others; or why does poverty lead to conflict in some cases and not in others; and so on.

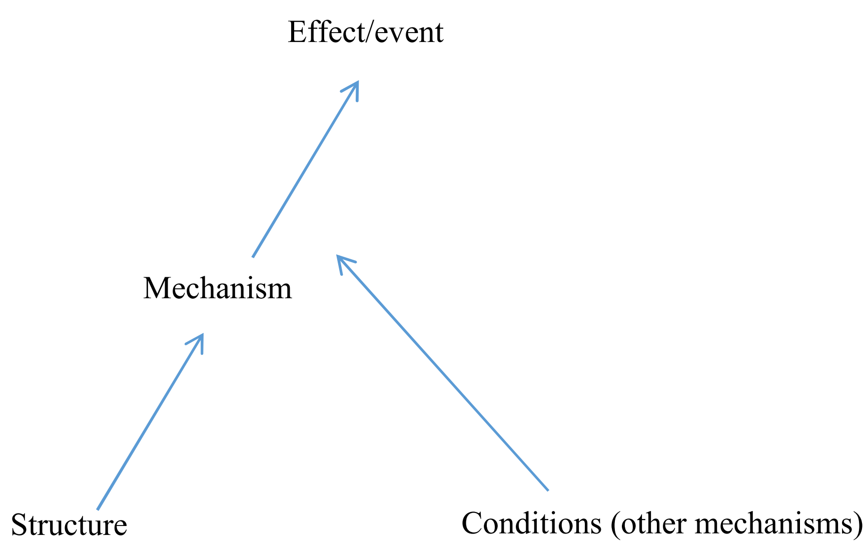


Fig. 3. 1: Critical realist view of causation
Source: Sayer (2000, p. 15)

Mechanisms open the black-box of succession, i.e. the how and why of the constant conjunctions. The black-box of the form I → O becomes:

$$I \rightarrow \text{through Mechanism } M \rightarrow O$$

A critical realist argues that there is more to the world than patterns of events. It has more ontological depth than is granted by a successionist Humean approach. It is true that constant occurrence of two events/objects gives an inkling of a causal effect, but in some cases it may not be the entire reality.

Critical realism can be useful in the climate-conflict research. There is almost consensus in the field that although there is no real evidence of statistical association of climate change and state instability and conflict, the latent disruptive power of climate phenomena cannot be dismissed. The reality of climate change and its disruptive effects exist regardless of our ability to comprehend them. Critical realism offers an innovative lens to incorporate the "actual" in the analysis.

Scientific ontology:

Scientific ontology, much more widely used in social sciences as compared to philosophical ontology, is concerned with objects, beings, processes, etc., that a given line of scientific research expects or believes to exist. In social sciences, scientific ontology refers to what constitutes social reality (Jackson, 2010, p. 28). In other words, when explaining a particular social process, answers to some ontological-choice questions — for example, "Does coherent social action originate at the individual level, the group level, or the collective level?" — determine the scale at which a social entity is thought to cohere or, more practically, the granularity at which an apparently coherent social entity is best evaluated. Whereas philosophical ontology determines the type of mind-world reality an analyst believes to be a part of, scientific ontology sets the stage for the entire analytical exercise, e.g. starting point of the analysis, type of data to be collected, hypotheses to be tested, etc. For example, proposing future directions for climate-conflict research, Buhaug (2015) points out:

> The formulation of plausible mechanisms and intervening factors conditioning a climate effect necessarily also involves identifying central actors at play. In furthering theory building along this line, it may be instructive to draw on the complementary dimensions of opportunity and motive. Regardless of the aspect of climate change under consideration, we should identify which segments of society are affected (farmers, pastoralists, urban poor, political elite, etc.) and assess their ability to act as a collective organization to redress their grievances. (Buhaug, 2015, pp. 271-272)

In addition to pushing for a theory-building approach to better understand the effects of climate change on a society, Buhaug seems to point at what may constitute such a theory. Identification of "central actors at play" and drawing on their "complementary dimensions of opportunity and threat" is an (scientific) ontological choice and can be reread as isolating segments of society affected by climate change, and investigating their calculus regarding the opportunity and threat of participating in violent collective action. This is a nod to the standard structuralist approach widely used in social sciences, where it is commonly believed that origins of all political processes can be traced back to mental calculations (or propensities) of individual human actors at the point of action; the underlying assumption being that individual human actions hint at general uniformities in human psychology. This assumption that most, if not all, individuals may behave the same way when exposed to similar stress, implies that identifying a single actor of a group can provide insights into an entire collectivity such as farmers, herders, pastoralists, women, etc. Same logic is extended to collective decisions of organizations, institutions, ethnic groups, etc., by assuming that entire collectivity acts as if it were a single human mind (G. T. Allison, 1971). Two of the major and inter-related scientific ontologies commonly used in political science are structuralism and rationalism (McAdam et al., 2001; Tilly & Goodin, 2006). I briefly describe them below in order to establish a contrast with relational realism that, along with a more inclusive definition of rationality, is used in this research.

Structuralism:

As mentioned above, structuralism holds that "social structures have their own self-sustaining logic" (Tilly & Goodin, 2006). Interests and capacities are imputed to entire collectivities such as institutions, different factions in a society, communities, social classes, or even entire societies etc. For the purpose of analyzing collective decision-making, a collectivity is assumed to act as if it were a single person (G. T. Allison, 1971). Structuralists concentrate on showing that social divisions are a good predictor of participation in collective action such as conflict, protests, voting, etc. For example, proposing a theory of demographics and environmental stresses and civil strife, Kahl (2006) claims that resource scarcity (caused by environmental degradation and demographic pressures) will result in groups resorting to violence:

> Organized anti-state and intergroup violence becomes a real possibility when individuals and groups calculate the benefits to be accrued from violence outweigh the cost. State weakness makes it more likely that individuals and groups will choose violence as a means of advancing their interests by lowering the costs of such action. (Kahl, 2006, p. 45)

Structuralism is a tool of choice in most climate-conflict studies, especially those focused on highly fragmented societies in Sub-Saharan Africa. Potential of conflict among farmers and herders is a common theme in such studies, and is based on the (ontological) assumption that resource scarcity may pit members of both groups against each other in violent conflict. Climate change does create winners and losers (Leichenko & O'Brien, 2008), but climate-induced divisions may not necessarily conform to the preexisting social and political divisions in a society. Even if they did, analysis at a much higher resolution may be needed to understand the micro-dynamics of conflict (Kalyvas, 2006, 2008) for effective prediction or policy intervention. Methodological individualism provides such a high-resolution picture.

Methodological individualism and rationalism:

Although, structuralism is useful in drawing broad associations between phenomena such as inflation and unemployment (Phillips curve), or poverty and conflict (conflict theory), etc., rather than providing satisfactory explanation of the association it gives rise to even more questions, such as “why is that so?” and “when and under what circumstances does the relationship exist?”, etc. (Boudon, 1998). In other words, the explanation is not “final” (ibid). Methodological individualism fills the gap and answers the “how” and “why” by emphasizing that “elementary ‘causal agents’ are always individual actors, and intelligible social science explanations should always include explicit references to causes and consequences of their actions” (Hedstrom & Swedberg, 1998, p. 12). This principle of methodological individualism makes the foundation of the mechanism-based approach which looks to enhance understanding of social phenomena by tracing links between two events (or states of a system) connected by a direct cause.

In order to open the black box of causation, methodological individualism requires more than mere stenographical account of events at the individual level. As Boudon (1998) argues, for an explanation to give the impression of being "final", it must show that "individual decisions are 'understandable,' or in more concrete terms, that they can be described as grounded on strong reasons" (p. 173). For example, with reference to the problem under discussion, making sense of why individuals respond to changes in the natural system in a particular manner would require comprehending the rationale behind these responses. Does such rationale come naturally to all the vulnerable individuals (and populations)? Is the level of abstraction high enough to allow generalization for varied manifestations of climate change, yet specific enough to allow effective policy interventions? Is the response (to climate change) generalizable at the local level, regional level, global level, etc.? Similarly, climate's potential to induce violent tendencies within and between affected populations raises more questions than can be answered by merely alluding to poverty or the scarcity paradigm. Does vulnerability brought about by climate change propel individuals to become more violent, and how exactly does it do that? Is greed of future earnings enough to induce a climate-victim to join an armed group, or can such a behavior be traced to relative or absolute deprivation among vulnerable individuals? The importance of figuring out the individual calculus of a quintessential victim of climate change is imperative for devising adaptation frameworks and policies that could be implemented across scales.

Methodological individualism is useful in figuring out the individual response to an external stressor – in this case, climate change. However, these individual responses may not always be driven by economistic calculations alone. Sometimes there are other reasons such as normative, cognitive, or even cultural, which affect an individual's decision-making calculus (Boudon, 1998; Hedström, 1998a). For example, as climate change imposes distributional conflicts on societies, potentially zero-sum decisions such as using water for irrigation as compared to hydroelectric power generation are becoming widespread around the world (Zeng et al., 2017). These decisions may not strictly fit the definition of rational thinking in that there is rarely any sorting of alternative options based on their "efficiency" or "benefit". Instead, these decisions may reflect a government's political expediency (e.g. dominant agriculturist elite); or may even be based on wrong beliefs (e.g. input intensification can counter the effects of climate change); or yet may have normative reasons (e.g. growing food is a common good and therefore trumps any and all distributional conflicts), etc. In such situations, utilitarian interpretation of methodological individualism fails to provide final explanations, and is hardly generalizable across societies.

Boudon (1998) makes a useful contribution to methodological individualism by broadening the definition of rationality. Calling his reinforced framework Cognitivist Model, he urges that rationality should not be looked at only from a utilitarian perspective, because most individuals in their everyday lives don't necessarily operate that way. Also, decisions that don't fit the utilitarian definition of rationality are not always irrational, and may, in fact, be based on cognitive, normative, or axiological reasons:

> Until the proof to the contrary is given, social actors should be considered as rational in the sense that they have strong reasons of believing what they believe, of doing what they do, and so forth. . . . In some circumstances, the core of some action is constituted by “cognitive” reasons: He did X because he believed that Z is likely or true, and had strong reasons for believing so. Example: The physician diagnosed depression on the basis of suicide attempt *because* he believed depression is a cause of suicide. (Boudon, 1998, pp. 190-191)

This is an important insight at many levels. First, this broader definition of rationality may provide fine-grained (and final) explanations – something that rational choice model struggles with – allowing for better capacity of deduction and prediction (ibid, p. 193). Second, by loosening the definition of rationality to include its other forms, the paradoxes raised by rational choice model become solvable (ibid, p.195). For example, the paradox of peasants revolting in some societies but not in others (J. Goldstone, 1994; Lichbach, 1994) may be solved by looking at the contextual environment as well as other factors (cognitive, normative, axiological, cultural, etc.) that lead to varied outcomes.

Boudon’s cognitive model has serious implications for climate-conflict research. By undermining the utilitarian interpretation of rationality, it raises questions about the validity of the central assumption in the adaptation framework, which states that vulnerable and affected populations employ economistic rationality to find optimal and efficient solutions. Since individuals and societies will respond to a climate stressor according to their respective cognitive and rational beliefs, not to mention their culture and history, their coping logics may differ from each other's, thus rendering the assumption of universally applicable adaptation measures moot. Some of the beliefs (and resultant coping measures) held by affected populations may be short-sighted, wrong, or even harmful, resulting in widespread maladaptation and/or complications of the effects of the original stressor. Moreover, in today's globalized world, these effects may travel to geographically distant locations through global commodity markets via formal and informal trade channels, and may catapult even those societies into instability that may not be experiencing any effects of climate change.

Effects of climate change do not readily transform societies into war zones. They interact with a society's preexisting processes and mechanisms, and elicit responses from vulnerable populations across scales through coping responses of affected individuals and groups. This interaction sets in motion other mechanisms that may or may not result in some sort of violent collective action. Methodological individualism helps with identifying individual level responses to the external stressor and will be used for that purpose in this research. But individual actions hardly paint the complete picture. For the part where individual actions merge into collective action, it is important to look at interactions among individuals, and how such interactions may give rise to previously non-existent mechanisms which in turn may lead to a collective outcome. Processes of collective action are born through interaction, which in turn shape individuals' thought process and decision making logic, thereby perpetuating the interaction between individual and collective behavior. The social activity that originates as a result has earned a separate ontological status termed as relational realism, and is discussed below.

Relational realism:

Proposed by McAdam et al. (2001), relational realism is based on the assumption that essence of social processes does not lie in meticulous calculation to find the most optimal option; rather "transactions, interactions, social ties, and conversations constitute the central stuff of social life" (Tilly & Goodin, 2006, p. 11). Therefore, the focus in this ontological approach is not on the individual's mental calculations or intentions at the point of action; rather it is on "connections that concatenate, aggregate, and disaggregate readily, forming organizational structures at the same time as they shape individual behavior" (ibid).

In this research, these interactions may be seen at both individual as well as group levels. In the case of the former, when faced with climatic variability and change, a farmer's decision to try a particular approach to coping with climate change may not be the outcome of exhaustive assessment of his constraints and assets; rather it may emerge as a result of interactions with fellow farmers, neighbors, friends, local traders, etc. As mentioned previously, since the assumption of utilitarian rationality as the sole explanatory logic is suspended, coping responses employed by farmers may not be efficient or optimal, and may in fact result in exacerbation of their financial burdens. In the worst, albeit not unlikely, scenario, maladaptive coping strategies may not only hurt individual farmers but also generate system effects and catapult an entire economy into chaos. Even in the less apocalyptic scenarios, "micromotives" not based on exhaustive rational calculation may result in emergent behavior and result in unpredictable effects in local and foreign economies.

On the final outcome side, the decision to participate in a violent collective action is not assumed to be made at the individual level; rather it is conceived to be a result of interactive mechanisms that link individuals with one another in the form of groups (J. Goldstone, 1994). These individual groups and (or) sites are in turn connected to each other via relational mechanisms such as brokerage, diffusion, cross-class coalitions, etc. before they take the form of a social movement, revolution, or civil conflict (J. Goldstone, 2011; McAdam et al., 2001). Analysis of flows of communication, chains of interaction at multiple levels, diffusion of contention from one location to the other, radicalization or use of increasingly violent expressions of unrest, building of cross-class coalitions, etc. may provide a better insight in how individual grievances attributable to climate change may be converted into collective expressions of unrest and instability.

A relational realist follows the flows of information, documents events that take place both at the individual level as well as in a group, and maps "observed association between events" (Hedstrom & Swedberg, 1998, p. 1) that repeat across episodes and contexts with almost identical immediate effects. Catalogs of events (also referred to as narrative analysis) formalize the observations of social interaction leading up to the outcome of interest (contention, for example), and help detect repeatable phenomena of general importance (Franzosi, 1994).

Epistemology – Mechanism based analysis

Once philosophical foundation for an analytical exercise has been established by choosing appropriate (philosophical and scientific) ontology, epistemology has to do with mechanics of data analysis and marshaling of evidence. It is concerned with finding a systematic approach to explain generalizable social phenomena, how and why they occur, and what are their implications. Although several approaches are used in social sciences to explain social phenomena,[6] two approaches, namely covering laws and skepticism, constitute the extremes when it comes to finding generalizability in social processes. Whereas the former seeks to mimic natural sciences to identify law-like accounts of social and political processes, e.g. conflict is caused due to the greed of future earnings, etc., the latter considers them to be too complex and contingent to allow for a systematic component generalizable to other situations. Although anthropological accounts of climate-induced instability are almost non-existent (Barnes et al., 2013), whatever qualitative work has been done is put in the interpretive category by labeling it as "anecdotal" and "nearsighted" (Gleditsch, 1998; Levy, 1995).

Most climate-conflict research, on the other hand, can be grouped in the other extreme of the covering-law model of the type proposed by Hempel (1942). Causal explanation in this approach consists of finding robust empirical generalizations and subsuming them under higher and higher-level generalizations, highest of which stands as covering law. This covering law can in turn be used to explain events of similar nature unfolding elsewhere by specifying "the general covering law and the conditions that make the law applicable in the specific case" (Hedstrom & Swedberg, 1998). For example, covering law of the form "poverty leads to conflict," will dictate that conflict in any society may be explained by poverty while precluding all other possible explanations.

[6] Tilly (2001) provides a list of major epistemological approaches used in political science.

There are several problems with this approach: One, it can be overly deterministic, and may miss out other potential causes for a particular effect. Since specific instances are explained by invoking covering law that is abstracted to a higher level of generalization, the explanatory power is weakened significantly (Merton, 1949/2012). Second, it provides justification for a black-box approach of causation (Hedstrom & Swedberg, 1998, p. 8). The explanatory mechanism(s), considered devoid of structure, is dismissed in favor of higher-level generalization. Statistical regularities "among presumed causes and presumed effects therefore serve as validity tests for proposed explanations" (Tilly, 2001). Third, covering law approach can result in generalizations that may be paradoxical in nature. For example, poverty may result in conflict in some societies but not in others.

If interpretive approach is "anecdotal" and barely generalizable, covering laws are too far removed from the specific situations to allow for a deeper understanding or "final" explanation of phenomena. At the end of the day, in addition to producing generalizable law-like theories, an important purpose of knowledge production, especially in social sciences, is to help develop effective policy proposals aimed at specific situations and circumstances. Vague, albeit generalizable, covering laws are often not helpful for this purpose. For example, even if there were a consensus that poverty is a necessary and sufficient condition for conflict, for an effective policy proposal one may need to know exactly what causal pathway(s) links poverty to conflict; what factors or processes lead poor individuals to mobilize, create, and join armed groups, shape a unified narrative, build coalitions, etc., before they can begin a conflict.

Mechanisms occupy middle ground between the postmodernist interpretive accounts and abstract covering laws. Compared with these and related explanatory approaches, mechanism-based analysis has modest ends – to identify and explain salient features of an episode.[7]

As scholars have struggled to find robust statistical correlations between variables of climate change and conflict, there has been a renewed interest in developing a mechanism-based understanding of the phenomenon. However, there is little consensus on the definition of causal mechanisms or approaches to identify and measure them. Most, if not all, quantitative-oriented scholars of political science conflate mechanisms with intervening variables. For example, King et al. (1994, p. 87) argue that mechanisms are simply a chain of intervening variables connecting independent and dependent variables. Others consider mechanisms to be merely descriptive in nature, used for explaining the relationship between a cause and its effect. Yet others use mechanism as a catchall entity for all things that cannot be captured in structural variables, thereby turning them into yet other, albeit smaller, black-boxes. In fact, the casualness with which the term "mechanism" is thrown around has caused confusion as to what exactly qualifies to be a mechanism, how is one to be identified, and how is it measured, etc. The next section provides a basic introduction of mechanisms, and how they are used in this research to explain the phenomenon under investigation.

[7] The main logic behind focusing only on salient features is to factor in complexity which dominates all aspects of reality, particularly social and political systems. For example, instead of using blanket explanations of why and how conflict occurs, mechanism-based approach looks to isolate important features or steps that usually take place in a conflict episode, and tries to locate them and the conditions under which they come into being and operate (or otherwise) in other similar episodes. This identification of generalizable bits of theory gives a better shot at not only piecing together the micro-dynamics of a complex phenomenon, but it may also be helpful in implementing effective policy interventions at various phases in a social or political phenomenon.

Causal mechanisms

Use of mechanisms in sociology (and political science) is traced back to Robert Merton who introduced the concept of "theories of middle range," and argued that instead of devising grand theories of social behavior, the main task of sociologists is to "identify mechanisms," and conditions under which they "come into being," "fail to operate," etc. (Merton, 1968, pp. 43-44). Merton defined mechanisms as "social processes having designated consequences for designated parts of social structure" (ibid). Following Merton's lead, Elster defined mechanisms to be "nuts and bolts, cogs and wheels … that can be used to explain quite complex social phenomena" (Elster, 1989, p. 3). Stinchcombe wrote that "mechanisms are bits of theory about entities at a different level (e.g., individuals) than the main entities being theorized about (e.g., groups) which serve to make the higher-level theory more supple, more accurate, or more general" (Stinchcombe, 1991, p. 367).

In recent years, there has been a renewed interest in mechanism-based explanations, even among scholars who adhere to different epistemological and methodological traditions. This interest, although welcome, has led to a plethora of definitions for causal mechanisms. Mahoney (2001, pp. 579-580) identified twenty-four definitions of causal mechanisms. The number may have increased since then. The simplest definition of mechanisms is that they open the black-box between a cause and its effect. But questions remain as to at what level of resolution do individual mechanisms exist? How are they to be spotted, and more importantly, how to identify conditions under which they are triggered, fail to operate, etc.? Before a concise definition can be provided, it is important to clear the air about what mechanisms are *not*.

1- Mechanisms are not descriptive and anecdotal records

Mechanism-based explanation should not be mistaken for purely descriptive and anecdotal account of unique chain of events connecting a particular cause with some effect. Mechanisms are generalizable pieces of theory "found in a range of different social settings, that operate according to same logical principles" (Hedstrom & Swedberg, 1998, p. 2), and that "simply making up an ad hoc story tailored to a specific case does not constitute an acceptable explanation" (ibid, p. 10).

Although there may be a number of factors connecting a cause to an effect, the emphasis in mechanism-based approach is to identify systematic component(s) that is portable to other scenarios and settings. It is this generality that gives them their explanatory power. Hedstrom & Swedberg (1998) provide an example of an individual (micro) level mechanism, namely "belief formation," that explains similar individual behavior and social outcome in three seemingly disparate sociological theories. First of these theories is Merton's "self-fulfilling prophecy" – "a false definition of the situation evoking a new behavior which makes the originally false conception come true" (R. Merton, 1948). In the second setting, physicians in various professional networks use their position to influence diffusion in the market of a newly introduced drug (J. Coleman, Katz, & Menzel, 1957). Finally, Granovetter's threshold theory of collective behavior dictates that an individual's decision to participate in collective behavior depends in part on how many other actors have already decided to participate

(Granovetter, 1978). Hedsrtom & Swedberg argue that human behavior in all three cases can be explained by a single individual level causal mechanism:

> [T]he core characteristic of these theories that gives them their nonobvious character and appeal is the general *belief formation mechanism* which states that the number of individuals who perform a certain act signal to others the likely value or necessity of the act, and this signal will influence other individuals' choice of action. It is this belief-formation mechanism that is at the heart of the self-fulfilling prophecies of Merton, the network effects of Coleman, and the bandwagon effects of Granovetter. On the fundamental level of mechanisms, the run on the bank, the prescription of the drug, and the emergence of collective movement, all are analogous. (Hedstrom & Swedberg, 1998, p. 21)

In other words, in mechanism-based analysis, analyst identifies and captures the *systematic component* at the heart of the phenomenon under investigation by sifting through empirical data that may be generated using descriptive accounts or quantitative datasets. "Robust mechanisms" are generalizable to other cases or to the different episodes in the same case, and produce uniform results under a given set of initial conditions across time and space (McAdam et al., 2001).

2- Mechanisms are not intervening variables

A common mistake in works using mechanismic thinking is to conflate mechanisms with intervening variables.[8] For example, to King et al. (1994), although, mechanisms

[8] Intervening variables are variables between dependent and independent variables, and do not have any independent effects on the outcome (George & Bennett, 2004, p. 246). For example, Kahl (2006) identifies

make “intuitive sense,” they consider them to be merely supportive in nature, useful only for identifying intervening variables or for creating new causal hypotheses to investigate (pp. 85-87). This perception is wrong. Unlike intervening variables, mechanisms dictate the final outcome. In some cases, mechanisms may produce phenomena that would otherwise not exist at all. In other cases, the final outcome of any phenomenon may depend on which mechanisms get triggered and concatenated to form a causal pathway.

Mahoney convincingly makes the case in favor of giving mechanisms a separate ontological status by arguing that comparing mechanisms with intervening variables is fallacious as it falls back on the original assumption behind the logic of correlation itself:

> [A] variable’s status as a “mechanism” as opposed to an “independent variable” is arbitrary. With this definition, then, a correlation is “explained” simply by appealing to another correlation of observed variables. (Mahoney, 2001, p. 578)

Relegating causal mechanisms to a supporting role of “intervening variable” is based on the ontological tradition where variables are considered to be the root causes of social and political processes. Mechanism-based approach follows a different ontology and is based on the assumption that mechanisms are entities that generate outcomes of interest, and not merely mediate or catalyze them.

---

two intervening variables, namely “institutional exclusivity”, and “groupness” to be responsible for mediating between environmental and demographics stresses and civil strife (pp. 51-56). These variables are not determinants of conflict traceable to environmental and population stresses, but conflict is more likely to happen in a fragmented society where state institutions are not inclusive and prefer certain group(s) in decision making during times of environmental scarcity and degradation.

Falleti & Lynch (2009) describe:

> Mechanisms tell us how things happen: how actors relate, how individuals come to believe what they do or what they draw from past experiences, how policies and institutions endure or change, how outcomes that are inefficient become hard to reverse, and so on. (p. 1147)

As discussed earlier in the ontology section, different ontological worldviews result in different understanding of reality, and conflating one with the other without paying attention to their respective philosophical bases is not only erroneous, it dichotomizes complex phenomena by oversimplifying them and results in impoverished analysis.

3- Mechanisms are not black-boxes or covering laws

Given the logic behind causal mechanisms to identify uniform and universal associations between causes and their effects, their search starts to look like that of covering laws, with mechanisms acting as (smaller) black-boxes. Although it is a logical concern, there is significant difference between mechanisms and law-like statements. The most important difference is in terms of their respective levels of abstraction. Covering laws are so far removed from the empirical data and provide so little details about the intermediate processes that it is virtually impossible to connect the dots between cause and effect in a particular situation. For example, according to covering laws, civil conflict would always be caused due to the same reasons, or democratization will happen in the same way everywhere. Mechanisms, on the contrary, open that black-box and provide insights as to how disgruntled masses channel their individual grievances into collective expression of unrest; form and connect groups of protesting individuals with each other; broaden and shift their identities; build coalitions; and radicalize under certain conditions before taking the form of a full-blown violent social or political movement.

Mechanism-based explanation in the case of climate change would not just settle on a vague law-like statement that climate change causes poverty which may lead to conflict. In order to be of scholarly (and policy) value, it would have to identify mechanisms that are at the root of climate-society interaction, and how and why (if ever) they result in imposition of financial burdens and incitement of violence.

Definition: Mechanisms and their types

I follow McAdam et al. (2001) in their definition of mechanisms as "delimited sorts of events that change relations among specified sets of elements in identical or closely similar ways over a variety of situations" (McAdam et al., 2001, p. 24).

As will be discussed in the next section, mechanisms operate at individual as well as group level. For example, rational calculation may take place at the individual level with an individual weighing his options based on his beliefs, value system, prior knowledge, as well as contextual factors such as culture, peer pressure, etc. Similarly, in social phenomena involving collective action, mechanisms may be observed at a group level. For example, belief formation is a group level mechanism in the example of run-on-bank, as its individual level interpretation would not amount to more than a customer drawing his money from the bank.

Breaking a causal chain into smaller bits of theory with uniform results across cases does not mean that context has no effect in determining the final outcome. Context is, of course, important, as it can change the initial conditions under which mechanisms get triggered, just like igniting damp gunpowder may not produce the same result as that of a dry one (Falleti & Lynch, 2009). But in general, mechanisms can be safely assumed to produce uniform results across a varied array of social processes across time and space.

A large number of mechanisms have been identified in social sciences literature. Some of them, most relevant to this research, are listed in Table 3.1 along with their brief definitions and notable references.

McAdam et al. (2001) divide mechanisms in three distinct categories based on the level of granularity at which they exist.

1. Environmental mechanisms

Unlike what their name suggests, environmental mechanisms are not limited to the environment or natural system. In fact, environmental mechanisms are a broad category to include all "externally generated influences on conditions affecting social life" (McAdam et al., 2001, p. 25). These mechanisms operate at macro level, yet their effects traverse through societies invoking and interacting with mechanisms at micro (individual) and meso (group) levels. For example, demographic changes, be they abrupt (massive and sudden migration) or gradual (population growth), generate pressures on a society that may influence the lives of individuals and groups (Goldstone & McAdam, 2001).

In this research, climate change (in all its manifestations) is considered to be an environmental mechanism, and its effects on society investigated.

2. <u>Cognitive or dispositional mechanisms:</u>

This class of mechanisms operates at individual or micro level, for example in response to an external (environmental) mechanism. Mechanisms such as belief formation, cognitive rationality, rational imitation, etc., constitute cognitive mechanisms. In this research, coping responses to minimize the adverse effects of the changed climate and weather patterns constitute cognitive mechanisms.

3. <u>Relational mechanisms:</u>

Relational mechanisms alter connections among people, groups, networks etc. These mechanisms come into being as a result of interactions among people, and change their relationships with each other. For example, brokerage, in the context of social movements and contention, connects two or more previously unconnected social sites with each other, establishing coalitions across social, political, or ethnic lines (McAdam et al., 2001).

Definition: Processes

Mechanisms seldom operate alone. In most cases, mechanisms at the same or different levels concatenate with each other to form complex social processes that may otherwise not be captured in neat datasets or explained through correlations between variables (Gambetta, 1998).

Causal mechanism	Brief definition	Notable reference
Belief formation	People act in accordance with signals from others.	Hedström & Swedberg (1998, p. 21)
Rational choice	Individuals act to maximize their (utilitarian) self interest.	Olson (1965)
Cognitive rationality	Individual actions are based on strong reasons that are not just utilitarian, but also may be cognitive, normative, or even dictated by culture or history.	Boudon (1998)
Rational imitation	Individuals may act according to beliefs that are influenced by observing the past choices of others.	Hedström (1998b)
Relative deprivation	Development of a sense of resentment upon realizing the gap between what people have and what they think they deserve.	Stouffer et al. (1949); Gurr (1970)
Resentment formation	Heightening of resentful emotions caused by the perception that one (individual or group) is located in an unjust position in a society.	Petersen (2001)
Brokerage	A mediating entity (individual or group) links previously unconnected sites in a collective social process (for example, contention).	McAdam et al. (2001)
Network diffusion	Information (about success of failure) of collective action (such as contention) gets transferred across existing lines of communication.	Hedström et al. (2000)
Radicalization (of contention)	Shift in collective action toward "more extreme agendas and the adoption of more transgressive forms of contention".	McAdam et al. (2001)
Uncertainty resolution	When faced with complexity, individuals try to resolve uncertainty by limiting the number of variables to be processed; focus on the value system that they believe in rather than processing vast sums of information that may or may not be available to them during complex situations.	Steinbruner (1974)

Table 3. 1: A partial list of causal mechanisms identified in the social sciences literature[9]

Processes are regular sequences of mechanisms that produce similar outcomes across contexts. These sequences of mechanisms occur regularly in complex social phenomena. Unlike mechanisms, however, the final outcome of processes is contingent on which mechanisms are concatenated, triggered, failed to operate, etc. For example, social mobilization is a process identified in contentious politics literature that occurs regularly, and often results in the similar outcome of mobilizing a class of people by building

[9] For more elaborate lists of causal mechanisms identified in the literature, see Petersen (2001), Falleti & Lynch (2009), Gambetta (1998).

coalitions among them, framing the problem that led to widespread resentment in the first place, and setting in order various contentious performances keeping in view the opportunity and threat of mounting a collective action effort (McAdam, 1999). In successful mobilization processes, all or most of these mechanisms may operate as expected. In unsuccessful mobilizations, such as failed rebellions or social movements, some mechanisms, such as coalition building, may fail to operate or get crushed by the state, thereby resulting in failed social movements or rebellions (J. Goldstone, 1998a, 2011).

Another process relevant to this research is adaptation to climate change. As discussed in the literature review chapter, adaptation to climate change is not merely a rational response that may stabilize the negative effects of changed weather and climate conditions. It includes individual coping strategies, as well as their impact on wider political economy as well as social and political processes. Mechanisms at the individual level concatenate with those operating at institutional and group levels, thus propagating throughout the society the combined effects of the climate stressor as well as the impact of coping mechanisms. These effects may also traverse to the rest of the world through global processes such as international trade.

The macro-micro-macro model

As scholars of social movements, revolutions, and civil conflict have often emphasized, these macro level phenomena are not, in any simple sense, born at the macro level. Several variables, by interacting with micro and meso level causal mechanisms and

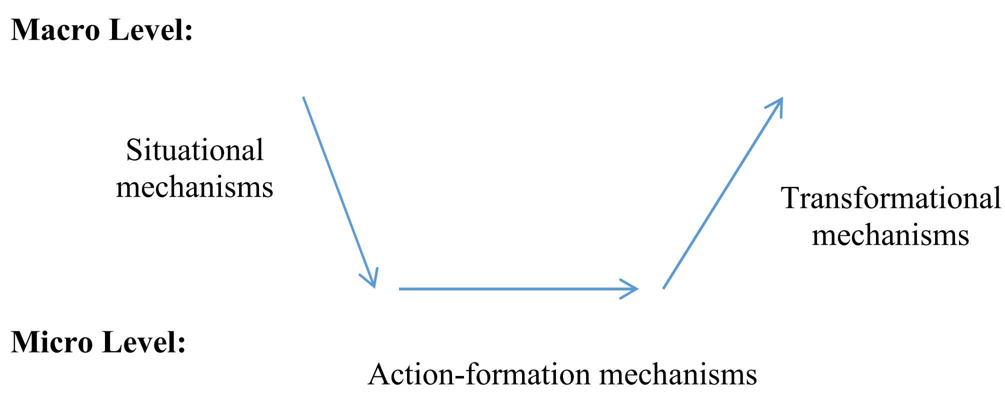


Fig. 3. 2: A typology of mechanisms (Hedstrom & Swedberg, 1998, p. 22)

processes, influence the behavior of individual actors; and over a period of time morph individual level grievances into collective expressions of unrest and contention that may turn violent. A wealth of empirical literature has been generated in the fields of rebellions, revolutions, social movement, ethnic and civil conflict, etc. that identifies structural variables and conditions that link individual grievances to collective violent expressions of conflict. However, the literature says little with regard to factoring in the converse: that is, how does a macro phenomenon such as climate change affect the behavior of human populations at micro and meso levels? Neo-Malthusian scholars invariably invoke scarcity as a plausible condition for conflict in a society, but they do not identify in sufficient detail the specific pathways explaining the effects of varied forms of climate change on individual behaviors, lifestyle changes, decision-making calculus, coping responses, expressions of unrest, contentious performances, etc. Humans have been adapting to changes in the natural system as a survival strategy for millennia; assuming a direct shift of a society into conflict on first signs of scarcity does not provide the full picture.

The effects of micro-level decisions and activities on the dynamics of a system have been an important topic of research in social sciences (McAdam et al., 2001; T. C. Schelling, 1978). The topic of detailing the effects of external (macro) processes on individual behaviors (i.e. macro-micro link), however, is still in its early phase of development (J. S. Coleman, 1986; J. A. Goldstone & McAdam, 2001; Hedstrom & Swedberg, 1998). Emphasizing the importance of factoring in the micro-level response to macro processes in the field of contentious politics, McAdam argues:

> [E]nvironmental factors should never be viewed as determinant. Rather, the beginning of contention must properly be located in the collective interpretations and resulting actions that people fashion in response to perceived environmental conditions. (McAdam, 2001)

The concept of traversing the effects of broad macro processes at the individual level can be best explained by using James Coleman's famous model (J. S. Coleman, 1986), also referred to as macro-micro-macro model or simply as Coleman's boat (Fig. 3.2).

The general idea behind the model is that proper explanation of what transpires at the macro-level in response to an external phenomenon (climate change in this case) entails showing how the latter influences the behavior of individual actors (step 1); how individuals try to adapt to its effects (step 2); and finally how the combined effect of actions taken by a number of individuals leads to the outcome at the macro-level (conflict, social movement, or peacemaking, etc.) (Hedstrom & Swedberg, 1998).

The labels situational mechanisms, action-formation mechanisms, and transformational mechanisms are descriptive of activities that take place in each phase. In the first two steps, the actor is the individual whose action is in response to the external stressor. In the case of climate change, for example, the first two steps would entail activities that affected individuals perform upon coming in contact with the climate stressor such as farm level or impromptu responses to adapt to climate variability and change. The third step entails the micro-to-macro transition. Here, multiple individuals interact and the mechanisms at play convert individual activities into a collective outcome. Hardin's "the tragedy of the commons" (Hardin, 1968), for example, is such a mechanism that converts self-interested (rational) activity of individuals into a collective outcome of an uninhabitable planet where commons are destroyed. Other examples include Schelling's "tipping point" model (T. C. Schelling, 1971), Merton's "run on bank" (R. K. Merton, 1948), and Stouffer's "relative deprivation effect" (Stouffer et al., 1949), etc.

Summary:

Where the extant climate-conflict agenda assigns central weight to structural variables and static relationships between them and the determinants of climate change, in the past few pages some intellectual resources have been introduced that may bring these variables into relation with one another and with other actors. This goal I aspire to is to identify, in a systematic manner, constituent generalizable mechanisms of the participating/relevant processes, and to provide a dynamic understanding of this complex phenomenon. Following key takeaways summarize the concepts discussed above:

- *Philosophical ontology:* Rather than settling for mere conjunctions of variables of climate change and conflict, it is argued to use critical realism as an ontological foundation to allow for causal explanation. In a complex and emergent phenomenon such as climate change, only the observable and the measurable often don't constitute the entire reality. Including the "actual" in the analysis may help explain the phenomenon.
- *Scientific ontology:* Instead of arbitrarily assuming entire collectivities in a society to behave in a uniform manner, it is proposed to perform analysis at a much higher resolution, and to turn attention to the microdynamics of the phenomenon under consideration.
- *Epistemology:* Rather than identifying high level and abstract covering laws based on correlational approach, the mechanism-based approach is favored in order to highlight interactions between processes of social change and actors at different levels in a society.

Having introduced these intellectual resources in some detail, the next section undertakes the task of parsing the climate-conflict problem into its constituent parts and discusses their interaction with each other and with the society at large. Mechanisms identified at the sites of their interactions may help propose a framework generalizable to other cases.

Dynamics of social and political unrest attributable to climate change

Concerns about global climate change in recent decades have spurred efforts in the scientific community to improve understanding of past trends and future projections. Using a wealth of data of environmental variables collected from sea, ice, land, and atmosphere, sophisticated computer models have been developed that are capable of generating future projections of the global environment. Despite such advances in knowledge, there remains a disconnect between these global climate trends and the magnitude and impact of climate variability and change at any particular location (Byg & Salick, 2009; Wilbanks & Kates, 1999). More importantly, even less is known about how local populations interact with changes in their local weather and climate patterns.

The climate-security literature has, to some extent, tried to bridge this gap by developing disaggregated datasets at subnational levels. Yet, for all its merits, I contend that contemporary work on climate-security seriously undervalues the role of the climate change *process* in destabilizing societies. Two problems are worth noting in this regard: First, following the positivist approach of maintaining scientific rigor and neutrality, there is emphasis on leaving out context specific details of interactions of climate change with society to focus only on measurable statistical regularities among structural variables. This is a significant omission because most climate-society interactions are contextual in nature, and often times depend on traits exclusive to a society and its people. Second, most work by climate-security scholars has been framed at the macro level and is concerned with structural determinants of conflict, thus leaving out the intermediate details before the final outcome of interest is reached.

In this section I propose a mechanism-based approach to trace the intermediate steps. I also make the case that climate change is an interactive process—not only do its effects destabilize local societies, they also have the potential to export this instability to remote societies through global processes of trade and globalization. More generally, any systematic effort to understand the relationship between climate change and social and political unrest and security will necessarily need to factor in the process-oriented nature of the phenomenon rather than treating the former merely as a variable and investigating its effects in a delimited manner.

At a conceptual level, climate-conflict phenomenon can be broadly divided in three logical processes:

1) *Climate impact* – It includes changes in the natural system, their nature and severity, and the extent and kind of direct stresses they impose. The focus here is not on global environmental trends such as global temperature average, Sea Surface Temperatures (SST), El-Nino and La-Nina trends, etc., but on its localized manifestations that are much more varied and becoming highly variable both spatially and temporally. Local and global trends are, of course, interrelated, and in fact the former is directly traceable to the latter. However, since local populations respond to changes in their local weather patterns, focusing on the local climate trends may be more helpful in establishing a causal link between climate stresses and their effects in a society.

As mentioned in the literature review chapter, most studies exploring the link between climate change and conflict use inter-annual variability of key climate variables, such as temperature and rainfall as an indicator of long and short-term changes in the natural system. Although this formulation of datasets is valid, it leaves out important *intra*-annual trends that may have serious implications on social and economic systems in a society, and which may not be visible in a conventional country-year approach.

With the exception of extreme climate events that draw public attention due to their severity and magnitude of their destruction, most climatic changes remain below the radar as they may have little or no effect on the annual average values. This, however, does not make them less destructive. Thousands of years of dependence on nature for basic human needs such as food, warmth, water, etc. have resulted in intricate systems of agriculture, farming, water harvesting, etc. sensitive to even slightest of changes in climate and weather patterns. The fact that smooth functioning of the social, economic, political, and even global trade processes is dependent on predictable weather and climate patterns makes climate change a potent threat to local, regional, and global security. For example, the mere shifting of rainfall schedule by only a few weeks can spell ruin for farmers without being detected in a country-year dataset. Similarly, spatial variability and change of climate and weather trends within a country (or even in a small agro-ecological zone within a country) can decimate local political economy and cause widespread chaos and unrest. Investigating climate trends at a much higher resolution than is possible by the country-year approach may reveal long-term trends at intra-annual and intra-seasonal levels.

Not only does climate change unfold differently in different societies, its impact is not uniform across and within different parts of the world. How much and in what manner local social, economic, and political systems are intertwined with the natural system determines which aspects of climate change are more destructive at the local, national, or regional level. Changes in rainfall patterns may have less effect in an economy that relies on consistent and timely availability of stream flow for its irrigation, power generation, and related needs as compared to a region dependent on seasonal rainfall for subsistence and survival of life. Similarly, unseasonal breeze and mild temperatures during summer may be welcome in some locales, but the same can have a devastating effect on a local economy built around hot and dry conditions. In addition, climate change is not only about changes in temperature and rainfall trends. It also entails shifts in meteorological calendars; sudden temperature drop (or cold-snap); changes in diurnal temperatures, winds, rain, degree-days, cloud covers, hail, etc. Changes in one or more of these variables can have destructive effects on a society, depending on which variables are essential for smooth functioning of its political economy.

2) *Society's adjustment to the impact* – With the exception of extreme climate events such as floods, hurricanes, etc. that have the potential to cause widespread destruction in a short time, often without warning, most changes in climate and weather patterns interact with a society via coping responses employed at varying levels. Farmers resorting to drawing water from aquifer to make up for surface water shortage, shifting of sowing and harvesting schedules, (random) switching of crop patterns, intensification of agricultural inputs such as pesticides, fertilizers, irrigation waters, etc. are just a few examples of individual level coping responses. Governments and institutions reassess their priorities in the face of unpredictability and change in available resources. Similarly, markets and businesses respond to not only climatic changes, but also to the impact of coping responses employed by vulnerable populations as well as meso-level institutions.

Efforts to adjust to the climate stressor impose new burdens and disturb the equilibrium of a society overall. It is impossible to paint a full picture of climate-induced instability and violence without understanding how a society's adjustment efforts mediate stresses imposed by the changing environment. Depending on how successful or disastrous they turn out to be, these adjustment efforts may determine whether a society plunges into instability and contention or becomes more resilient to environmental changes.

3) *Contention attributable to climate change* – This involves tracing social and political stresses and contention resulting either from primary manifestations of climate change, or from indirect effects of failed adaptation, maladaptation, system effects triggered by both climate change and society's response, etc. The term "contention" is used broadly, and is considered a spectrum ranging from non-violent expressions of unrest to full-blown conflict (Chenoweth & Lawrence, 2010; McAdam et al., 1996; Petersen, 2001). Isolating the effects attributable to climate change from those of confounding variables can be done by identifying causal mechanisms, or independent (and generalizable) links in a causal chain. These mechanisms, when concatenated, constitute a causal pathway connecting climate change with its perverse and destabilizing effects on a society.

The three processes, discussed in detail below, do not necessarily occur in a linear fashion or one at a time. Sudden and severe climate impact, for example flash floods or heat waves, can immediately lead to expressions of social and political unrest before a society has time to adjust. Farmer suicides and protests in India (Carleton, 2017), or food riots in Haiti (Collier, 2008) are examples of such instability traceable directly to sudden climate effects. Effects of a climate disaster may fester, and may even multiply by interacting with social, political, and economic processes, long after a climate event has occurred. Also, since climate impact does not necessarily follow a particular pattern, and may manifest variably from one month or (and) season to the next, it causes unpredictability and confusion among vulnerable populations, resulting in conflicting coping responses, thereby complicating an already intricate situation.

In what follows, using a mechanism-based approach discussed in the previous section, a conceptual framework is proposed that aspires to develop an in-depth understanding of the phenomenon. The proposed framework does not claim to be the last word or to definitively explain the climate security phenomenon. Its goals are rather modest: 1) Identify varied forms climate change may take locally, and propose a way to observe their interaction at micro (individual) and meso (institutions, broader political economy, etc.) levels; 2) trace generalizable pieces of the causal chain or diagnostic pieces of evidence (Brady & Collier, 2010, p. 201) that constitute trajectories of climate-society interaction; 3) identify mechanisms and processes that convert micro level grievances (attributable to climate change) into macro expressions of social and political unrest. The last part is overlapped by social movements and contentious politics literature from which I draw extensively to develop my argument. At best, this framework hopes to provide an initial blueprint of a flexible model to which varied manifestations of climate change, its direct and indirect effects, and antecedent processes may be added, and repository of generalizable and robust mechanisms in all three components enriched.

Climate impact

The earth's climate is a complex system in that it is composed of different biophysical components interacting with each other to create an environment conducive for social and ecological systems to survive. This implies that change in any one (or more) of these components will have system-wide ramifications. This complexity is cascaded in climate systems at regional as well as local levels. A society's hydrology and weather patterns, such as temperature, precipitation, humidity, wind, meteorological calendars, etc., for example, produce a unique combination of environmental conditions. A society's economy, culture, and lifestyle of its people revolve around these conditions, each of which is in turn interwoven to produce a seamless functioning of social, economic, and political systems. Even a slight change in any of the environmental variables is bound to generate effects that may traverse through a society like seismic waves.

Although intuitive to experts and laypeople alike, this framing of climate-society interaction is too complex and dynamic for generalized linear models that currently dominate the field of study. Based on a review of sprawling literature on social-ecological systems, listed below are some key considerations about climate change and its interaction with social systems that, if included in climate-conflict models, may enrich the debate.

1- *Climate change has many manifestations*

Despite explosion of knowledge about the emergent nature of the natural system, climate-conflict scholars have maintained a rather limited focus as to which climate variables are prone to inducing instability and causing security challenges. In the quantitative climate-conflict literature, only four climate related independent variables, i.e. inter-annual change in their averages are frequently invoked. These include: 1) change in precipitation, 2) rising temperatures, 3) rising sea levels, and 4) natural (hydro-meteorological and climatic) disasters (Theisen, Gleditsch, & Buhaug, 2017). Although changes in these variables' trends are reliable indicators of global climate change, they are not the only ones.

Unseasonal (to the extent of being alien to an ecological region) weather and climate events such as cloud bursts, drizzle and downpours, hail, cold snaps, changes in snowfall, snowpack, and snowmelt, breezes, blizzards, and typhoons also constitute climate change, and can spell ruin for affected populations. In fact, reports from the field show that changes in climate and weather patterns are varied not only among societies but within them as well. For example, Savo et al. (2016) conducted a meta-analysis of climatic changes across the globe and reviewed 10660 observations from 2230 different localities in 137 countries. They reported that the observed changes in climate and weather ranged from unpredictable weather patterns, to shifting meteorological calendars, to highly variable snowfall and snowmelt trends, to spatial and temporal changes in wind directions and intensity, to increased severity of rainfalls, etc. This finding is consistent with a growing realization among climate scholars that the term "global climate disruption" (Holdren, 2017a) is more appropriate, and accurately explains the magnitude and intensity of instability brought about by changes in the earth's temperature.

2- *Changes in natural system are not uniform spatially or temporally*

Despite the illusion of uniform climatic changes, owed in part to a consistent rising trend of global temperature, effects are not uniform at a local level. The desire to distill the complex climate process to a few structural variables for ease of analysis has led to the most commonly used assumption that consistent increase in temperature and decline in rainfall levels will result in lowering per capita availability of freshwater renewable resources. Although not wrong at the aggregate level, this assumption is lacking. Just as is true of global climate, local and regional climates are complex systems too. There are several intra-annual and intra-seasonal long-term trends that maintain social-ecological balance at local and regional levels. Observations of historical trends determine not only what sort of weather to expect in a particular place at a particular time of the year, but also which crops to grow; what arrangements to make for steady irrigation; how to protect crops and livestock from the natural elements, pest attacks, etc.; when to harvest, as well as how to plan for the next season crops. Predictable seasonal and intra-annual trends are at the very root of the social and ecological equilibrium in a society. As evidence from the field indicates, climate change disturbs these systems by plunging local climates into disequilibrium (Svenning & Sandel, 2013).

Although limited work exists that maps natural system at the *local* level, changes in local climate and weather patterns relevant to this research fall in some of the categories listed below. The list, not exhaustive, contains only a handful of the ways climate change is unfolding in regions and localities around the world:

1. Increased intensity and severity of extreme climate events (Goswami, Venugopal, Sengupta, Madhusoodanan, & Xavier, 2006; Krishnamurthy, Lall, & Kwon, 2009; Papiez, 2009; Trenberth & Fasullo, 2012; Trenberth, Fasullo, & Shepherd, 2015)
2. Shifting and/or changing of meteorological seasons (Crate et al., 2008; Doyle, Redsteer, & Eggers, 2013; Phuong, 2011; R. K. Singh, Bhowmik, & Pandey, 2011)
3. Intra-annual/intra-seasonal (spatial and temporal) variability of rainfall (Jonas Ø Nielsen & Reenberg, 2010; Jonas Østergaard Nielsen & Vigh, 2012; Shimola & Krishnaveni, 2013; Zaheer, 2012)
4. Intra-annual/intra-seasonal (spatial and temporal) variability of temperature (Phuong, 2011; Shimola & Krishnaveni, 2013; Wang, 2012)
5. Intra-annual/intra-seasonal variability in stream flows (Christensen, Wood, Voisin, Lettenmaier, & Palmer, 2004; Nijssen, O'Donnell, Hamlet, & Lettenmaier, 2001; Novotny & Stefan, 2007; Qian, Fu, & Yan, 2007)
6. Changes in diurnal temperatures (L. Alexander et al., 2006; Hansen, Sato, & Ruedy, 2012; Karl et al., 1991)
7. Compound climate events – "the combination of processes (climate drivers and hazards) leading to a significant impact" (Zscheischler et al., 2018)

Depending on the local ecological system and changes it has gone through, the impact of climatic and weather variability in a particular region and society can vary from widespread destruction due to extreme climate events, to reduced and degraded crop yield, to increased pest attacks, to delayed sowing and harvesting schedules, to complete crop failure, etc. Climate impacts are not limited to agriculture sector alone. Climatic changes in a river basin, for example, may set in motion an array of stresses on downstream populations. For example, distributional conflicts such as using water for irrigation vs. power generation can create acute energy shortage, thereby setting in motion yet another series of stresses in virtually every part of the society from urban populations, to businesses, to manufacturing sector, etc.

3- *Different agro-ecological zones are affected differently*

Given the fact that a country is a political division and not an ecological one, it may consist of more than one ecological zone based on its topography and meteorological composition; with each ecological zone undergoing different manifestations of climate change, or behaving differently to the same stress. Local populations have, over long periods of time, perfected their modes of interaction with the natural system and rely on it not just for their survival but their entire local political economy revolves around predictable weather and climate patterns. A slight change in even a single environmental variable can erode their livelihoods.

Agro-ecological zones (AEZ) are commonly used in the United Nations' Food and Agricultural Organization (FAO) studies that divide global agricultural land on the basis of combinations of soil and climate characteristics. In addition to keeping inventory of agricultural potential of the countries of the world, the purpose of this virtual division of agricultural land is to devise development projects appropriate to a society based on its natural resources and climatic constraints. FAO defines AEZ as follows:

> Agro-ecological Zoning (AEZ) refers to the division of an area of land into smaller units, which have similar characteristics related to land suitability, potential production and environmental impact. An Agro-ecological Zone is a land resource mapping unit, defined in terms of climate, landform and soils, and/or land cover, and having a specific range of potentials and constraints for land use. (FAO, 1996)

In recent years, climate scientists have developed high-resolution datasets to record climatic changes at sub-national levels around the world. These datasets record climate data at a high spatial resolution, e.g. 0.1^{o} x 0.1^{o}, or 0.5^{o} x 0.5^{o}, etc. Their use has percolated to climate-conflict research as well. Although these datasets provide detailed climate information at the sub-national level, their use in climate-conflict datasets is not backed by equally high-resolution information about the agricultural (or other economic) practices of populations living in that grid. In other words, they have high-resolution datasets about climate change, but very little to no information about its effects on lifestyles of people who experience that change in their local weather and climate.

4- *Coupled natural and social systems*

We exist in linked social and ecological systems. This self-evident truth, however, is not incorporated in the way either social or ecological systems are traditionally analyzed. For example, most climate modeling systems study past trends or future projections of climate change with respect to its effects on the biosphere, but usually fail to include ramifications such changes may have on social, political, and economic systems. Similarly, economists, sociologists, political scientists, etc. narrowly focus their studies on their respective pieces of the puzzle instead of analyzing the entire system. The problems faced by populations vulnerable to climate change, however, are not restricted by these disciplinary divides. For example, when a river basin becomes unstable, its effects are not limited to the natural system alone. They travel far and wide to downstream populations and related social, economic, and political systems built around predictable and timely availability of water from the river. Similarly, ramifications of unseasonal breeze in an otherwise dry and hot AEZ may lead to decimation of local agriculture, destabilize domestic political economy, and even travel to other societies through international trade.

Due to the strategic importance of food security and its effects on social and political stability, the hypothesis that climate change adversely affects agricultural production has attracted much attention in climate-conflict research. However, as discussed in the literature review chapter, this hypothesis suffers from a host of conceptual and methodological challenges. More importantly, it tries to capture the effect of climate change on security by isolating agriculture from the rest of the society. Humanity depends on nature for survival, but in the modern world this relationship is not limited to food security alone. The analytical lens of social-ecological systems (F. Berkes et al., 2000; Ostrom, 2009), or coupled human and natural systems (Liu, Dietz, Carpenter, Folke, et al., 2007) is useful in understanding this dynamic.

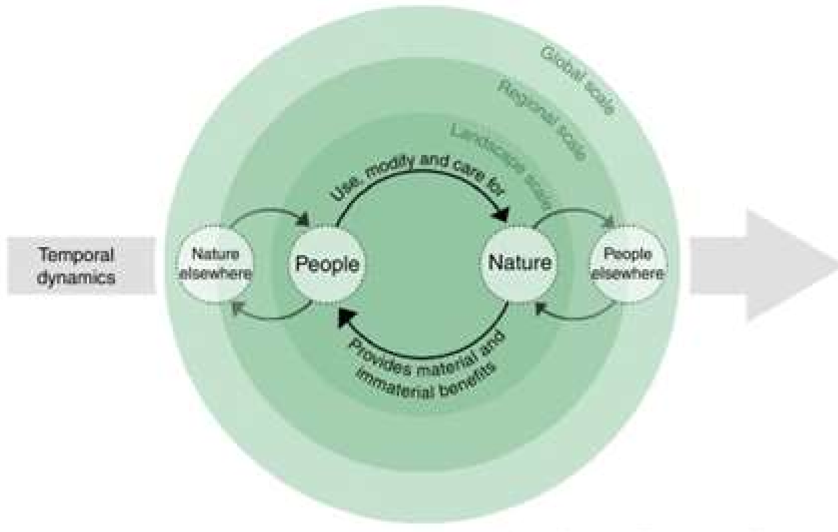


Fig. 3. 3: Coupled (and nested) social-ecological systems
Source: Fischer et al. (2015)

In the developing world, agriculture is not only the main source of employment; it is also important for local businesses and industrial units that are built around domestically produced cheap agricultural products such as cotton, sugarcane, wheat, rice, jute, coffee, seafood, etc. The effects of failed agriculture in such tightly coupled social-ecological systems may show up not only in farms but also in factory-towns and urban centers. Similarly, the preferential use of water for irrigation to ensure food security in the face of reduced water availability in a society may generate distributional conflicts among different sectors of society. For instance, hydroelectric power generation versus irrigation for agriculture (Zeng et al., 2017), which in turn may set in motion diverse array of problems and system effects not captured in narrowly focused datasets.

Social and ecological systems are complex adaptive systems with emergent characteristics and potential for generating feedback loops and system effects across scales (Folke, Hahn, Olsson, & Norberg, 2005; Holling, 2001; Walker et al., 2004). The fact that globalization has connected local social and ecological systems with each other across the globe has really taken this complexity to new heights (Holling, 2004). Fischer et al. (2015) provide a useful framework (Figure 3.3) to explain this interweaving of social-ecological systems across scales.

Coupled social-ecological systems provide a powerful lens to study not only the effects of climate change but also its interaction with a society as it attempts to adjust to the climate shock. Since local societies are interwoven in the global fabric through global trade via both formal and informal means, the effects of local climate change have the potential to instigate social and political disruption elsewhere in the world. The global food crisis of 2010 is a good example when the 2008 drought in China and the 2010 wildfires in Russia led to widespread instability in commodity markets in societies not affected by changes in their local climates.

Society's adjustment to the climate shock

Given the interactive nature of climate change, understanding its effects on a society would be incomplete without taking into account the intermediary role adjustment efforts play in the process. Adapting to changes in the natural system is instinctual to humanity, and responding to or interacting with changes in local climate and weather conditions has enabled the survival of most (but not all) social-ecological systems thus far. Based on this historical track record of successful adaptation over millennia, it is commonly believed that mankind can prevail over climate change in the same manner.

Although plausible, this line of reasoning needs to be put in the context of a few caveats regarding the present conditions. First, widespread changes in the earth's climate have triggered complex and in some cases catastrophic ecological responses around the world (Hansen et al., 2015). With the ongoing "press" of gradual climatic changes being superimposed by the "pulse" of extreme events (Harris et al., 2018), local climate and ecological systems have become unstable and highly unpredictable. This instability is unprecedented in recorded history; latent adaptive capacity alone is not enough to tackle problems of this magnitude and complexity.

Second, unlike in the past, social and ecological systems of today are so intertwined with each other that the line of demarcation between the two is blurred. Economic systems have been optimized for the sake of attaining efficiency, albeit at the cost of resilience (Walker & Salt, 2012). The interdependence of the two systems has reached such a level that changes in the natural system now have the potential to destabilize entire societies before their effects travel to geographically distant societies through formal and informal global trade channels.

This level of climate unpredictability and systemic interdependence between social and ecological systems across scales requires a well thought-out, coordinated, and nimble adaptation approach. Unfortunately, most countries taking the brunt of climate change lack the resources and knowledge necessary for such an approach, and often fall victim to shortsighted and uncoordinated coping measures at micro and meso levels. System effects and feedback loops that originate as a result complicate an already complex situation and impose stresses that have system-wide ramifications.

If the premise is accepted that effects of climate change are mediated through coping responses employed at micro and meso levels, and that success or failure of adaptive measures determines whether climate change destabilizes a society, then figuring out how people adapt becomes the most important piece of the puzzle. Accepting this formulation broadens the scope of the inquiry. It is not only climate change that imposes burdens resulting in societal instability, but also human responses at individual and group/meso levels that mediate these stresses, even complicate them. Together, they determine the trajectory of causal chains linking the climate "cause" to the "effect" of social and political instability and violence.

Although the literature is silent regarding theorization of dynamics of adaptation process across scales, allusion to (utilitarian) rational behavior can be surmised even when it is not explicitly stated. Similar appeals to human rationality can be noticed in political ecology literature that stresses equitable distribution of resources necessary for successful adaptation (Adger, 2006a; Adger & Kelly, 1999). The underlying assumption is that if resources necessary for adaptation are made available to vulnerable populations, human rationality will guide a society toward successful adaptation. Here as well, there is no mention of dynamics of the adaptation process, especially if it is carried out in an uncoordinated and unorganized fashion.

As discussed in the previous section, most definitions of rationality in social sciences are limited only to its utilitarian interpretation that expects an omniscient actor to choose the optimal solution based on economistic considerations. This assumption of omniscience, although already questionable, becomes even more suspect in the case of climate-society interaction where the original stressor can change its shape/nature in no time, or has multiple undercurrents (long-term intra-annual and intra-seasonal trends) interacting with each other to produce emergent stresses. And even if a stressor remains uniform, human interaction across scales and across societies may introduce complexity in the system.

If Boudon's call to broaden the definition of rationality is heeded by including cognitive, normative, and contextual logic, the assumption of private coping responses resulting in "efficient" and "optimal" adaptation begins to fall apart. Boudon (1998) warns that just because it does not satisfy the utilitarian interpretation of rationality, an action should not be dismissed as irrational. People have strong reasons for doing what they do, and those reasons may be different from each other depending on the respective belief systems on which they are built (ibid). But what other logic can there be when one is trying to avert the devastating effects of climate change? Shouldn't human cognition guide everyone to the same conclusion when adapting to variability and change in the natural system? The answer is: it depends on the perception of the stressor as well as that of a successful outcome of a coping strategy, which in turn may depend on an intricate belief system and values an individual, group of individuals, or a society may hold.

As previously mentioned, the first step toward solving the climate-security puzzle is to identify not just the climate impact but also the logics behind a society's response to it. Identifying generalizable social mechanisms may be helpful in developing a theory portable across cases. To that end, two theoretical constructs from established theories of resilience and information theory are briefly discussed below.

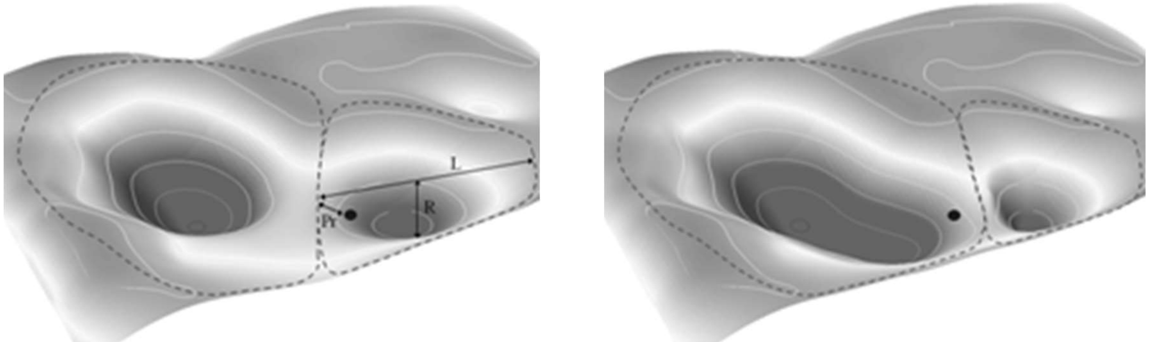
1) System as a ball in a basin

The "threshold model" in the resilience framework is a useful tool to explain the climate-society interaction. In this model, the metaphor of "ball in a basin" (Walker et al., 2004) is used to explain the dynamics of resilience, adaptability, and transformability that social-ecological systems undergo when acted upon by forces both external (e.g. climate change) and internal (e.g. society's response to the external force(s)) (ibid). In this apt conceptualization, a system is likened to a ball rolling to the bottom of a basin (of attraction). This basin, or "state space", is nothing more than a combination of variables of relevance at a given state of the system. For example, in a system of livestock grazing in a pasture, there are two variables relevant to the system, i.e. livestock and grass, thus making it a two-dimensional system. A basin may consist of as many or as few variables pertinent to the system under consideration. Also, there may be multiple basins to a system, although the latter can be in only one basin at a given time. Figure 3.4 shows a three-dimensional system reproduced from Walker et al. (2004) for explanatory purposes.

The system, or the ball, is a combination of values that each of the variables contains at any given time. As one or more variables change their values, the ball moves to a different point in the basin. Ideally, the ball must reside at the bottom of the basin to remain in an equilibrium state. However, as Walker et al. (2012) point out, this is rarely the case because of all the internal and external forces constantly acting on the system. These forces also tend to change the structure and shape of the basin itself. Within a particular basin, a system may maintain its structure, functionality, and feedback mechanisms as long as it remains in the same basin. The various basins a system may occupy as well as their boundaries are collectively termed as “stability landscape” (Beisner, Haydon, & Cuddington, 2003).

External changes, such as climate impact, as well as endogenous processes, such as coping responses and other processes internal to a society, may affect the stability landscape by changing the number of basins, position of a system in a particular basin, or thresholds of different basins, etc. Upon transferring to another basin of attraction, a system’s structure, functionality, and feedback mechanisms may change, and it may not be easy to revert it to the previous equilibrium state. Resilience then, is a function of how much stress a system can absorb before being pushed out of a particular basin of attraction. Once its equilibrium is disturbed, a system’s adaptation and transformability may help it attain equilibrium in a new basin of attraction.

Viewed through this lens, one can apply the same logic to studying complex climate-society interactions. Earth’s natural climate as well as a society are not just complex systems, their respective emergent behaviors are rooted in the fact that both contain multiple subsystems, each of which in turn is a complex one. The complexity of the natural system is well documented (Donner et al., 2009; Liu, Dietz, Carpenter, Alberti, et al., 2007; Rind, 1999). Complexity related to social systems, however, is usually not incorporated in most, if not all, climate-conflict studies. The prolific fields of system analysis and complexity have yet to catch up in the exploration of this particular research topic.



a) Three-dimensional stability landscape with two basins of attraction.

b) Changes in the stability landscape. System's original basin of attraction has contracted. Without itself changing, the system has changed basins.

Fig. 3. 4: System as a ball in a basin
Source: (Walker et al., 2004)

Although it may not be possible to analyze climate-society interaction without massive computing resources, given the level of nested complex systems involved, a simple mental visualization may be useful to drive home the point that the current formulation is not only inadequate, it may in fact be misleading.

What follows is an attempt at such a visualization. Once a climate impact is introduced, it destabilizes a society at many levels. Distributional conflicts result in major revamping of the preexisting resource distribution schemes; agriculture systems may be strained by unpredictable climate and weather patterns; commodity markets may become unstable as a result of disturbance in the agriculture sector; energy generation may take a hit due to variability in hydrological patterns; and temperature and precipitation changes may provide ambient environment for fertilization of pests as well as viruses and vector-borne diseases; to name a few. Depending on their exposure to and intensity of the original stressor, each of these systems may or may not be in its respective original basin at a given time. In case a system has already moved to a new basin of attraction, moving it back may not be just difficult, it may be impossible, and adaptation efforts to bring it back futile.

All of the subsystems mentioned above are complex adaptive systems in their own right. Although each subsystem may try to readjust independently upon experiencing a disturbance, the impact of such readjustment may reverberate across all systems in a society. For example, farmers' attempts to regain equilibrium in crop yields and financial viability of agriculture may have direct impact on commodity markets. Commodity markets may try to adjust unpredictable crop yields through price adjustment and international trade, which in turn may affect local agriculture, supply chain, etc. Similarly, a state's recalibration of natural resource distribution across various economic sectors as well as population groups may affect just about everyone in the society. Depending on cognizance of nature and level of the stress, readjustment efforts in a particular subsystem may range from trying to regain previous equilibrium point, or adapting to the new equilibrium in a new basin. This is where the role of adaptation comes in. In addition to concerns about equitable distribution of resources necessary for "successful" adaptation (Adger, Paavola , Huq, & Mace, 2006), the question becomes: how aware are vulnerable populations about not just the original stress, but also of the ramifications of their adaptive measures on other systems, and stability and equilibrium of the society as a whole? Extant adaptation frameworks assume rationality on part of the vulnerable populations, with the wishful expectation that there is nothing that human ingenuity cannot handle. This is a bold claim and requires revisiting.

2) Adaptation under complexity: Uncertainty management

Adaptation enjoys center stage in climate change research as one of the key approaches, if not the only one, to deal with the problem. An important reason behind the sanguinity about climate adaptation is the track record of mankind to survive changes in the natural system during our tenure spanning over millions of years (Hetherington & Reid, 2010). Another equally important and related reason is the bet some are willing to make on capability of the "rational thinking human" to carry the day by making efficient decisions in the face of changes in the natural system. The proponents of this model of decision-making claim that mankind's ability to adjust its decision-making calculus according to changes in the central variables of the problem makes us particularly adaptable to changes climate change is expected to introduce in the system. This assumption of rationality, as well as mankind's continued streak of survival go hand in hand in popular accounts at the root of climate-adaptation frameworks.

Despite its elegance, and the dominance it enjoys in popular opinion over other decision-making frameworks, especially when it comes to everyday decisions-making, the rational model has been questioned by many for its effectiveness in more complex problems. As discussed above, climate change is a non-linear process, and the uncertainty and complexity it introduces can overwhelm evaluative powers of human mind. Steinbruner (1974) argues:

> [The] question is not whether the mind *can* operate in this fashion; the issue is whether that is the only pattern of thought one need worry about. . . . Cognitive theory suggests, in other words, that analytical decision processes are highly

sensitive to uncertainty and that under high uncertainty a different pattern of mental operations appears. (pp. 104-105)

As concerns about maladaptation and backdraft of adaptive measures have grown in recent years, Steinbruner's skepticism of effectiveness of rational model under uncertainty can be expected to gain credence. Economists Mullainathan & Shafir (2013) make a related point by arguing that mere perception of scarcity can overwhelm the human mind to such an extent that its evaluative capability is compromised. They define the phenomenon as tunnel vision, or "the narrowing of the visual field in which objects inside the tunnel come into sharper focus while rendering us blind to everything peripheral, outside the tunnel. (p. 29). This approach of decision-making "makes us less insightful, less forward-thinking, less controlled" (ibid, p. 13). Reports from the field echo this concern by pointing out that shortsighted adaptation measures result in maladaptation (Barnett & O'Neill, 2010; Magnan et al., 2016), and may even lead vulnerable populations in "social-ecological traps" (H. E. Allison & Hobbs, 2004; Boonstra & Hanh, 2015; Cinner, 2011).

If a rational model of decision-making is unrealistic and is not expected to do well under immense complexity and uncertainty that climate change imposes, then what other approach may explain human behavior in times of climate variability and change? How do we adapt under such circumstances, and can there be implications for social and political stability? Clearly human beings are no strangers to uncertainty and complexity. We deal with it on a daily basis from tasks as mundane as crossing a busy street or driving a car to work, to as complex as making intricate decisions related to international security. Boudon (1998) argues that most people do not strictly adhere to utilitarian concept of rationality, but in fact are driven by their respective sets of beliefs that may be cognitive, normative, or axiological (value judgment). This is a fine point, and to some extent explains the paradoxes the conventional (utilitarian) interpretation of rationality regularly runs into. However, it does not say how individual minds would operate under inordinate complexity and uncertainty of the sort climate change is expected to introduce. Steinbruner's cognitive model takes up the issue in a systematic manner by elaborating "high-level thought processes of human mind", and may be useful in developing insights for the purposes of this research.

Cognitive model of decision-making:

Based on scientific research in the field of information-processing, Steinbruner's cognitive model (Steinbruner, 1974) sketches out basic principles which dictate how human mind collects information, processes it, stores it, and uses it to make decisions of varying complexity, most of them under uncertainty. Although recounting the theoretical details of this approach may appear to be removed from the subject matter at hand, a preliminary familiarity may be helpful in explaining human behavior under complex situations that climate change imposes. According to Steinbruner's cognitive model, there are five principles that dictate the workings of human mind, and are responsible for its strengths as well as the constraints it imposes on human cognition and behavior:

1. *Inferential memory:*

The content of memory is organized in such a manner that mind remembers the overall concept but is "very loose with its details" (ibid, p. 96). For example, when asked to recall a particular piece of information, a person "will think first of *some* general notion and will be a good deal more confident (justifiably) about that than about his grasp of subordinate detail" (ibid, p. 97).

2. *Consistency:*

This simply means that mind processes information based on pre-established sets of beliefs and values. Any new information is processed in such a way that it *becomes* consistent with the belief system an individual may hold.

This "constraint which affects both the organization of memory and processing of new information" (ibid, p. 97) explains why perception matters so much in everyday life and is often a determining factor in human behavior.

3. *Reality*

The reality principle asserts that human mind is in contact with reality and can reliably perceive the "stable important features of the environment" (ibid, p. 101).

This capability of human mind to be keenly aware of reality can be seen to be responsible for survival instincts in the face of danger, adapting to different situations, reflexes, etc. It should be noted that the "reality link" is the strongest in times of relative stability in the environment. In times of uncertainty, the link is significantly weakened and has ramifications as will be discussed below. Also, the mind is selective in attention and perception when it comes to collecting and processing information.

4. *Simplicity*

Beliefs maintained by a mind are simple. It is this simplicity that makes processing of complex information manageable. Among human beings, there is "observable tendency, other things being equal, to regularize complex figures; that is, to make circles, triangles, squares, etc., out of irregular figures" (ibid, p. 102). Unlike what is claimed by the rational model, upon receiving new information, the mind does not make exhaustive calculations of probabilistic nature before making a decision. Instead, it infers new information based on prior beliefs, and uses categorical judgment before making a decision. An example Steinbruner uses is that of a tennis player who hits an approaching ball with minimal thought whatsoever, rather than thinking through all possible options for the most efficient strike. The decision in this situation is primarily based on a simple set of beliefs that a player may have developed in the past.

5. *Stability*

A belief structure, once established, is unlikely to change. Cognitive mechanisms resist change in the core set of beliefs. Restructuring of belief system is likely to destabilize elaborate "lateral and hierarchical relationships within a system of beliefs" and may "set off a chain reaction, imposing severe burdens upon the information-processing system" (ibid, p. 102).

Steinbruner argues that it is this resistance to change in the core belief system that is responsible for stable attitudes people exhibit over their lifetimes.

> Voters display stable party loyalties throughout their lives, and in many cases these appear before adolescence. Mathematicians tend to form their major ideas at a very early age. Once they have matured, their minds become less flexible. They are able to work out the implication of their early insights, but generally they do not strike out in completely new directions. (ibid, p. 103)

Even though it is out of the purview of this research to compare the cognitive model with other approaches of decision-making and information processing, a cursory look, of the sort presented above, is enough to show that cognitive model offers a more realistic and grounded approach of decision-making as compared to that of the omniscient actor put forth by the rational model. As will be discussed below, maladaptive responses to the changing climate can be seen to be a result of the constraints the human mind imposes on cognition. Omniscience about climate and weather patterns is unrealistic, and assuming individuals and societies to be able to make efficient and most optimal decisions in the face of extreme uncertainty is misleading, to say the least.

Decision-making under uncertainty:

The above-mentioned five principles lay the groundwork for all information processing that the human mind performs in everyday life in relatively stable conditions.

But what about human behavior in conditions of uncertainty and complexity? Steinbruner argues that in times of intense uncertainty the "reality principle" is suspended, i.e. the mind's grasp of changes in important features of the environment is compromised, and its evaluative capability significantly weakened. This, however, does not keep human beings from decision-making in time of complexity. Cognitive model dictates that mind operates under complexity by leaning more heavily on its belief structure and by maintaining consistency while processing new information. Two important mechanisms of decision-making under complexity are worth noting, 1) value separation, and 2) resolution of uncertainty.

Value separation:

Value separation is in fact the opposite of value trade-off – a mechanism mind uses for decision-making in times of stable environment (little or no uncertainty) in order to choose between two negatively associated sets of "factual information arranged under a governing value assertion" (ibid, p. 105). An example of the phenomenon may be the choice between pursuing climate mitigation and burning fossil fuels. Ideally, the choice between the two negatively associated options would be easy for a decision maker who may choose whichever option is in line with his belief system.

In times of intense uncertainty, however, when the reality link is weakened significantly, "trade-off is a matter of some subtlety and hard to see" (ibid, p. 106). This is when mind adopts a different mechanism to resolve uncertainty. By suspending the trade-off between two opposing values, the decision-maker treats each value as separate or unrelated to the other, hence the mechanism name, value separation. Under uncertainty, decision maker would consider the two values as unrelated to each other and would pursue both separately. This simple adjustment in information processing has serious implications and is an important cause of exacerbating complexity and generating system effects.

It is easy to find apparent examples of this phenomenon in situations related to climate-society interaction. Governments around the world taking measures to adapt to the effects of climate change, while simultaneously continuing to expand their use of coal for power generation is a notable case of value-separation. Another example is that of farmers adapting to climate change without changing their agricultural and lifestyle practices. Aquifer depletion to make up for reduced water availability without pursuing conservation shows separation of values of adaptation and conservation in the minds of individual farmers. Similarly, herders migrating in search of pasture and trespassing on lands of farmers is a separation of values of adaptation and maintaining peace. The two are treated separately as climate change makes access to renewable resources uncertain for vulnerable populations.

Subjective resolution of uncertainty:

Another cognitive mechanism pertinent to climate-society interaction under complexity is “subjective resolution of uncertainty” (ibid, p. 109). Mind resolves uncertainty not by objective assessment of the unknown, but by limiting the processing of new information. In other words, rather than actively processing new information and nuances brought about by complexity and resultant uncertainty, mind shuts down the connection with reality and starts operating under the influence of its pre-established belief system.

All new information is inferred using very simple beliefs during the decision process. An example of this phenomenon is how individuals perceive the existence of climate change. A person experiencing changed climate and weather patterns may perceive the existence of climate change and take appropriate adaptation measures only if it is included in his prior belief structure. Spells of good weather may reinforce the beliefs of a climate denier, while bouts of bad weather and climate events may do the same to those who believe that earth's climate is changing.

Steinrbruner argues that in times of uncertainty, in addition to relying on their prior beliefs, individuals resolve uncertainty by leaning on small group interaction (ibid, pp. 112-121). There too, individual mind pays attention to only those views that are in line with his own thinking. In a way, mind creates an echo chamber where only those views are allowed entry that are consistent with its preexisting beliefs.

<u>Mechanisms of climate-society interaction:</u>

Every society interacts with climate change based on the type and severity of the stressor itself, its vulnerability to changes in climate, and how its populations respond to the stress. However, some generalizable mechanism identified from the literature may be useful in developing a basic understanding of the phenomenon, and are discussed below.

Uncertainty resolution

A mechanism of information processing hardwired in the human mind, uncertainty management has to do with humans' ability to operate in times of uncertainty (Steinbruner, 1974). When overwhelmed with unpredictable and conflicting information due to uncertain environment, mind isolates itself from new information by focusing on only a few variables of environment. Decisions in such situations are made not by exhaustive calculation of all possible scenarios and the probabilistic outcomes of the unknowns, but by categorical judgment based on limited information in line with one's beliefs. All the information counter to one's beliefs is discarded. Reinforcement of one's decisions or tendencies is sought from likeminded individuals and groups, thereby creating an echo chamber of sorts. Due to the shortsighted decisions it may result in, uncertainty management is expected to exacerbate vulnerability instead of decreasing it.

Belief-formation

Originally identified by Hedstrom & Swedberg (1998), the belief-formation mechanism states that "the number of individuals who perform a certain act signal to others the likely value or necessity of the act, and this signal will influence other individuals' choice of action" (p. 21). This means that a short-sighted adaptation measure can go "viral" in no time and exacerbate vulnerability of a local community in medium and long run. Farmers cutting down trees (for charcoal trade) in order to survive a drought in Sub-Saharan Africa is an example for maladaptive response being replicated by a vast number of hurting populations. Similarly, a large number of farmers switching to the cultivation of the same crop as a coping mechanism when their previous crop has failed is another example of belief-formation. An oversupply may create a glut in the market and depress prices, thus resulting in an increase in vulnerability.

Hedstrom & Swedberg argue that belief-formation is at the heart of phenomena such as run on the bank, and the emergence of the collective movements, etc.

Tunnel vision

Mullainathan & Shafir (2013) point out that absolute and perceived scarcity have the effect of "tunneling" on peoples' minds. The mere perception of not having enough of something can drain the "bandwidth" or the cognitive resources necessary for achieving an optimal outcome in a given situation. People stuck in the scarcity trap continue to make poor choices, and spiral down with no hopes of climbing back up unless somehow the trap is broken. The uncertainty and complexity attributable to climate change is already creating all sorts of absolute and perceived scarcities around the world. The mechanism of "tunneling" or "tunnel vision" may explain why such situations may lead to less than optimal decisions on part of vulnerable populations that sometimes may exacerbate the original stress.

Tunneling behavior under perception of scarcity is not singular to individuals. Distributional conflicts in the face of perceived and absolute scarcity or shortage of resources may induce institutions and even states to make poor decisions that result in distributional conflicts and system effects. For example, preferential treatment of irrigation (for food security) over hydroelectric power generation in the face of reduced water availability is bound to generate system effects. Reduced electricity production may result in power blackouts, or increase in the cost of business or manufacturing etc., thereby generating social and political unrest. This unrest, although apparently unrelated to climate change, is in fact directly related to the coping measure taken in response to it.

Double exposure (to climate change and global trade)

Double exposure refers to the interaction of the effects of climate change and globalization (Leichenko & O'Brien, 2008). Due to integration of commodity markets through globalization, effects of climate change do not remain local, instead they have the potential to generate system effects on a global scale through international trade (both formal or otherwise). This implies that for a society to be vulnerable to the effects of climate change, it does not have to experience climate change directly; its political economy and food security can unravel by climate events taking place elsewhere in the world. For example, climate-induced crop failure in a major wheat exporting country (or a bunch of smaller countries in case of a region-wide climate event) may drive up wheat prices in the international market. This may result in the outflow of wheat from otherwise non-exporting or smaller countries, threatening their food security. Examples of double exposure have happened in the global food crises in 2008 and 2010 when extreme climate events disrupted agricultural production in major food exporting countries, impacting global supply chain and catapulting several faraway societies into chaos and political turmoil.

Contention (attributable to climate change)

Given its deleterious effects on livelihoods, the level of unpredictability and confusion it instills, and the system effects and feedback loops it generates, climate change is bound to sow social and political unrest potentially resulting in violence. Under what conditions will climate-ravaged individuals and groups pour into streets and mount violent campaigns against their fellow citizens or launch insurrection against the state? Will climate change align vulnerable individuals and groups along ethnic, political, or social lines, or create new fragmentations in a society? And more importantly, how would individuals disgruntled by the effects of climate change organize into groups, mobilize, define goals of their struggle, build coalitions, and wage effective campaigns to voice their concerns using non-violent and violent means?

The answers to these questions, scarce in extant literature, are of utmost importance if one is to draw a causal link between effects of climate change and its impact on local, regional, and ultimately international security. Climate change is notorious for muddying the waters by exacerbating preexisting systemic vulnerabilities in a society (Ribot, 2010). A clear articulation of the problem, its impacts on societies, as well as interaction with mechanisms and processes of contention may help identify robust and salient features of the causal chain.

To recapitulate, previous sections have highlighted the nature of the climate change *process,* and tried to shift the focus from a variable based approach to one of identifying mechanisms generalizable to other cases. Instead of depicting society as a docile/passive recipient of the blows dealt by climate change, predominantly via scarcity, this dissertation argues that climate change and vulnerable populations are in a state of constant interaction via coping mechanisms/responses and antecedent processes. Also, if it comes to it, contentions result from both direct effects of climate change as well as complications and system effects generated by climate-society interaction.

When it comes to investigating the role of climate change in the onset of conflict, as discussed in the literature review chapter, individual grievances do not readily transform into contention. The desire to link "sudden" popular uprising to the nearest social change (in this case attributable to climate change) has to do with the allure of telling stories with crisp beginnings, middles, and ends (Polletta, 2009). But as scholars of social movements, revolutions, and ethnic conflict have argued, such complex contentious events rarely, if ever, spring up in such extemporaneous fashion (J. Goldstone, 1998a; McAdam et al., 1996). Instead, in most cases, non-violent expressions of unrest fester over a period of time before transforming into violent contention. Unlike how it is depicted in the extant climate-conflict theories, where climate-induced stresses are sufficient to align individuals and groups along predefined ethnic, political, social, fault lines, it is the interaction among vulnerable populations that realigns them by mobilizing and demobilizing certain actors, building coalitions, broadening identities, etc. Expressions of unrest too go through an evolution phase depending on political opportunities the political entrepreneurs foresee as well as state's response and capacity in the early phases of a social movement.

This is not to say that extreme climate events such as flash floods, droughts, etc. do not have the potential to push a society into chaos in a short duration. Similarly, as in the case of the Arab Spring, impacts of a climate event taking place in distant land(s) may travel to unsuspecting societies and destabilize their social and political systems. As plausible and disturbing as these scenarios are, the formulation is too static and invariant to provide any insight of value for analysis, or prevention.

The conflict potential of climate change has often been explained using the concept of scarcity, considered a sufficient reason for individual grievances to surge and result in widespread violent contention. This excessive focus on isolated movements and invariant causal sequences does not shed light on as to how people respond to such "critical junctures"; how relations among individuals and groups change; how new fault lines emerge and contention radicalizes, etc. Also, such formulation of the problem does not explain the paradoxical behavior, i.e. climate events and scarcity may create instability and violence in some cases but not in others, befuddling both analysts and policymakers alike.

Interaction among actors and their perceived opposition or rivals is not satisfactorily explained either. Structural accounts divide societies in vague collectivities based on social or ethnic identities, or even their geographical location with reference to access to natural resources (e.g. upper riparian vs. lower riparian, etc.). In such accounts, it is assumed that individuals' participation and action in contentious episodes will conform to the collectivity to which they belong. For example, all (or most) herders are supposed to fight all (or most) farmers in times of resource scarcity. Similarly, all upper riparian populations are supposed to band together against all lower riparian populations. The purpose here is not to dismiss these societal divides that sometimes may become active in times of resource scarcity. Rather, it is argued that a systematic approach is needed to look beyond the obvious and identify and analyze the microdynamics (Kalyvas, 2006, 2008) that are otherwise not visible in aggregate models.

Finally, the role of the state is not very well explained in extant climate-conflict theories. As McAdam et al. (2001) argue, state and its challengers continuously interact with each other, and it is this interaction that determines the trajectory of a contentious episode. Goldstone (1998a) argues that a state's mild or weak response to a social movement may transform the latter into a rebellion by emboldening political entrepreneurs and insurgents, while strong repressive actions may render a social movement ineffective, albeit temporarily (1998a, p. 129). Similarly, De Fazio (2013) points out that state repression meant to crush a social movement may eventually result in its spread to other sites of contention, as well as radicalize and intensify contentious performances.

With these concerns vis-à-vis the dynamics of contention, three broad principles regarding how it is envisaged in this framework are listed below.

1) Contention is a spectrum

As is the practice in most of the political violence literature, conflict is coded dichotomously in the climate-conflict literature as well. This coding technique is partly a result of insularity of various fields of study narrowly focused on parts of a larger phenomenon, and partly due to the dominant approach of looking for structural variables correlated with the onset of conflict. However, there is a growing realization among scholars of protests, movements, conflicts, and revolutions that there are a lot of similarities in these seemingly disparate phenomena (J. Goldstone, 1998a; McAdam et al., 1996; Petersen, 2001). Treating these complex processes as merely structural variables limits analysts' ability to properly investigate their causes and consequences (Chenoweth & Lawrence, 2010).

Goldstone (1998a) points out that social movements and revolutions originate from similar processes, but, depending upon the interaction with the state, evolve to different outcomes (p. 128). McAdam et al. (1996) argue that there are "continuities between movements . . . and revolutions" and that what path actors take is a matter of choosing "the most appropriate response to their resources, their opportunities, and their constraints" (p. 27). Similarly, Petersen (2001) argues that "at a most fundamental level rebellion involves individuals moving across a set of multiple possible roles . . . from neutrality . . . [to] mobile and armed organization, meaning membership in guerilla unit or rebel army" (pp. 8-9).

McAdam et al. (2001) provide a framework to analyze such a wide range of expressions of unrest. Calling the entire gamut contentious politics, they argue:

> [D]ifferent forms of contention – social movements, revolutions, strike waves, nationalism, democratization, and more – result from similar mechanisms and processes. . . . [W]e can learn more about all of them by comparing their dynamics than by looking at each on its own. (McAdam et al., 2001, p. 4)

I follow this conceptualization of contention with the logic similar to the one listed above: climate change creates conditions where vulnerable populations have no clear idea about the enemy or the threats it poses. Unpredictability in the natural system upends preexisting approaches for sustainability and threatens livelihoods. The social unrest introduced into the system in this manner may initially be in the form of non-violent protests and strikes. Violent collective action, however, may ensue and spread across society activating preexisting fault lines and creating new ones. Syria's civil war is a case in point where popular uprising started as localized non-violent protests, allegedly traceable to historic drought (Gleick, 2014; Kelley et al., 2015), and ended up in one of the most violent civil wars in recent history (Leenders, 2013). Using a mechanism-based approach to "trace" the process may also help resolve the paradox of climate-induced contention where climate stresses may create social and political violence in some societies but not in others.

2) Mobilization is a dynamic process

The conflict theory that serves as the bedrock of the climate-conflict literature is mainly concerned with why men rebel (Gurr, 1970) but not necessarily with *how* they do it. However, keeping in mind the stakes involved, it is important to understand the mobilization processes through which climate-induced stresses may lead a society into social and political turmoil.

As depicted by the Coleman's Boat model discussed in the intellectual resources section of this chapter, the origins of protest cycles, movements, and revolutions lie in the interpretation of the threats and responses at micro level that dictate the mobilization process. This is not to discount the broad processes an external stressor like climate change triggers, such as economic turmoil, instability in commodity markets, disequilibrium of political economy, etc. However, how a threat is perceived and interpreted determines which actors get mobilized, who the perceived enemies are, and how the political struggle is framed, etc.

In the case of climate change, the external stressor unfolds in a varied manner. Moreover, with the exception of extreme climate events, most climatic changes are often gradual, and seamlessly interact with stakeholders until the stress becomes unbearable and further coping untenable. This process of climate-society interaction results in the original threat getting muddled with auxiliary sources of stress. For example, inequitable access to ever-dropping water table may shift the attention of vulnerable populations away from the original reason(s) such as reduced rainfalls, drought, or flash floods that kept the aquifer from recharging. Instead, relative deprivation may result in directing anger to those with more resources to chase down the depleting aquifer by renewing their wells every few months. Similarly, although it may be the reduced runoff in a river basin that may cause distributional conflict over allocation of water among different sectors of society, the threat may be perceived differently by vulnerable groups and individuals who may look at the situation through a historical, cultural, or even political lens and organize accordingly.

Mobilization in such cases may take place based on perceptions of threats to livelihoods, identities, or a general sense of injustice, rather than a clearly defined source of stress. Since climate change affects almost all aspects of life in any given society, this is where the confusion lies in tracing a direct causal chain linking a clearly defined cause (climate change) to a specific outcome of interest (conflict).

Mechanisms of mobilization:

Just as is true of any other social movement, climate-induced instability turns into a sustained campaign of social unrest by way of mobilization of aggrieved populations. Simply, mobilization indicates emergence of contention. In what follows, some of the mechanisms leading to contention, as identified in the contentious politics literature, are defined and their relevance with the current problem explained. This is not an exhaustive list. Specific mechanisms may vary not only from one case or society to the next, but also from one episode of contention to another.

Cognitive liberation

McAdam (1982) defines cognitive liberation as "transformation of consciousness within a significant segment of aggrieved population" (p. 51).

As climate change creates winners and losers (Leichenko & O'Brien, 2006) and gives rise to feelings of relative deprivation among vulnerable populations, cognitive liberation may trigger the process of mobilization. Keeping in mind the signature randomness with which climate change unfolds, lines drawn between the "makers of claims" and "objects of claims" may be arbitrary and cut across a society's preexisting social, political or ethnic landscape. Similarly, as previously noted, effects of climate change are often indirect; thus, the trigger of mobilization may appear to be removed from the original stressor. Although such a link may be invisible in aggregate datasets, even preliminary process tracing may be able to uncover it.

Framing of injustice, and *resentment formation*

Aminzadeh et al. (2001) argue that it is not just dispassionate cognition that leads to such a consciousness, but also the emotional aspect of being treated unfairly in a society. Gamson (1992) argues that cognition of injustice alone is not enough for constructing social protest. In order to mobilize and organize aggrieved populations, a strong feeling of injustice as well as a sense of identity has to be part of the mix. This feeling of injustice, he argues, is more emotional in nature than cognitive:

> This is not merely a cognitive or intellectual judgment about what is equitable, but is what cognitive psychologists call a "hot cognition" – one that is laden with emotion. (Gamson, 1995, p. 90)

This "hot cognition" or perception of unjust treatment heightens when aggrieved individuals reflect on their experiences and those of people they know. In addition to rational stocktaking of costs and benefits, it is the personalization of cognitive framing of injustice that recruits motivated actors "who carry some of the onus for bringing about harm and suffering" (Gamson, 1995, p. 90).

A similar mechanism instrumental in the emergence of contention is "resentment formation" (Petersen, 2001) that deals with the complex task of identity development in a contentious episode. Petersen (2001) argues, "if there is going to be a rebellion, there has to be something or someone to rebel against – that is there must be a perception of an enemy" (p. 33). The task of assigning identities is a highly complex one. How people take sides is a function not just of individual perception but also of how the threat is framed, and how peoples' personal experiences and biases condition the framing and the perception, etc. The problem becomes even more complex in the case of climate-induced stresses and inequalities because it is hard to organize a protest against rains that did not come or flash floods that came without warning. Assigning blame for what is perceived as unjust and unfair treatment in such a case may be arbitrary and a function of the framers' perceptions (and biases).

As climate change upends a society's social order by destroying some livelihoods and sparing others, the sense of injustice and subsequent assigning of blames may result not just from preexisting divides but also from new ones. Petersen (2001) points out, "individuals of formerly dominated groups resent living in hierarchies that have placed them in newly subordinated positions . . . they feel more resentment the more they perceive an unjust hierarchy" (p. 35). As discussed in the literature review chapter, inequitable access to means necessary for successful adaptation plays a big role in developing such a perception (Adger & Kelly, 1999). Based on who can survive (or even prosper) in the aftermath of climate events, resentment formation may be within-group as well. It may also be anti-state if vulnerable populations consider that the state is negligent in its responsibility to protect them from vagaries of a changing climate.

Political opportunities and threats of retribution

No matter how much "hot cognition" or emotional sense of unjust treatment prevails in an affected group, leaders of a contention have to assess whether the political environment is conducive for mounting a successful movement at any given time. McAdam (1982) refers to it as political opportunity, and considers it to be a combination of state weakness and elite divisions, etc. Kahl (2006) argues that demographic and environmental stresses can impose enough pressures on the state that it can cause an "internal security dilemma" thereby paving the way for a violent insurrection to commence (p. 47). These accounts, among many others, point to a broadly accepted notion that a suitable political environment is necessary for a contentious campaign to begin. McAdam et al. (2001) argue that identification of political opportunity is a dynamic mechanism, and is a function of perception rather than structure. Instead of waiting around for a more suitable time to emerge, political entrepreneurs, elites, insurgents etc., are in constant interaction with the state each offering competing interpretations of threat and opportunity. Sometimes opportunities come in the form of "historical events" (Sewell, 1996) when political pressure and elite disaffection makes the existing political structure untenable. In other cases it may be a result of erosion of legitimacy if enough of vulnerable groups feel that the threat of extinction is too real (Kahl, 2006). Similarly, the state may choose to quell a movement with impunity if it senses a political opportunity that it can get away with it. In more unstable times, however, the state may be forced to give concessions (such as policy transformation) to demobilize the challengers.

Innovative collective action or repertoires of contention

Sometimes, it looks like social changes caused by some external process e.g. climate change may impose such stress that vulnerable and aggrieved populations extemporaneously break into protest or related collective public expressions of unrest. This is rarely really the case (Polletta, 2009). Although sudden outbursts of anger or frustration may occasionally take place, as Charles Tilly argues, there is consistency in the forms a sustained campaign of public collective action takes. He termed these sets of displays of contentious collective action as "repertoires of contention" (Tilly, 1978), and "contentious performances" (Tilly, 2008), and argued that just like a well choreographed theatrical production, public displays of contentious collective actions are well coordinated and strategically chosen by members of a movement. From a whole array of public performances associated with a particular form of political contention, organizers of public collective action choose a small set of routines most relevant to their settings and purposes. Sometimes the purpose is to convey claims to other actors, draw public sympathy, or express unity and resolve of its members. McAdam et al. (2001) argue:

> [P]articipants in public claim-making adopt scripts they have performed, or at least observed, before. They do not simply invent an efficient new action or express whatever impulses they feel, but rework known routines in response to current circumstances. Doing so, they acquire the collective ability to coordinate, anticipate, represent, and interpret each other's actions. (p. 138)

In Tilly's usage, the performances that may constitute repertoires of contention include sit-ins, marches, protests, strikes, freedom rides, etc. (Tilly, 1978). Based on their effectiveness during the length of a political contention, repertoires may come into or go out of use. Leaders of a movement do innovate, but usually tend to stay within limits set by the history of respective performances' effectiveness in the past (ibid). For example, farmers burning their crops as an expression of frustration and total despair is an innovative variation on a well-known theme (riots that damage protestors' own neighborhoods), than a sudden outburst of emotions. More conventional contentious performances such as farmers' marches and protest rallies too are organized and planned well in advance to ensure maximum effectiveness.

3) Contention is an iterative process

No matter how extemporaneous they may appear, social movements do not arise overnight, and rarely have clearly defined beginnings and ends. In fact, as McAdam et al. (1996) point out, instead of occurring issue by issue, they unfold in an iterative fashion, with each cycle bringing in an increasing number of actors, and decreasing civility. Early risers spot and capture political opportunities to transform palpable resentment and social unrest into action by employing established repertoires of contention (Tilly, 1978). More actors join the fray and jostle for control and leadership. Interactions among actors, state, institutions, and established political actors turn social movements into sites of social activity. This is what McAdam et al. (2001) refer to as "relational realism", and it is this interaction that shapes the framing, goals, and trajectory of social movements. Unlike the assumption of the rational model, individuals' decisions to join the contention are not made in isolation, but are shaped in large part by these interactions.

After reaching their climax, waves of protests decline in frequency and success, thereby reducing the chance of new participation (Koopmans, 1993). In order to keep the struggle alive, "social movements must compensate the loss of novelty by increased numbers or increased militancy"(ibid, p. 655). Therefore, political entrepreneurs spend their time building coalitions with other political actors, and developing broader collective identities around such coalitions. Stronger identities, built around disgruntlement and unrest of a much larger segment(s) of society are needed to keep the movement going even under unfavorable conditions. For example, even if protests were triggered by failed farmers (or any other group or individuals affected by climate change), in order to maintain vitality and novelty of the movement, the coalition may shift the focus toward broader issues of poverty, corruption, governance, or other relevant issues depending on a society's politics, history, culture, etc. This point is in fine print and usually missed in studies trying to explore direct links between climate change and onset of conflict.

McAdam et al. (2001) warn that contentious cycles or episodes are not natural entities, but in fact are "observers' lenses, bounded and observed according to conventions established by participants, witnesses, commentators, and analysts of past episodes" (p. 29). The logic behind dividing a social movement, rebellion, or conflict into episodes of contention has more to do with methodological concerns or analysts' worldview as discussed in the intellectual resources section of this chapter. McAdam et al. argue:

> We employ mechanisms and processes as our workhorses of explanation, episodes as workhorses of description. We therefore make a bet on how the social world works; that big structures and sequences never repeat themselves, but result from differing combinations and sequences of mechanisms with general scope. Even within a single episode we will find multiform, changing, and self constructing actors, identities frames of action and interaction. (ibid p. 30)

Viewing varied forms of contentious politics as episodes of contention is useful not only for methodological reasons but also for comparative purposes. As episodes wax and wane, strategic situations of actors change, some actors gain prominence while other retreat to background or secondary positions. Effective contentious performances replace the ones that are no longer novel and effective. This iterative process is where "different streams of mobilization and demobilization intersect, identities form and evolve, and new forms of action are invented, honed, and rejected as actors interact with one another and with opponents and third parties" (ibid p.30).

Mechanisms of sustenance of social movement:

Brokerage

McAdam et al. (2001) define brokerage as the mechanism that links two or more previously unconnected social sites in a social movement by mediating their relations with one another. This is done usually by political entrepreneurs who identify commonalities between different groups (or individuals) and try to unite them by appealing to their commonalities for a particular political goal. Coalitions built using brokerage are emergent, as they do not exist in nature. Also, the final outcome of the mechanism of joining different entities is irreducible to the effect produced by constituting components. McAdam et al. point out that usually brokerage results in broadening of a movement's goals, as disparate entities previously pursuing different goals combine their resources and merge their claims. Usually such coalitions aim for a combined opposition against a government or another group. Established political entities, for example, may join hands with an insurgent entity such as farmers, if they sense a political opportunity to unseat an incumbent government. Small groups of aggrieved populations may join hands against a government or another group they perceive to be responsible for their plight, etc.

Political identity formation

Participants in contentious events make great effort to establish their identities. After all, a lot depends on establishing the fact as to who acted and in whose name. Individual identities are transformed into collective identities. Leaders of a movement go to great lengths to forge identities that clearly represent their values as well as the cause of their struggle. They also take great pains to contrast themselves with their competitors or detractors. Political activists and entrepreneurs strategize, manipulate, and reinterpret their identities and that of other parties throughout the duration of the contentious process. As the struggle evolves, so do its members, goals, and identities.

Diffusion

Diffusion has to do with the spreading of claims of contention as well as contentious performances across a society (McAdam et al., 2001, p. 68). Hedstrom et al. (2000) argue that meso level networks as compared to microlevel ones, are particularly effective in spreading a contention much faster. Regardless, diffusion may connect likeminded individuals and groups across a society and strengthen a movement quickly.

Radicalization

Radicalization is "the expansion of collective action frames to more extreme agendas and the adoption of more transgressive forms of contention" (McAdam et al., 2001, p. 68). Koopmans (1993) argues that once an episode of contention is on a downward trajectory, it needs to compensate for its lack of novelty by either increase in numbers or increase in militancy (p. 655). Increase in numbers is possible if established political actors are willing to join hands with the movement. However, established political groups usually prefer moderation in contentious performances as well as goals. More radical members, however, may resort to more violence and militancy to remain relevant and maintain their identity (ibid). De Fazio (2013) argues that repression of a social movement by the state is often responsible for members of a contention to resort to more violent means. Goldstone (1998a) makes a similar point by arguing that the state's inability to vanquish a social movement completely emboldens its members who may now try to seize the opportunity by launching a rebellion to overthrow a government through violent means. New alliances are built by including other actors who too may see an opportunity, thus strengthening a social movement.

<u>Trajectory in contentious politics:</u>

McAdam et al. (1996) argue that beginnings of social movements and revolutions have striking similarities. Both start from what they term "institutional politics" (McAdam et al., 2001) where aggrieved populations make claims using established means of claim-making in that polity, e.g. elections, referendums, parliamentary politics, etc. However, as intensity increases, the repertoires of contention become less civil. As a split within the polity widens, new coalitions give rise to broader collectivities, rivalries, and offensive and defensive mobilizations. At their climax, social movements may start to look like the beginning of revolutions or civil conflict depending on the goals set by the claim makers. Goldstone argues that although cross-class coalitions are necessary for a successful social movement (J. Goldstone, 2011), the state plays a big role in determining its trajectory (J. Goldstone, 1998a). Successful repression can crush a movement before it has embroiled a larger section of society. Unsuccessful repression, on the other hand, may embolden insurrectionists who attribute it to the state's weakness (a political opportunity) and try to fight even harder and with more violence.

Postulates of a mechanism based framework to study climate-induced unrest and contention

The theoretical explanations and constructs discussed in the previous sections can be summarized in the form of the following postulates:

1. Climate change is a complex process and manifests in a varied fashion across time and space. In addition to extreme climate events, its effects include disruption of local climate and weather patterns that may be intra-annual and intra-seasonal in nature.
2. In addition to immediate effects, such as destruction of life and property in extreme climate events, gradual climatic changes interact with local and global antecedent processes. Changes in seasonal patterns introduce an element of unpredictability and chaos in the lives of those who depend on predictable climate and weather patterns for their livelihoods.
3. Most adaptation takes place at the micro and meso levels in an impromptu manner where vulnerable populations try to cope by resolve uncertainty introduced in their

lives by unpredictable climate and weather. This uncertainty resolution is often suboptimal and shortsighted, and may lead to system effects and emergent behavior in the system.

4. Direct and indirect effects of climate change produce unrest. Depending on a plethora of factors, contention may range from waves of non-violent protests, to isolated violent events, to sustained social movements, to rebellion.

It follows from the postulates that all three processes, i.e. climate change, adaptation, and political contention, are complex processes, and their interaction leads to behavior that may be emergent in nature, rendering difficult the task of analyzing their interaction. Particularly because climate change does not manifest in a uniform manner, and is interactive, the dominant positivist model is unsuitable as an analytical approach. Instead, a mechanism-based approach, aimed at providing limited understanding of salient features of the phenomenon in all three constituent processes may be more effective.

The distinction between the real, the actual, and the empirical, discussed in the intellectual resources section of this chapter, is especially important for analyzing the impact of climate change on societies, especially its dynamics of introducing instability and contention. How climate change unfolds is observable and can be measured. However, since the nature of the stressor is interactive, and the final impact depends at least as much on the response to climate stress as on the stress itself, the "actual" may be different in different cases, or in different episodes in the same society. The central question of this research can be restated as follows: *what mechanisms and processes best explain the climate-society interaction, and constitute the causal chain linking the* *original stressor of climate change with social and political unrest and contention in a society?* As argued earlier, causal chains and final outcomes may be different based on the nature, severity, and frequency of climate changes; impacts of coping responses, across time and space, not just on vulnerable populations but on other sectors of society; and mechanisms and processes invoked during political contention.

Based on the presumption that big structures and sequences never repeat themselves exactly, but result from varying combinations of generalizable mechanisms and processes (Tilly, 1984), this dissertation argues that a mechanism-based framework may be of greater analytical and descriptive value to explain this complex and emergent phenomenon than hypothesizing a singular causal chain. Such a framework will provide a basic workspace where different manifestations of climate change and their respective effects; mechanisms of adaptation and their impacts; and processes of unrest, mobilization, and contention may be separately identified, and the causal chain(s) constituted. This approach makes the case that with regards to climate-induced contention, no truly general accounts are attainable. However, limited explanations and comparisons are possible by identifying robust recurrent mechanisms and processes of salient components of the causal chain.

Figure 3.5 shows such a framework in which the three phenomena are shown as separate processes with *some* of their mechanisms identified. As argued earlier in this chapter, the three processes are not linear and do not take place in a sequential fashion or one at a time. Climate change, for example, can cause such an acute shortage of resources or impose such enormous burdens on populations in such a short time that vulnerable populations do not have the opportunity to adapt in a timely manner. In such situations immediate and abrupt contention in some form may ensue. Armed conflict between herders and farmers in Sub-Saharan Africa during various types of extreme weather events is an example of such a scenario. These isolated incidents of violence may subside as soon as the weather lets up. In situations of preexisting social and political turmoil, however, these isolated episodes of contention may fester when combined with preexisting stresses and sources of aggrievement. The climate stressor in such cases would be nothing more than the straw that broke the camel's back, and at best be considered as a "threat multiplier" or "catalyst for conflict". This scenario may completely bypass the box of "maladaptation trap" shown in the diagram, and may directly take the society from vulnerability to contention.

Arguing that climate change is a significant reason for social and political stresses and contention is a different story, and requires much elaborate tracing of the stressor and the inroads it makes in a society. No general accounts of immediate climate-contention association or co-variation of the sort explored in the extant literature are possible. Instead, this framework argues in favor of identifying mechanisms in the three constituent processes separately. Contention may take place only when the mechanisms thus identified concatenate in such a manner that the circuit is completed. As the diagram shows, maladaptation and social-ecological traps, as well as double exposure of climate change and globalization are some of the mechanisms that may complete the circuit and trigger contention. Since a contention process, once triggered, takes a life of its own, it may result in attracting aggrieved populations from across society, who build coalitions, and set off on a trajectory that may or may not end in full-scale conflict. Although the resulting episode(s) of contention may be the outcome of a combination of grievances and coalitions developed in the process, attributing a significant share of the blame to climate change may be possible by connecting at least some of the contentious performances to stresses and vulnerability associated with it.

Bennett (2010) likens mechanism-based analysis to a "detective attempting to solve a crime by looking at clues and suspects and piecing together a convincing explanation, based on fine-grained evidence" (p. 208). Like all detective work, a mechanism-based approach may or may not solve the case. But given the adaptive and emergent nature of the problem, the framework proposed in this chapter offers a starting point for opening the black box and analyzing the dynamics of climate-society interaction and its potential to induce political contention.

In the next two chapters, I apply this framework on the case study of Pakistan. The country has been experiencing serious environmental stresses for some time. These stresses, in turn, are interacting with and eliciting coping responses at micro and meso levels of society. Since vulnerable populations lack access to long-term climate data, as well as computational resources to develop a decent understanding of the nature of the stress to which they are being exposed, the coping responses are bounded rational and shortsighted to the extent of being haphazard. The result is major disruption in the agriculture sector, as well as in domestic commodity markets. In the last few years, this unrest has led to farmers organizing at grass roots level, and mounting a social movement aimed at policy change. Applying this framework on the case study may help identify mechanisms of some generality, and assess whether social and political unrest among farmers can be traced back to climate change.

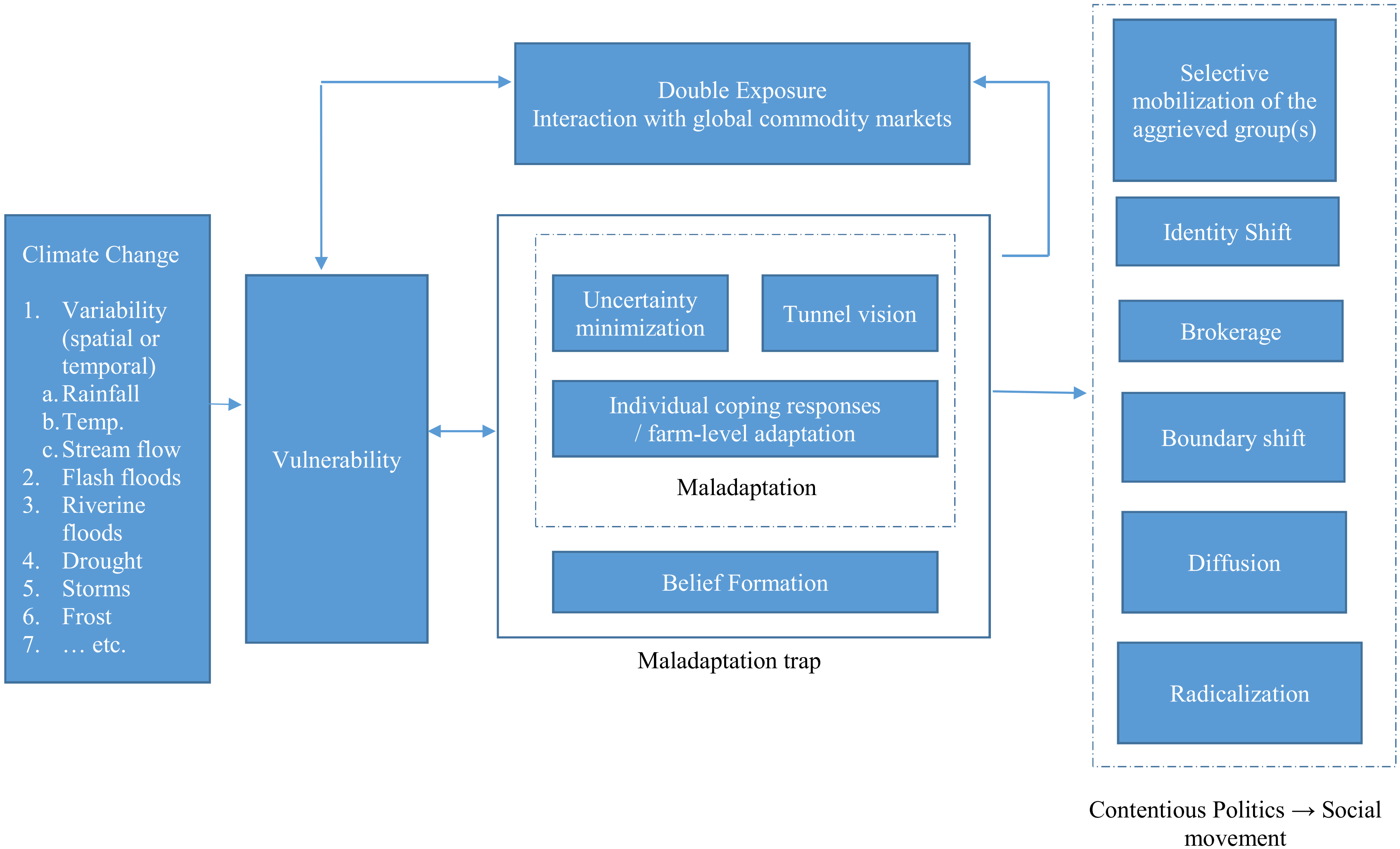


Fig. 3. 5: Mechanism based framework for climate-conflict analysis

Chapter 4: Spatial and temporal variability of climate trends in Pakistan

Abstract

Using the framework proposed in chapter 3, this chapter marshals the evidence of climate change process as it unfolds in Pakistan. Insights from analyzing Pakistan's long-term hydro-meteorological data attest to the claim made earlier that climate change manifests in a varied fashion within and across societies. Also, its interaction with a society's antecedent economic, political, and social processes determines the nature and severity of stresses imposed on that society.

Long-term sub-annual trends of stream-flow of the Indus River and its tributaries show that changes in Pakistan's hydrological system are manifesting at intra-annual level. Similarly, long-term (sub-annual) trends of monthly minimum and maximum temperatures, as well as total monthly rainfall, at three distinct sites, each located in a different agro-ecological zone in the country demonstrate both temporal and spatial variability of climate change in the country.

These climatic stresses are eliciting impromptu responses from Pakistan's farmers, and interacting with the country's political economy, particularly the agro-based industry which was built around stable Indus stream-flows and predictable weather trends. In addition to an incomplete understanding of changing climate trends, the complexity and emergence of climate change is catching local farmers off guard. The

coping strategies employed in response are proving to be shortsighted and add to the burdens imposed by the original stressor.

This chapter is organized as follows: the first section provides a brief summary of the agriculture sector in Pakistan and elaborates its importance in the country's political economy. It also includes a summary of Pakistan's irrigation system development, especially the trans-national and domestic water distribution agreements, Indus Waters Treaty and Water Apportionment Accord of 1991 respectively, that have been instrumental in shaping Pakistan's economy and politics. The purpose behind providing this brief overview is to illustrate how a society's climate as well as its natural resources are important not only for agriculture, but also act as an engine of growth for other sectors of its political economy.

The second section takes stock of changes in spatial and temporal trends in the Indus stream-flows as well as some of the climatic variables in three different parts of the country. Almost eighty percent of Pakistan's cultivated land is irrigated and relies on the Indus waters for its irrigation needs. Based on time series analysis of the Indus stream-flows, this section documents intra-annual variability and change in irrigation water availability and the stresses this change is imposing on vulnerable populations.

In addition to analyzing hydrology, trend analysis of temperature and rainfall variables is performed for three locations in the country. Each of these sites is located in a different agro-ecological zone, and demonstrates spatial and temporal variability in climatic changes in the country.

Brief overview of agriculture and irrigation system development in Pakistan

The agriculture sector has traditionally served as the backbone of Pakistan's economy. Until the 1950s, agriculture generated approximately 55 percent of the nation's GNP and comprised about 80 percent of its workforce (Stern & Falcon, 1970, p. 36). Since then, growth in the agriculture sector has languished, outpaced by progress in manufacturing and service sectors. In fiscal year 2017-2018, the share of agriculture in the national GDP was 18.9 percent, while 81 percent came from industrial and service sectors (Pakistan, 2018).

Despite structural transformation of Pakistan's economy, agriculture still plays an important role in the country's political economy. As compared to the global average of 26 percent, it absorbs 41.3 percent of Pakistan's labor force, or approx. 29 million people, making it the largest sector of employment in the country (Pakistan, 2018).

In addition to it being the source of food security for the country's rapidly growing population (207.7 million according to the 2017 census), agriculture is the centerpiece around which most of Pakistan's agro-based industry and services are built. Farm equipment and fertilizer industries in particular rely on local agriculture sector as their main market. Similarly, manufacturing units responsible for value addition in agricultural products are built around cheaply available local commodities such as cotton, rice, wheat, sugarcane, vegetables, fruits, and leather, etc. Textile manufacturing, for example, the biggest contributor of Pakistan's total industrial GDP, is highly dependent on domestic cotton production. Similarly, foreign exchange earnings are dependent on locally produced commodities. In 2017-2018, textile and related cotton products accounted for about 60 percent of Pakistan's total export earnings (Pakistan, 2018).

As is true elsewhere in the world, the rural economy in Pakistan is not limited to agriculture, although its role remains pivotal. More than 63 percent of Pakistan's population lives in rural areas (*World Urbanization Prospects*, 2018). Those who are not directly involved with agriculture rely on small and medium businesses in the nonfarm rural economy for their livelihoods. In the period from early to mid-2000s, there were roughly 3.8 to 5 million non-farm rural enterprises in Pakistan (World Bank, 2007; Farooq, 2015). These non-farm income sources include a vast array of small businesses such as neighborhood shops selling everyday use items, farm equipment repair shops, wholesale and retail traders, transportation and storage facilities for agricultural products, social and personal services such as schools, dispensaries, etc. As climatic changes impose burdens on agriculture in Pakistan, their effect will not be limited to farmers alone. Climate-induced instability will traverse through the society by way of related non-farm small and medium enterprises as well as large-scale agro-based industrial and services sectors.

Pakistan's Agro-ecological diversity:

Pinckney (1989) divides Pakistan's agricultural land in nine distinct agro-climatic or agro-ecological zones based on spatial and temporal variations in temperature, precipitation, moisture, soil quality, etc. (Table 4.1, 4.2). He observed that it is the bio-physical characteristics of a region, in addition to other factors, that shape land use and agricultural livelihood strategies. In other words, local weather and climate conditions vary from one zone to the next, determining the type of crops to grow and farming techniques to follow. Local small and medium businesses, commodity markets, and agro-based industries are developed around a region's agricultural activity accordingly. In various parts of Pakistan, sugar, rice, and flour mills are conveniently located in areas where related crops are grown.

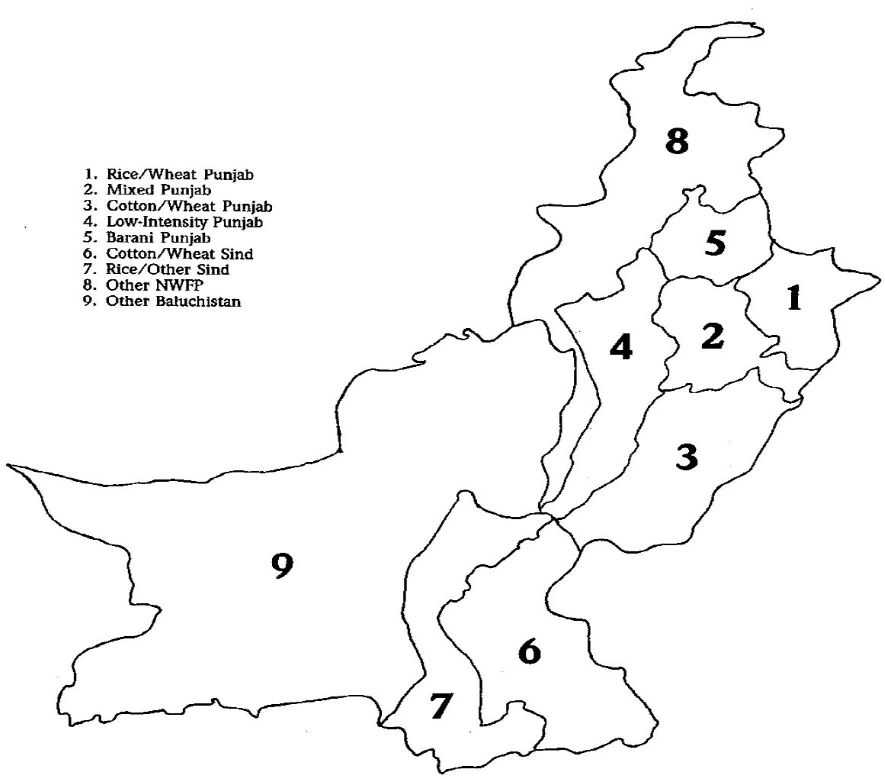


Fig. 4. 1: Agro-ecological zones in Pakistan
Source: Pinckney (1989)

There are two main cultivation seasons in Pakistan. The first is *Rabi* or winter cultivation season, which begins in November and lasts until April. The second is *Kharif* or spring cultivation season, which lasts from April to November. However, since the composition of local weather such as intensity of temperature, precipitation, cloud cover, breeze, degree days, etc. is different from one zone to the next, which crops are grown is highly dependent on a particular zone's specific climate and weather trends. *Barani* (rain-fed) Punjab is a region which relies on rainfall for almost all of its irrigation needs. The Cotton/Wheat belt in Punjab relies on hot and dry summer months, and contributes the largest share in the total cotton produced in the country. The Rice/Wheat belt in Punjab, on the other hand, has sweltering and humid summer months with abundant monsoon rains that make it suitable for rice cultivation. Mixed Punjab is a hub for sugarcane cultivation and produces nearly 30 percent of all sugarcane in the country (Malik et al., 2016). Similarly, Sindh, Khyber-Pakhtunkhwa (KPK), and Balochistan provinces are divided in different agro-ecological zones where different weather and climate trends have shaped agriculture, history and culture accordingly.

Wheat, being the staple food, is grown in almost every part of the country. However, depending on local climate conditions, crop yields vary significantly from one zone to the next (Briscoe & Qamar, 2005).

In recent years, local climate and weather trends in different ecological zones in the country appear to have shifted, or at least become variable. Historically hot and dry summers in Cotton/Wheat Punjab and Sindh appear to be getting cooler, thus adversely affecting the growing time and yield of cotton - the most important cash crop in the country. Similarly, short yet intense winters are reportedly stifling germination of wheat kernels, resulting in either crop failure or shriveling of wheat grains. The shifting of rainfall schedule, as well as intra-annual variability in the amount of precipitation in various parts of the country is also imposing burdens on agricultural production, creating drought-like conditions in some parts of the country while flooding in others.

Agro-ecological zone	Districts
Barani (rainfed) Punjab	Attock, Rawalpindi, Islamabad, Jhelum, Chakwal
Mixed Punjab	Sargodha, Khushab, Faisalabad, Toba Tek Singh, Jhang, Okara
Low-intensity Punjab	Mianwali, Bhakkar, Muzaffar Garh, Layyah, D.G. Khan, Rajanpur
Cotton/wheat Punjab	Sahiwal, Pakpattan, Multan, Lodhran, Khanewal, Vehari, Bahawalpur, Rahimyar, Khan, Bahawalnagar
Rice/wheat Punjab	Gujrat, Mandi Baha-ud-din, Sialkot, Narowal, Gujranwala, Hafizabad, Sheikhupura, NanKana Sahib, Lahore, Kasur
Cotton/wheat Sindh	Khairpur, Ghotki, Sukkur, N. Feroze, Nawabshah, Sanghar, Thar parkar, Mirpur khas, Umarkot
Rice/other Sindh	Jacobabad, Kashmore, Shikarpur, Larkana, K.S.Kot, Dadu, Jamshoro, Hyderabad, Matiari, Tando Allahyar, T.M. Khan, Badin, Thatta, Karachi
Southern KPK	Peshawar, Kohat, Hangu, Karak, D.I. Khan, Tank, Bannu, Lakki Marwat, Mohmand Agency, Northern Waziristan, Southern Waziristan, F.R. Peshawar, F.R. Kohat, F.R. Bannu, F.A. D.I. Khan
Plains/foothills KPK	Charsadda, Nowshera, Mardan, Swabi, Mansehra, Battagram, Abbottabad, Haripur, Kohistan, Malakand, Swat, Bunir, Shangla, Dir Lower, Dir Upper, Chitral, Khyber, Kurram, Orakzai, Bajour
Balochistan	All districts

Table 4. 1: Agro-ecological zones in Pakistan.
Source: Malik et al. (2016)

Zone	Total Area (km^2)	Area in zone (% of total)	Area under cultivation (million ha)	Area cultivated (% of area cultivated)	Rural population (% of total)
Barani Punjab	23,205	3.02	609	3.8	19.8
Rice/wheat Punjab	28,945	3.76	3013	18.8	3.1
Mixed Punjab	34,866	4.53	2213	13.8	7.9
Cotton/wheat Punjab	66,758	8.68	4342	27.1	50.1
Low intensity Punjab	52,890	6.87	1694	10.6	53.5
Cotton/wheat Sindh	79,356	10.31	1284	8.0	75.0
Rice/other Sindh	61,589	8.01	931	5.8	64.2
KPK	77,038	10.01	1351	8.4	71.6
Balochistan	344,712	44.81	611	3.8	93.8

Table 4. 2: Area under cultivation in different agro-ecological zones in Pakistan.
Source: Malik et al. (2016)

In order to demonstrate spatial variability in climatic changes at the sub-national level, this dissertation has randomly selected three agro-ecological zones for which long-term trends of meteorological data are analyzed. The three agro-ecological zones are Rice/Wheat Punjab, Cotton/Wheat Punjab, and Rice/Other Sindh. Since weather and climate trends within an agro-ecological zone are uniform, three meteorological gauging stations (Lahore, Bahawalpur, and Hyderabad), one from each agro-ecological zone, are randomly selected for the analysis. Long-term meteorological data of select climate variables is collected from the Meteorological Department of Pakistan for each of these cities, and trend analysis performed. This analysis is discussed in great length later in this chapter.

Another important aspect in the case of Pakistan is variability and change in climate trends in the Upper Indus Basin, the glaciated region in the Himalayas from where Pakistan's all three rivers originate, and on which the entire agriculture and arguably the entire economy of the country is hinged. As is discussed in the next section, although annual average values of the Indus stream-flows fail to show significant change from one year to the next, intra-annual trends are quite revealing.

Given its importance in Pakistan's political economy, the agriculture sector has always been at the forefront of the country's policymaking agenda. Highly regulated domestic commodity markets, heavily subsidized agricultural inputs, and most importantly abundant and timely availability of irrigation water at prices much below market price have historically protected agriculture from the vagaries of commodity markets and competition from the outside world. Now, as the Indus waters continue to shrink, and costs of agricultural production soar, the entire protective infrastructure appears to be under stress. A brief historical overview is necessary to develop a working familiarity of the structural landscape on which climate change is laying additional burdens.

Indus Waters Treaty and subsequent water management:

The partition of the British India, where on the one hand culminated in the creation of a separate homeland for Muslims in the Indian subcontinent, it put the newly established state of Pakistan at a major disadvantage in terms of access to and control of the vital natural resource of the Indus Waters. The hastily drawn plan of India's partition did not include any arrangement regarding control/usage rights of all the rivers that flowed through the nascent country. In fact, all the rivers flowing through Pakistan had their origins and (or) regulatory infrastructure, such as headworks and barrages, in the upper riparian India and the disputed territory of Kashmir. Tensions between the two nations grew as India questioned Pakistan's right to use the water of the eastern rivers of Ravi and Sutlej, and closed all canals crossing the India-Pakistan border on April 1, 1948, and subsequently in 1952 and 1958 (H.-u.-R. Khan, 1959), triggering international diplomatic efforts to peacefully resolve the issue.

Mediated by the World Bank, the Indus Waters Treaty was signed between the two countries in 1961. The treaty gave full control of three western rivers (Indus, Jhelum, and Chenab) to Pakistan, while India's sovereign rights were accepted on three eastern rivers (Ravi, Sutlej, and Beas).

To make up for the lost waters of the Ravi and Sutlej (India's rivers), massive water management and storage projects were initiated in Pakistan that diverted waters from Indus, Jhelum, and Chenab (Pakistan's rivers) to the plains of Punjab (Fig. 4.2). One of the most consequential effects was the emergence of a political economy which was tightly coupled with, and highly dependent on timely and abundant availability of

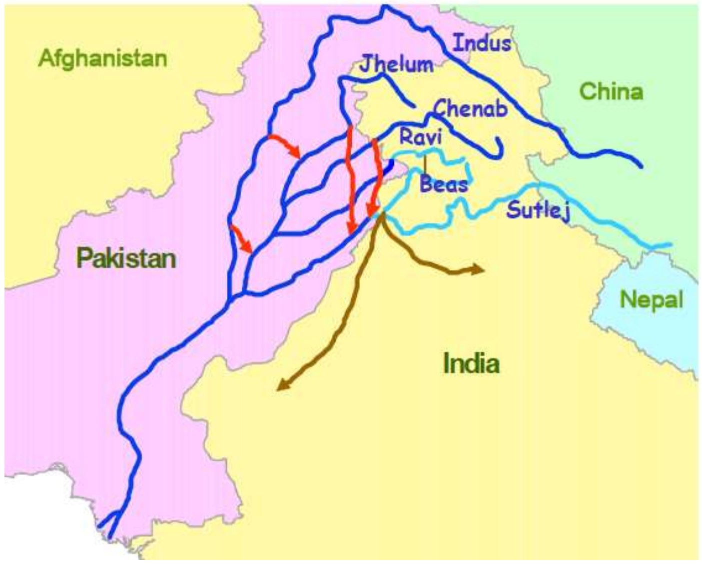


Fig. 4. 2: An illustration of the effects of Indus Waters Treaty on the Indus Basin Irrigation System
Source: Briscoe & Qamar (2005)

waters from the Indus and its tributaries. The vulnerability that was built into the system has recently come to define the domain and range of the impact of the changing climate trends in the Indus Basin.

The Indus Basin Irrigation System – a water management plan in the wake of the Indus Waters Treaty - was developed in consultation with and with financial assistance from the World Bank as well as several friendly European countries. It transformed Pakistan's irrigation and energy systems for decades to come. Massive link canals were built that transferred waters from Indus, Jhelum, and Chenab to those areas in Punjab that were previously dependent on Ravi, Beas, or Sutlej (India's rivers). In addition, new irrigation channels were laid out in previously non-irrigated areas. The effort resulted in developing the world's largest contiguous irrigation system (Fig. 4.3).

Two main storage dams, namely Tarbela and Mangla, were built on the Indus and Jhelum rivers respectively for the purposes of regulating the re-plumbed system as well as to revolutionize Pakistan's energy generation infrastructure. In a case study of Tarbela dam, the largest earth-filled dam in the world at the time of its construction, the World Commission on Dams estimated that water regulated through the dam came to affect the lives of about 40 percent of the country's population (Asmal et al., 2000). In addition to irrigation benefits, electricity produced at Tarbela contributed approximately 30 percent of Pakistan's total installed capacity for energy production (ibid). The effect was not limited to irrigation and power generation alone; it also spurred growth in several other sectors and resulted in an overall economic boom in the country. Briscoe & Qamar (2005) note the forward and backward linkages emanating from development of the Indus Basin Irrigation System.

> The irrigation and hydropower are the "direct benefits", which in turn generate both inter-industry linkage impacts and consumption-induced impacts on the regional and national economy. Water released from a multipurpose dam provides irrigation that results in the increased output of agricultural commodities. Changes in the output of these commodities require inputs from other sectors such as seeds, fertilizers, pumpsets, diesel engines, electric motors, tractors, fuels and electricity.. Furthermore, increased output of some agricultural commodities encourages setting up of food processing (sugar factories, oil mills, rice mills, bakeries) and other industrial units. Similarly, hydropower produced from a multipurpose dam provides electricity for households in urban and rural areas and for increased output of industrial products (including fertilizers, chemicals, machinery). Changes in the output of these industrial commodities require inputs from other sectors such as steel, energy, and chemicals. Thus, both increased output of electricity and irrigation from a dam result in significant backward linkages (i.e., demand for higher input supplies) and forward linkages (i.e., providing inputs for further processing).
> (Briscoe & Qamar, 2005, p. 29)

The gains accrued from the engineering feat were concentrated mostly in Punjab. Its share of the irrigated lands was significantly higher than the other three provinces (table 4.3), and resulted in intensification of agricultural production in the province. Modern varieties of wheat and rice were introduced in Punjab where new wheat varieties were grown on 52 percent of the area under wheat cultivation. Similarly, modern varieties of rice boosted growth and developed interest among farmers to grow rice as a cash crop. Overall, the agricultural sector grew by an average of 6.4 percent per year between 1966 and 1970, and the production of major crops increased by 9 percent per year (Spielman, Malik, Dorosh, & Ahmad, 2016b). Abundant water allowed expansion in cultivating water-intensive crops as major exportable commodities. Three of the most water-intensive crops, namely rice, cotton, and sugarcane soon developed a stronghold in the country's economy. Rice cultivation grew from 1.2 million hectares in 1961 to 2.9 million hectares in 2014. Area under cotton cultivation grew from 1.24 million hectares in 1947 to 2.9 million hectares in 2014 (USDA, 2019). In an attempt to modernize the economy, the government offered major incentives to attract investment in textile sector. The number of textile mills grew from 3 in 1947 to 600 in 2000 (A. A. Khan & Khan, 2010), while that of sugar mills grew from 2 in 1947 to 90 in 2014. Subsidies, soft loans, and protectionist policies led to the growth of local industries in fertilizer, farm equipment, as well as food processing units, etc.

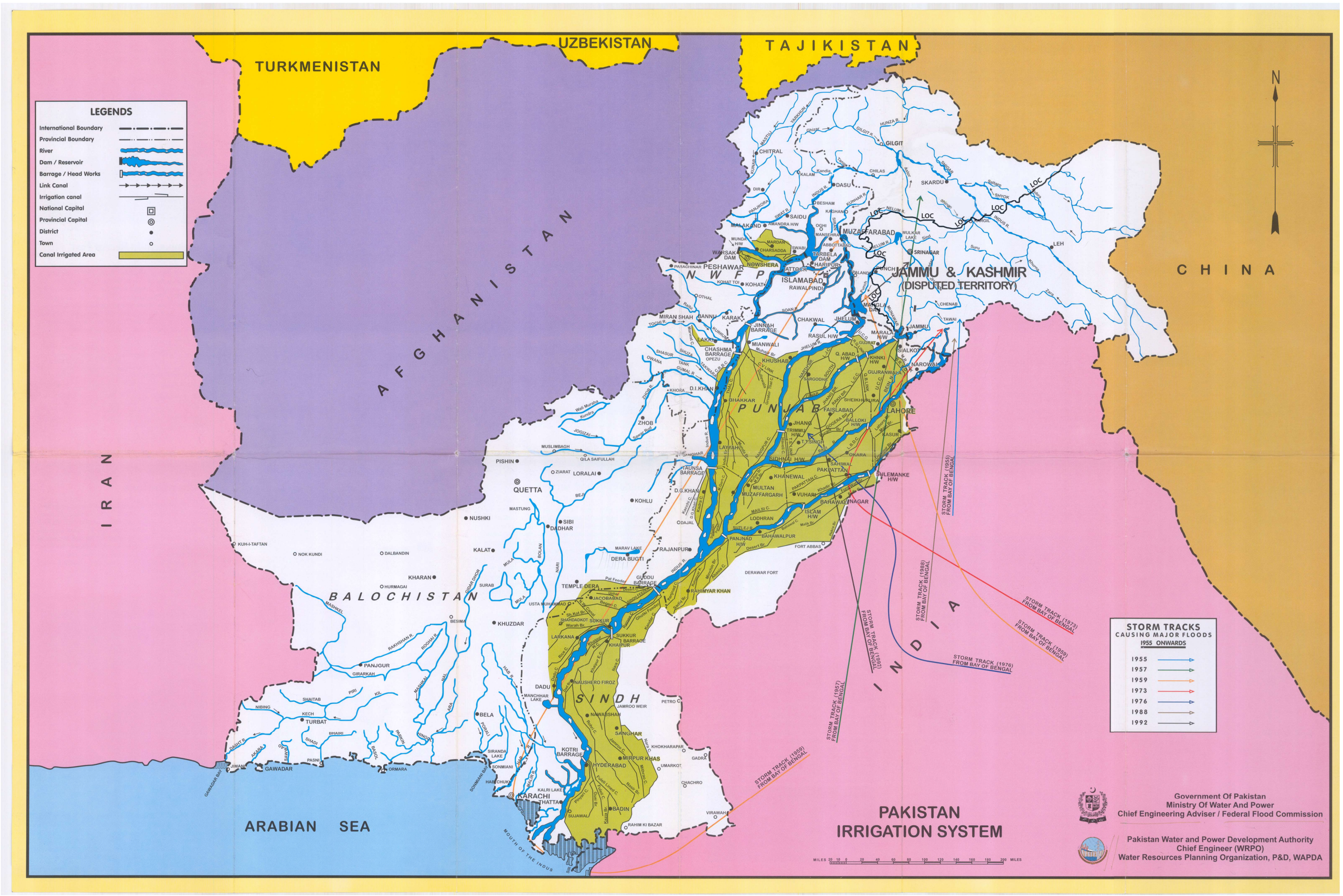


Fig. 4. 3: Irrigation system of Pakistan
(Source: Water and Power Development Authority of Pakistan)

Cultivated area, by irrigation type	Punjab	Sindh	KPK	Balochistan	Total
Total cultivated area (thousand acres)	27,034.0	7,643.5	4,453.1	3,491.9	42,622.5
Rainfed (%)	17.6	6.6	41 .8	37.0	19.7
Irrigated (%)	82.4	93.1	57.4	62.2	80.0
Area with irrigation facilities					
Canal and tube-well (%)	58.2	10.3	4.9	3.5	40.7
Canal only (%)	18.9	86.2	52.0	30.1	36.1
Tube-well only (%)	22.0	1.7	11.8	35.4	17.8
Other (%)	0.2	0.2	16.4	5.6	1.8
Not irrigated (%)	0.6	0.5	13.7	18.2	2.7

Table 4. 3: Cultivated area by water source and irrigation type, 2010

Source: Malik et al. (2016)

Water apportionment accord of 1991:

Climatic changes in the Indus Basin cannot be seen in isolation from the inter-provincial politics around distribution of water between upper and lower riparian populations in Pakistan. Such conflicts date back at least a hundred years. In 1920, before the partition of the Indian subcontinent, a dispute over the use of Indus waters arose between the states of Punjab, Bahawalpur, and Bikaner. The government of British India intervened and persuaded all three states to sign a compromise pact called Sutlej Valley Tripartite Agreement. In 1939, a similar complaint was lodged by the government of Sindh against Punjab for building irrigation infrastructure over the river Indus. Sindh, the original seat of the ancient Indus Valley civilization, claimed exclusive rights over the Indus due to historical importance for its autochthonous culture and society, and requested that upper-riparian Punjab be barred from “stealing” its water. A three-member commission, called Rao Commission, passed a verdict in favor of Sindh and awarded it exclusive rights over the river Indus. Punjab was allowed to use the Indus waters only after Sindh had met its water needs.

After the creation of Pakistan, and especially under the threat of India cutting off Pakistan’s water supply, the issue of water was elevated to a national security concern, thereby superseding any and all inter-provincial feuds surrounding the subject. The Indus Waters Treaty and subsequent development of the Indus Basin Irrigation System set aside all preexisting agreements between the two provinces while laying out a network of link canals, dams, barrages, distributaries, siphons, headworks, etc., thus transferring a large portion of the Indus waters to fertile alluvial soils of Punjab.

Until 1991, as Punjab continued to reap dividends from the Green Revolution, water allocation among the provinces was carried out in an ad hoc manner. In 1991, a committee of chief ministers of all four provinces of the country agreed on a water-sharing formula, which would grandfather preexisting allocation, and equitably distribute surpluses and flood discharges among provinces. Total water allocations amounted to

Province	Kharif (MAF)	Rabi (MAF)	Total (MAF)
Punjab	37.07	18.87	55.94
Sindh	33.94	14.82	48.76
Khyber-Pakhtunkhwa	3.48 + 1.80	2.3 + 1.2	5.78 + 3.00
Balochistan	2.85	1.02	3.87
Total	**77.34** +1.80	**37.01** + 1.2	**114.35** + 3.0

Table 4. 4: Water Apportionment Accord of 1991

114.35 Million Acre Foot (MAF) [10] each year. Table 4.4 shows inter-provincial distribution as per the accord. The balance river supplies, including flood waters and future storage, were to be distributed as follows: a) Punjab and Sindh, each 37 percent; b) Khyber- Pakhtunkhwa 14 percent; c) Balochistan 12 percent. A minimum of 10 MAF was mandated to escape to the Arabian sea to keep seawater from intruding inward into the Indus Delta.

The accord, the only piece of legislation related to water allocation among the provinces, was vague at best in terms of sharing losses, especially if the Indus flows fell below 114.35 MAF. Also, the water-sharing formula dealt primarily in total annual values, and did not consider the possibility of intra-annual and intra-seasonal variability in the Indus stream-flows.

---

[10] Million Acre Foot is a unit of volume commonly used to measure large-scale water resources such as river flows, reservoirs, canals, etc.

In recent years, as intra-annual variability of stream-flows has increased, provinces, especially lower riparian populations have blamed upper riparian Punjab for not sharing the losses. Even within Punjab, populations from the southern part of the province have voiced their concerns for not getting their fair share of irrigation water. The effect of the reduced Indus flows is particularly high in Sindh where, in addition to shortage of water for irrigation purposes, sea intrusion has led to rapid deterioration of the Indus Delta. Once ranked sixth largest in the world, Sindh's mangrove forests shrank from 260,000 hectares in 1980s to 80,000 hectares in 2002 (Kumar & Wood, 2010).

Vulnerability built into the system:

The period after the development of the Indus Basin Irrigation System was hailed as the golden period of Pakistan's agricultural and industrial growth. However, in hindsight, one cannot ignore the vulnerability that was built into the system from the beginning. The plan to develop the "whole Indus Basin as a unit" (H.-u.-R. Khan, 1959, p. 329) was based on the assumption of dependable and virtually everlasting flows of the Indus waters, without any attention paid to the possibility of shrinkage or temporal (intra-annual) variability in stream-flows. In recent years, as flows in the Indus basin have receded, the country's energy generation system has taken a big hit. Moreover, intra-annual variability in recent years, particularly during the sweltering summer months, has resulted in the government making a tough choice of using the Indus waters for irrigation instead of power generation. Since river flows are too weak in times of scarcity for turbines to generate electricity, and irrigation needs are time-sensitive, the rule-curve for the country's two dams favors releasing water for irrigation over power generation.

The trade-off has resulted in an acute shortage of electricity in the country. In recent years, shrinkage in the Indus flows during times of peak demand has led to power outages of up to 20 hours per day in most parts of the country. Riots have broken out in cities, factory towns, as well as in rural areas. Tens of thousands of industrial units have either shut down or relocated to other countries such as Bangladesh, Sri Lanka, etc.

The preferential treatment of agriculture over power generation has not benefitted all farmers either. Preexisting inequities in the society have translated into inequitable distribution of stress among farmers. As flows in the Indus rivers have shrunk, cheaper surface water is used up by influential farmers in the upper riparian central Punjab. Lower riparian populations, particularly small farmers in the southern Punjab and Sindh have resorted to dipping into the aquifer to meet their irrigation and everyday needs. In the absence of electricity, tube-wells to pump underground water are operated using diesel engines, an additional cost for already cash-strapped farmers. As underground water table sinks to new lows, the cost of harvesting water has been steadily rising, thereby increasing the overall cost of production of agriculture in the country.

One of the goals of this chapter is to call into question the overly simplistic scarcity argument, and to highlight that the connection between climate change and social and political is not as straightforward as it may seem. It meanders through and interacts with a society's preexisting political economy, culture and history, as well as the politics surrounding the use and distribution of renewable natural resources. This does not mean that the role of climate change is supplemental or secondary. To the contrary, the evidence presented in this chapter is in line with the argument that climate change not only exacerbates the preexisting stresses, but also interacts with a society's processes to impose burdens that did not exist before.

Changes in Pakistan's weather patterns as well as stream-flows are imposing severe burdens on vulnerable populations in particular, and the entire political economy in general. The next section documents changes in the spatial and temporal trends of key climate variables, and Indus stream-flows.

Climate change in Pakistan

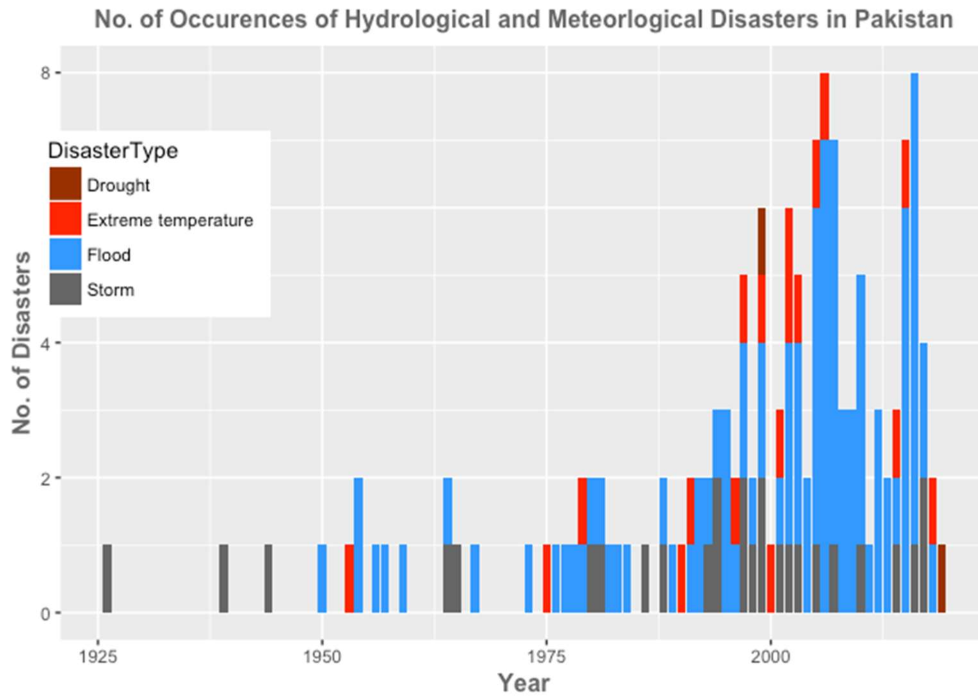
With an overview of Pakistan's agro-ecological as well as irrigation systems in the backdrop, analysis of spatial and temporal trends in Pakistan's hydrology and climate are presented in this section, and constitute the first component of the framework proposed in chapter 3. Just like elsewhere in the world, extreme climate events in Pakistan are increasing in frequency and intensity (Fig. 4.4). Flash floods, droughts, heat waves, cold snaps, storms, etc. have become the new normal. However, extreme climate events explain only a part of the story. An equally important part has to do with less dramatic and arguably more destructive aspect of climate change - spatial and temporal variability in long-term climate trends at sub-annual and sub-seasonal levels.

Three notable insights are developed from time-series analysis of Pakistan's hydro-meteorological data presented in this section:

1: Long-term trends of the Indus stream-flows are exhibiting more intra-annual variability than inter-annual variability, although the overall discharge has a downward trend in recent years. Stream-flows in summer months have particularly reduced in volume since the early 1990s, with slight increase in discharge during the winter months. However, since most stream-flow in the Indus Basin takes place during summer season, the overall trend is still negative. Moreover, it is the peak summer months when demand for the Indus waters is the highest for both irrigation as well as hydro-electric power generation. Downward trend of stream-flows in these months has implications for both.

2: Long-term intra-annual trends of meteorological variables show a significant warming in winter months, and cooling in summer. Similarly, minimum and maximum temperatures show higher temperatures beginning much earlier in the year, and point to longer summer season, and significantly shorter winters. Rainfall has become erratic, with its schedule having shifted in some parts of the country by as much as two months.

3: In addition to temporal variability and change, meteorological trends are changing spatially as well. Previously hot and dry regions have become wetter and relatively cooler during the summers. Temporal and spatial variability and change in meteorological trends is resulting in reduced crop yields and even crop failures, thereby disrupting crop patterns as well as local political economies that rely on them.



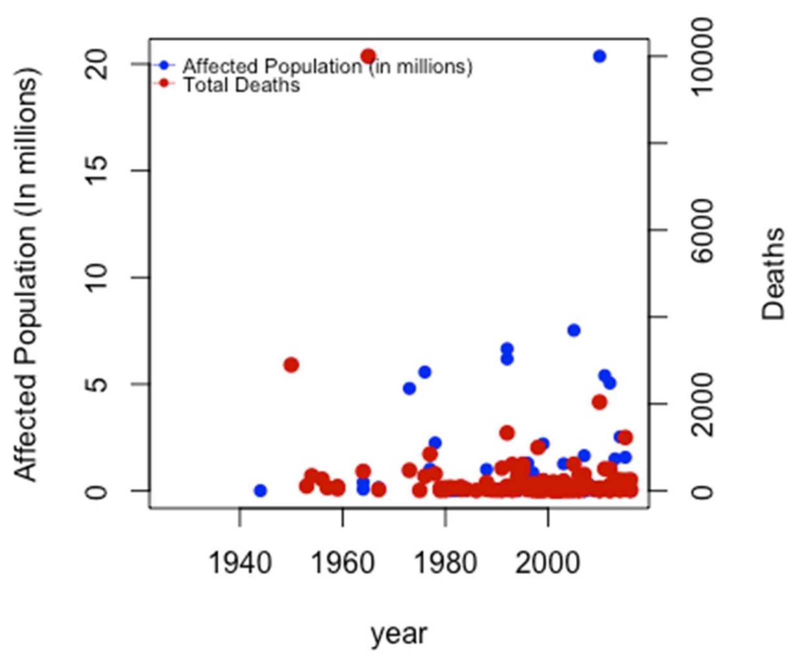


Fig. 4. 4: Extreme climate events in Pakistan over the years

Data source: EMDAT

Data:

Hydro-meteorological analysis conducted in this study is based on two important sources of data:

1: Long-term time series data of the Indus river and two of its tributaries, Chenab and Jhelum, are used to analyze temporal changes in the Indus basin stream-flows for the time period 1922-2011. These data are obtained from National Engineering Services of Pakistan (NESPAK), for rivers Indus, Jhelum, and Chenab at points of entry (rim stations) into Pakistan's elaborate irrigation system. The rationale behind measuring stream-flow at rim stations is to detect variability and change in stream-flows, likely due to the changes in climate conditions in the Upper Indus Basin, before any human manipulation, e.g. diverting waters to link canals, reservoirs, etc., has taken place.

Novelty of the Indus stream-flows dataset:

One of the novelties of this dissertation is the high-resolution Indus stream-flow data used in this research. To the best of my knowledge, the Indus stream-flow measurements recorded at the level of granularity of ten-daily values measured at rim stations of Pakistan's hydrological system have not been used in other studies conducted on the topic.

2: Monthly mean maximum and minimum temperatures, and total monthly precipitation, for three meteorological gauging stations namely Lahore, Bahawalpur, and Hyderabad are used to analyze the changing meteorological trends. These gauging stations are located in three distinct agro-ecological zones, namely, Rice/Wheat Punjab, Cotton/Wheat Punjab, and Rice/Other Sindh, respectively. The data are obtained from the Meteorological Department of Pakistan.

Rationale for the selection of the gauging stations:

As previously mentioned, the meteorological gauging stations are randomly selected from three randomly chosen agro-ecological zones. Also, these meteorological stations are linked to the field research sites (discussed in chapter 5) where farmers' interviews were conducted. The rationale behind doing so was to place observed climate trends side by side with farmers' perceptions as well as coping responses. This way, similarities/contrasts in coping strategies employed by vulnerable populations may be revealed. It may also reveal spatial variability of climate change at sub-national level.

Methods:

Non-parametric tests are more often used in trend analysis because of their suitability for non-normally distributed data, and for allowing missing values – both problems inherent in hydro-meteorological data. In order to identify an overall trend, Mann-Kendall test is used. It is one of the most used non-parametric tests, and provides a long-term monotonic trend, as well as the slope of that trend (Sen, 1968). Correction is applied based on Yue et al. (2002) that provides trend-free pre-whitening (TFPW) for cases when both trend and lag-1 autoregressive AR(1) processes exist in time series. P-values to check for significant change in trend are calculated at 1, 5, and 10% significance levels.

Robson et al. (2000) argue that without proper exploratory data analysis, trend results alone may not be enough to reveal existence of sub-trends in a time series. Therefore, in addition to Mann-Kendall tests, decadal variability plots, and anomaly plots of stream-flows and meteorological variables are generated to identify sub-trends.

Field interviews revealed that variability in the stream-flow and weather patterns is manifesting at intra-annual levels. That is, the overall amount of rainfall in any given year may not be too different from the long-term annual average, but its pattern seems to have shifted within a given year. For example, farmers in Sindh and Punjab reported that sowing patterns for almost all crops have been pushed forward by at least two months because of change in the schedule of rains. Similarly, record rainfall has been reported in the past several years, caused by downpour of a season's worth of rain falling in just a few hours (days), resulting in flash floods.

Therefore, instead of looking for variability in the annual averages of stream-flow and meteorological variables, trends have been calculated for time series of individual calendar months, i.e. variation in the records of January for the entire time-period (1922-2011), and so on.

Given that Indus stream-flows are integral to Pakistan's economy (and political stability), it is important to briefly describe the hydrological regime in the Upper Indus Basin (UIB) from where Indus river and its tributaries (Chenab and Jhelum) originate, and where climatic changes are reportedly resulting in variability and change in the stream-flows.

Hydrology, and the changing climate trends in the Upper Indus basin (UIB):

Extant literature on climate change in the Indus basin is scarce. This may be, at least in part, due to lack of data collection resources, remote location, and complex terrain of the Himalayan and Karakoram glaciers which constrained government agencies from installing, gauging stations at high altitudes. There are only five hydrometric stations installed to measure climate data of 11,000 glaciers and perennial snow fields spanning an area of 160,000 km^2 (Siddique & Hashmi, 2012). There are less than twenty manual climate stations (Archer, Forsythe, Fowler, & Shah, 2010) before the main stem of Indus river enters Tarbela dam – Pakistan's first major rim station at the mouth of the Indus Basin Irrigation System (IBIS). Moreover, the fact that the Himalayan glaciers are spread across four countries (China, India, Pakistan, and Afghanistan), two of whom have been at a border standoff for over thirty years over the control of Siachen glacier in the Karakoram range, may be another reason for difficulties in gaining access to the glaciated region for scientific analysis.

In addition to the above-mentioned problems of data availability, complex behavior of the UIB glaciers poses challenges to developing a clear understanding of climatic changes in the region. Archer (2003) divides hydrology of the UIB in three distinct parts, each of which exhibits different behavior under changing weather conditions. The three hydrological regimes are as follows:

1) Glacial regime, or high-altitude catchment, is composed primarily of glaciated regions of the Karakoram. Melting of these glaciers during summer contributes to runoff in the Indus rivers. Of the total runoff generated in the UIB, approx. 18

percent (19.6 MAF) is generated by the ice-melt in the glacial regime (Yu, Yang, Savitsky, Brown, & Alford, 2013, p. 71).

2) Nival regime, or middle altitude catchments (such as Rivers Astore and Kunhar), depend on precipitation in the preceding winter for their summer runoff. Snowmelt in this regime contributes up to 82 percent (79 MAF) of total water generated in the UIB catchment (Fowler & Archer, 2005).
3) Rainfall regime, or foothill catchments such as Khan Khwar, is controlled mainly by liquid precipitation during winter as well as monsoon. The contribution of water generated in this regime is much smaller in comparison to that generated in the above two regimes. Immerzeel et al. (2010) show that contribution of snowmelt and glacier runoff is 151 percent of the total discharge naturally generated in the downstream areas.

Based on mass balance data at lower elevations, simulations, as well as satellite imagery, there is a growing consensus among scholars on the anomalous behavior of the Karakoram glaciers, i.e. less ablation or even accretion at higher altitudes (glacial regime) resulting in reduced runoff in the Indus Basin catchment (Bolch et al., 2012; Gardelle, Berthier, & Arnaud, 2012; Kenneth Hewitt, 2005; Kapnick, Delworth, Ashfaq, Malyshev, & Milly, 2014). Seasonal and annual trends of temperature data in the UIB show a significant increase in winter's mean and maximum temperatures, along with a decrease in summer's mean and minimum temperatures (Fowler & Archer, 2005; Siddique & Hashmi, 2012). Reduced glacial melting is attributed to the falling trend in summer temperatures at the higher altitudes (D. Archer & H. J. Fowler, 2004; Sharif et al., 2013), which in turn is resulting in reduced stream-flows in the Indus Basin rivers.

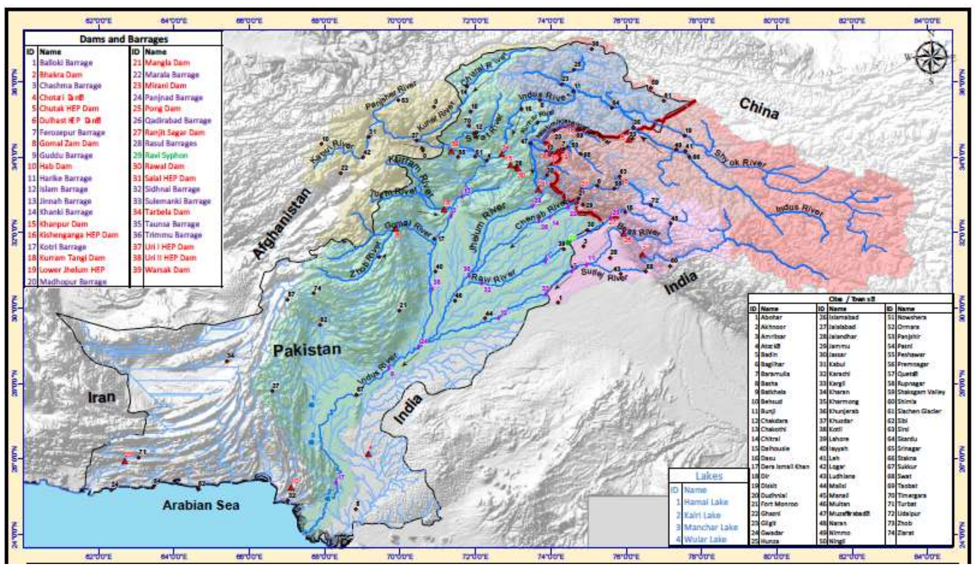


Fig. 4. 5: Hydrological basin of Indus system of rivers
(Source: NESPAK)

River Indus:

The Indus River is the main stem of the Indus Basin rivers, and has its headwater tributaries spread out in China, India, Pakistan, and Afghanistan. It originates from snow and glacier fields of Himalaya-Karakoram-Hindukush region and enters northern Pakistan through Gilgit-Baltistan region. With most part of its catchment "thrust up in the middle troposphere", the altitudes of mountains and glaciers that feed the Indus basin catchment range from 1000-8000m (Yu et al., 2013, p. 60). In fact, more than 40 percent of the basin is located at the elevation higher than 2000m above sea level (Laghari, Vanham, & Rauch, 2012, p. 1064). Before it takes the form of a large river and enters Pakistan, Indus is joined by several small tributaries originating from the Shyok, Shiger, Hunza, and Gilgit basins, as well as the Astore River. By the time it reaches the Tarbela reservoir in Pakistan, the Indus river has reached an average stream-flow (1976-2009) of 60.85 MAF, of which approx. 85 percent is glacier and snow melt (Siddique & Hashmi, 2012).

River Jhelum:

Jhelum, the second major river of the Indus system of rivers, originates in the slopes of Himalaya and parts of Pir Panjal range in Jammu & Kashmir (Archer & Fowler, 2008). Joined by its major tributaries of Kunhar and Neelum, river Jhelum is fed by glacier melt and snow precipitation. It enters Pakistan at Mirpur district in the Pakistan-controlled Kashmir, where a large reservoir, Mangla Dam, is built.

River Chenab:

Another of Indus's major tributaries, Chenab, rises in the mountains of Himachal

Pardesh in India, and drains through the India-controlled part of Kashmir, covering a catchment area of 22,200 km^2, before it enters Pakistan at Marala Headworks near the city of Sialkot (P. Singh, Jain, & Kumar, 1997).

Both, Jhelum and Chenab drain through the plains of Punjab before merging into the main stem, Indus, at Mithankot, and finally fall into the Arabian Sea at the port city of Karachi.

River stations	Time period	Average Annual flows	Ice and snow contribution
River Indus at Tarbela	1961-2011	60.82 MAF	85%
River Chenab at Marala	1922-2011	25.48 MAF	50%
River Jhelum at Mangla	1922-2011	22.64 MAF	65%
River Indus at Kalabagh	1922-2011	89.47 MAF	

Table 4. 5: Indus River and its tributaries

Descriptive statistics of Indus and its tributaries:

Monthly box plots of stream-flows (Fig. 4.6) show that median stream-flow is the highest in July in all three rivers. All the Indus rivers show a strong seasonal pattern.

Histograms of the stream-flow records (Fig. 4.7) show that the Indus stream-flows at Tarbela vary between 45MAF and 80MAF, while Chenab and Jhelum vary between 10MAF and 35MAF. Despite this wide range of variability over the years, in general the

River	*CV (percentage)*	*Source*
Indus	13	This study
Chenab	16	This study
Jhelum	19	This study
Amazon	27	Villar et al. (2009)
Congo	0.3	Global Runoff Data Center (GRDC)
Ganges	27	Mirza et al. (2001)
Mississippi	21	GRDC
Yellow	26	Miao and Ni (2009)
World average	49	Dettinger and Diaz (2000)

Table 4. 6: Coefficient of variation of major world rivers

Source: Adapted from (Yu et al., 2013)

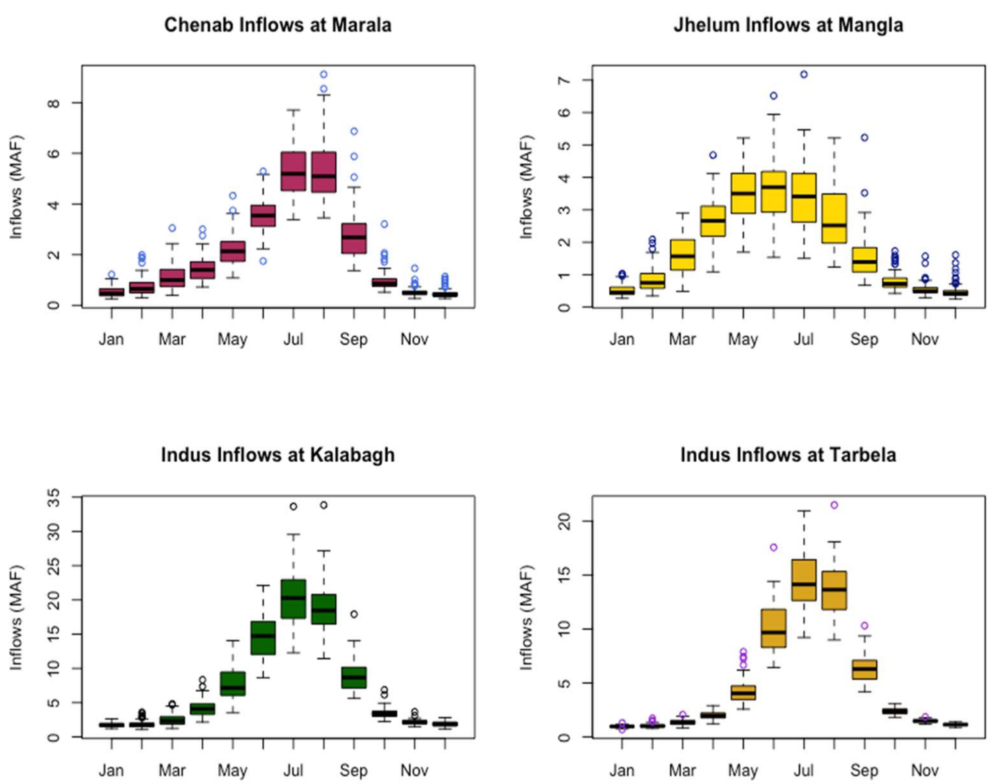


Fig. 4. 6: Monthly box-plots for stream-flows

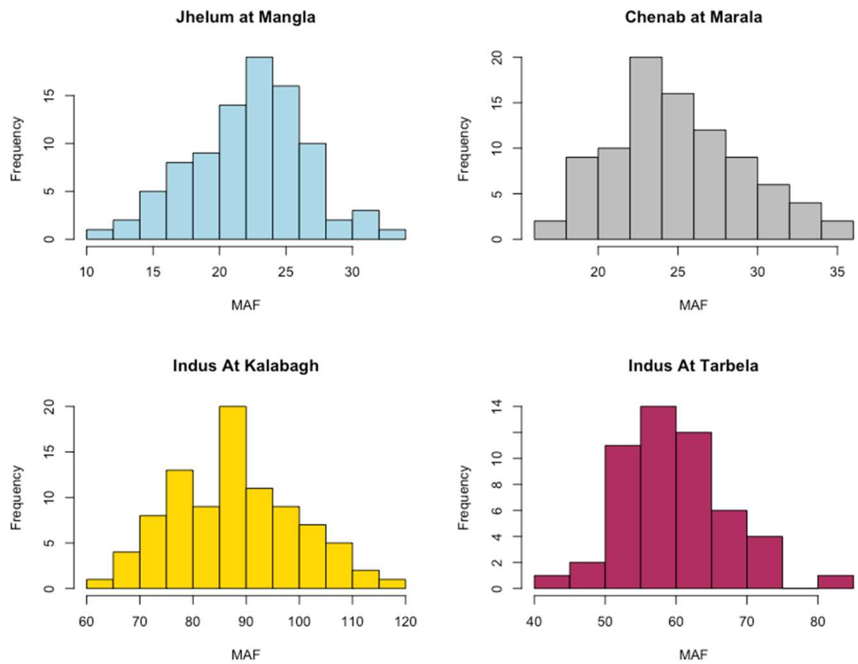


Fig. 4. 7: Histogram of annual Indus, Jhelum, and Chenab inflows

Indus Basin Rivers exhibit relative stability. Table 4.6 lists coefficient of variation of inter-annual flows of various major rivers in the world. The global average for coefficient of variation of inter-annual stream-flows is 49 (Dettinger & Diaz, 2000), as compared to 13 for Indus, 19 for Jhelum, and 16 for Chenab.

Annual long-term trend:

Annual historical stream-flows in the Indus and its tributaries are shown in figure 4.8. The flows show a falling trend in all three rivers in the recent past, especially since 1990. In the case of Chenab at Marala, and Indus at Kalabagh, falling stream-flows seem to be part of a larger trend that may or may not repeat itself. In the case of Jhelum,

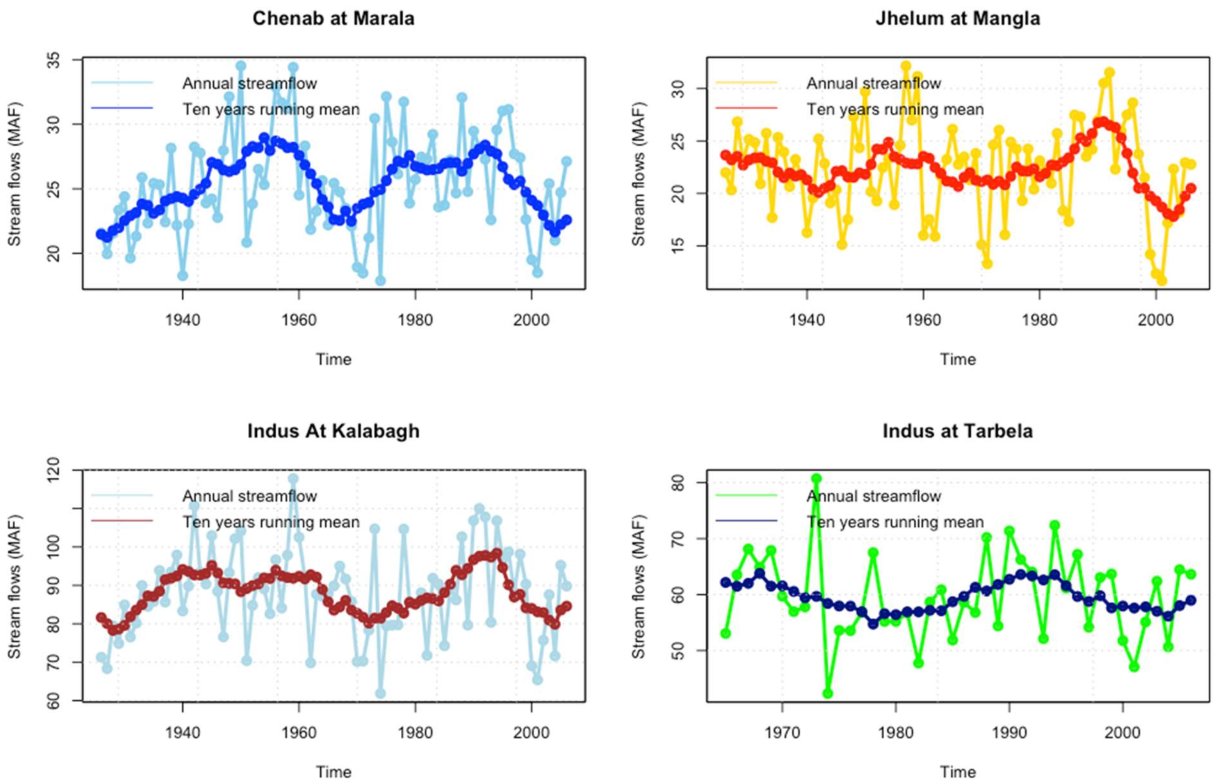


Fig. 4. 8: Annual historical stream-flows

however, the shrinkage of stream-flows seems to be unprecedented, at least for the time-period available for this study. Fowler & Archer (2006) report shrinkage in stream-flows in the high altitude basins in the Glacial regime - a finding reported in other studies as well (Khattak et al., 2011; Sharif et al., 2013).

Sub-annual trends in the Indus stream-flows

As mentioned earlier, trend analysis of annual average values of climate variables has limited explanatory power when it comes to analyzing the effects of climate change.

From the downstream populations' point-of-view, two seasons, summer and winter, are the most important with respect to the Indus stream-flows. The need for water is the highest for both irrigation and hydroelectric power generation in the summer months. This is the time when important cash crops such as cotton, rice, and sugarcane are being sowed. Shortage of water at this time would mean weaker saplings, and would result in additional expenses on underground-water extraction, as well as use of fertilizers. Simultaneously, competing demand of water for hydroelectric power generation also reaches to a maximum at this time of the year due to high temperatures throughout the country.

The second season important for irrigation water availability is winter. This is when the most important staple crop, wheat, is in its germination phase. As temperatures drop in winter, the crop needs water to avoid frostbite and shriveling of wheat kernel.

In what follows, sub-annual trends are calculated to see if there are any short or long-term changes in stream-flows at the intra-annual and intra-seasonal level.

Mann-Kendall Test (MK) results for stream-flows in Indus Basin Rivers:

Mann-Kendall test is used to detect presence or absence of monotonic trends in time series data. In light of importance of sub-annual trends in this research, this test is applied to long-term stream-flow records of individual months to check for variability and change at intra-annual and intra-seasonal levels. The null hypothesis, H_0, is that there is no upward or downward trend in time series of stream-flow in individual months. The alternative hypothesis, H_a, detects the presence of a monotonic trend. Positive or negative signs in z-value and Sen's slope show, respectively, whether a detected trend is upward or downward.

River	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Indus at Kalabagh	**3.385** (0.001)	**2.513** (0.012)	**2.366** (0.018)	0.157 (0.875)	0.568 (0.570)	**-2.192** (0.028)	-0.983 (0.326)	-0.443 (0.658)	0.613 (0.540)	**3.575** (0.000)	**1.956** (0.050)	**4.796** (0.000)
Indus at Tarbela	**1.789** (0.074)	**3.070** (0.002)	**2.737** (0.006)	1.283 (0.199)	**4.248** (0.000)	-1.048 (0.295)	-1.543 (0.123)	**-1.803** (0.071)	-0.374 (0.709)	1.064 (0.287)	**3.404** (0.001)	**3.161** (0.002)
Chenab at Marala	**2.391** (0.017)	**2.067** (0.039)	1.624 (0.104)	**2.059** (0.039)	**1.752** (0.080)	0.035 (0.972)	-0.677 (0.499)	-0.597 (0.550)	0.059 (0.953)	1.298 (0.194)	**2.559** (0.010)	**2.000** (0.045)
Jhelum at Mangla	1.011 (0.312)	**3.949** (0.000)	**1.823** (0.068)	1.328 (0.184)	0.160 (0.873)	**-2.387** (0.017)	**-1.807** (0.071)	**-2.224** (0.026)	**-1.787** (0.074)	-0.457 (0.648)	1.031 (0.302)	1.058 (0.290)

Table 4. 7: Mann-Kendall results for monthly stream-flows of Indus at its tributaries

Table 4.7 shows Z-statistic and p-values for monthly time series of stream-flows of the selected gauging stations using the modified MK test. Bold values are significant at up to 10 percent level (up to 90% CI).

Summer:

Mann-Kendall values for summer and monsoon months (Jun., Jul., Aug., Sep.), the time when most of the flow takes place in the Indus Basin, show a negative trend for two of the three rivers. Negative values for Z-score and Sen's slopes for the three rivers are found for Indus at Kalabagh in June (2% significance), Indus at Tarbela in August (7% significance), and Jhelum at Mangla in June, July, August, and September (2%, 7%, 3%, and 7% respectively). Mann-Kendall values for Chenab at Marala show absence of any downward trend in the data.

Winter:

Rising trend in stream-flows in winter season (Oct, Nov, Dec, Jan, Feb, and Mar), although statistically significant, is not as important hydrologically as only a small fraction of the total stream-flow takes place in those months. However, this rising trend does point to the changing climate conditions on the upstream. Fowler & Archer (2006), in their study of the temperature patterns in seven valley floor meteorological gauging stations in the UIB, report that winter mean and maximum temperatures are rising in the UIB. Increase in stream-flows in those months may be a result of the warming winter at the lower altitudes in UIB.

Decadal, and stream-flow anomalies plots:

As mentioned earlier, Mann-Kendall tests identify only monotonic trends, i.e. a trend is detected only if the combined slope of sub-trends is different from zero. Opposite sub-trends may cancel each other out, reporting no trend in a time series. To account for this, anomaly plots and decadal variability plots are generated and produced below. Decadal variability plots are ten-year moving averages of stream-flows in individual months. For anomaly plots, individual data points are subtracted from their respective long-term averages (1961-1990), and the difference plotted with reference to a straight horizontal line depicting the long-term average.

Decadal variability plots in all three rivers show a declining trend in the summer months, while a rising trend in winter and spring (Fig. 4.9). However, the volume of stream-flows is much larger in the summer, so an overall decline in stream-flows is observed.

Figures 4.10 shows stream-flow anomalies (blue dots) for each month, with their respective long-term mean (1961-1990) taken as a reference point. The red dotted line is the 5-years moving average of anomalies, and shows the general trend anomalies have followed over the years.

What follows is an explanation of trends and sub-trends observed in different seasons in all three rivers, and what they mean for populations depending on them.

Summer (JJAS):

The most important and hydrologically significant trend in terms of volume is a consistent decline in stream-flows in the summer months of June, July, August, and September (JJAS). The main stem of Indus at both Kalabagh and Tarbela shows a decline in stream-flow, especially after 1990. Being mean-reverting in nature, although the stream-flows have meandered above and below the long-term mean line, there is a consistent downward trend since 1990.

Declining trends in Chenab and Jhelum stream-flows are seemingly more drastic. Before 1990, stream-flows in both catchments appear to have stayed stable around their respective long-term means, but recent decades show a more precipitous decline in stream-flows in the two rivers.

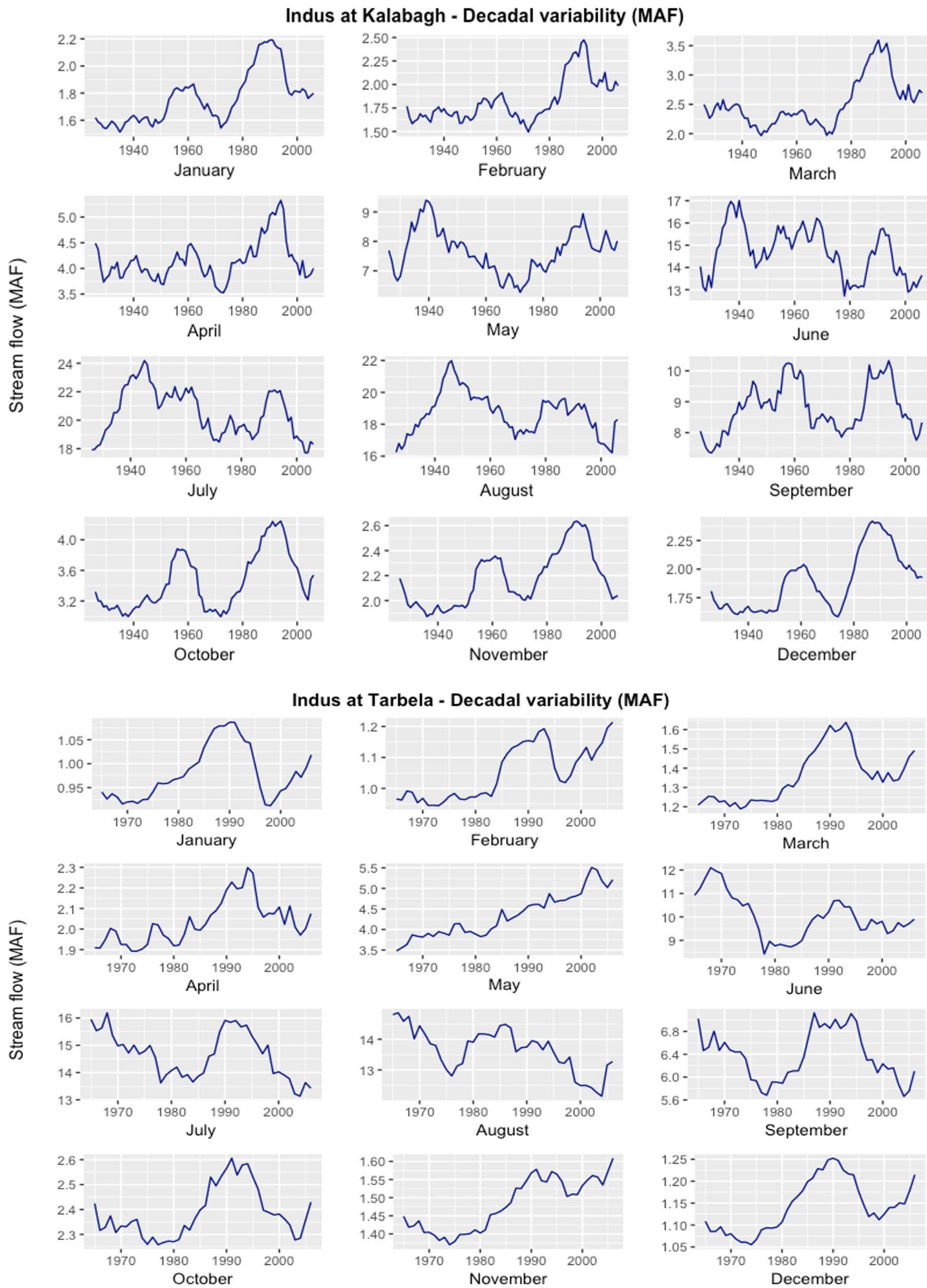
Spring (MAM):

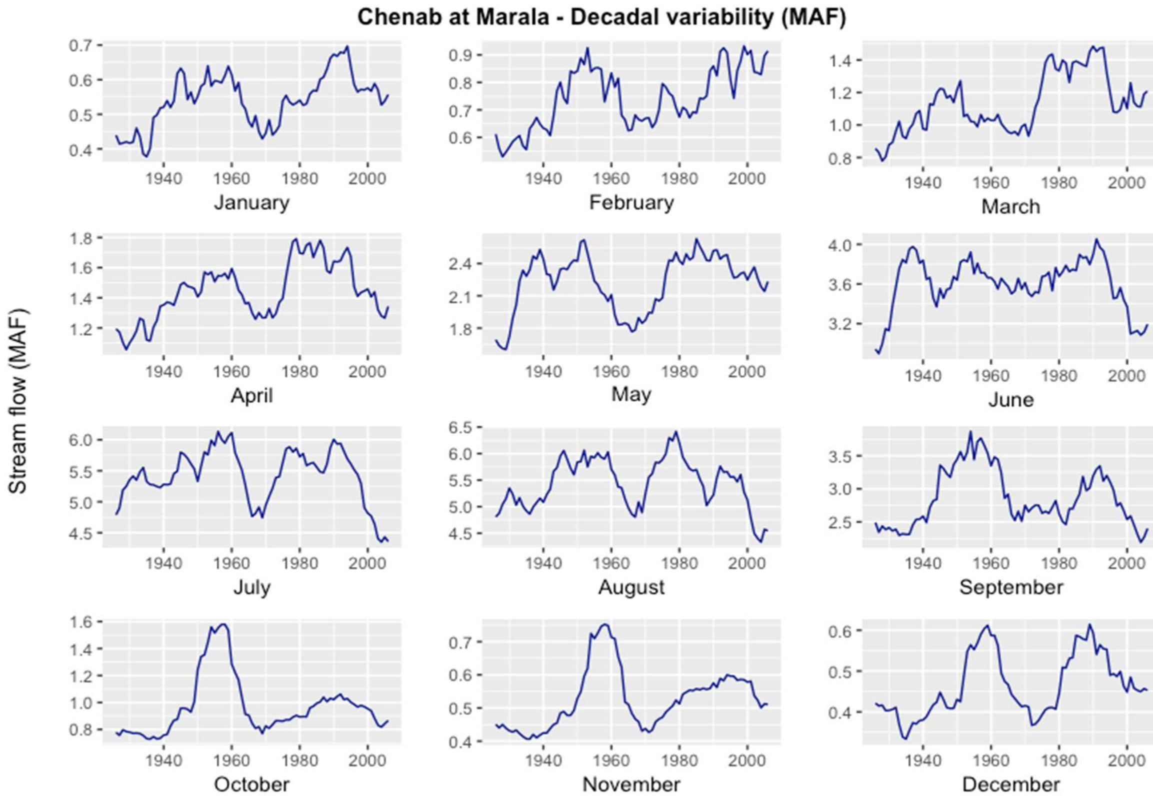
Anomaly plots for the months of March, April, and May (MAM) show increasing variability above and below the respective long-term means. MK values for all three rivers for MAM show an increasing trend. However, looking at the anomaly plots, it appears that the significant trend is due to higher than normal variability with much higher than usual stream-flows in one year followed by below average stream-flows in the next.

Winter (NDJF):

Winter flows seem to be increasing in all three catchments. Anomaly plots show increased variability in winter volumes. However, keeping in view the small quantity of waters carried by all three rivers during winter, and less demand for water for irrigation, power generation, as well as for basic needs, this variability is not felt as strong by the local populations as the stream-flow variability during summer and spring.

Fig. 4. 9: Decadal plots for stream-flows in individual months




Chenab at Marala - Decadal variability (MAF)
Stream flow (MAF)
January
February
March
April
May
June
July
August
September
October
November
December

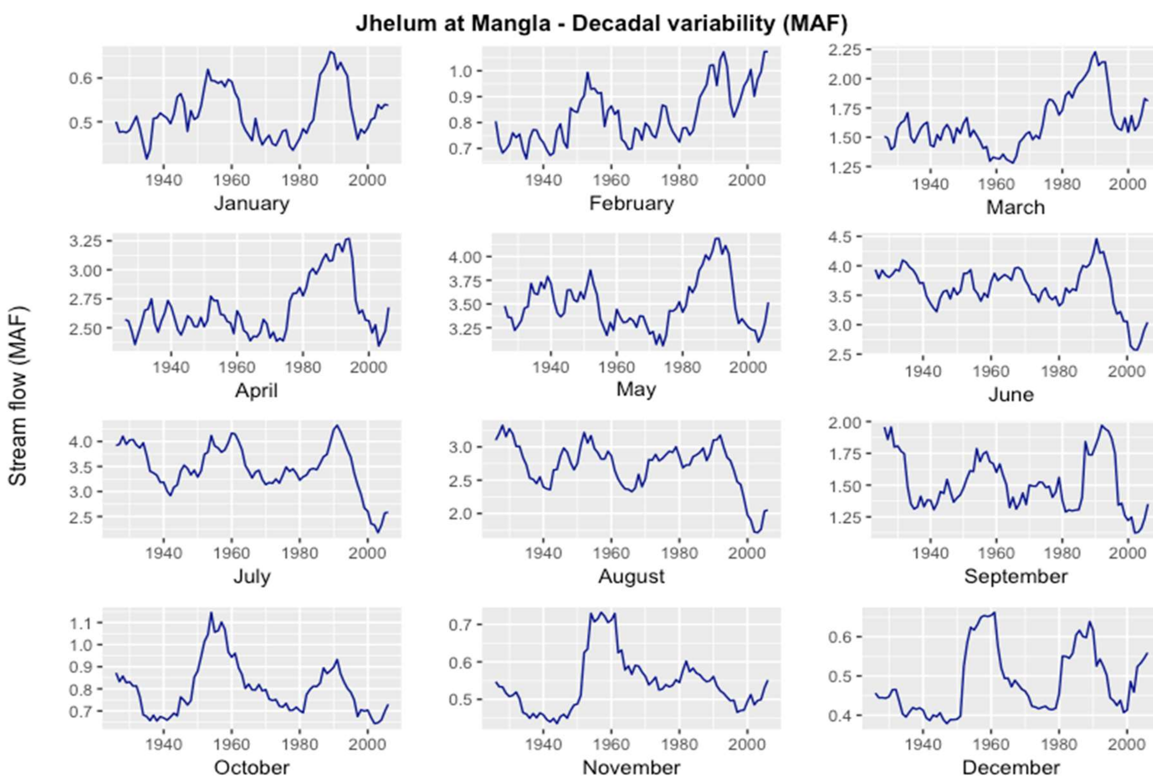
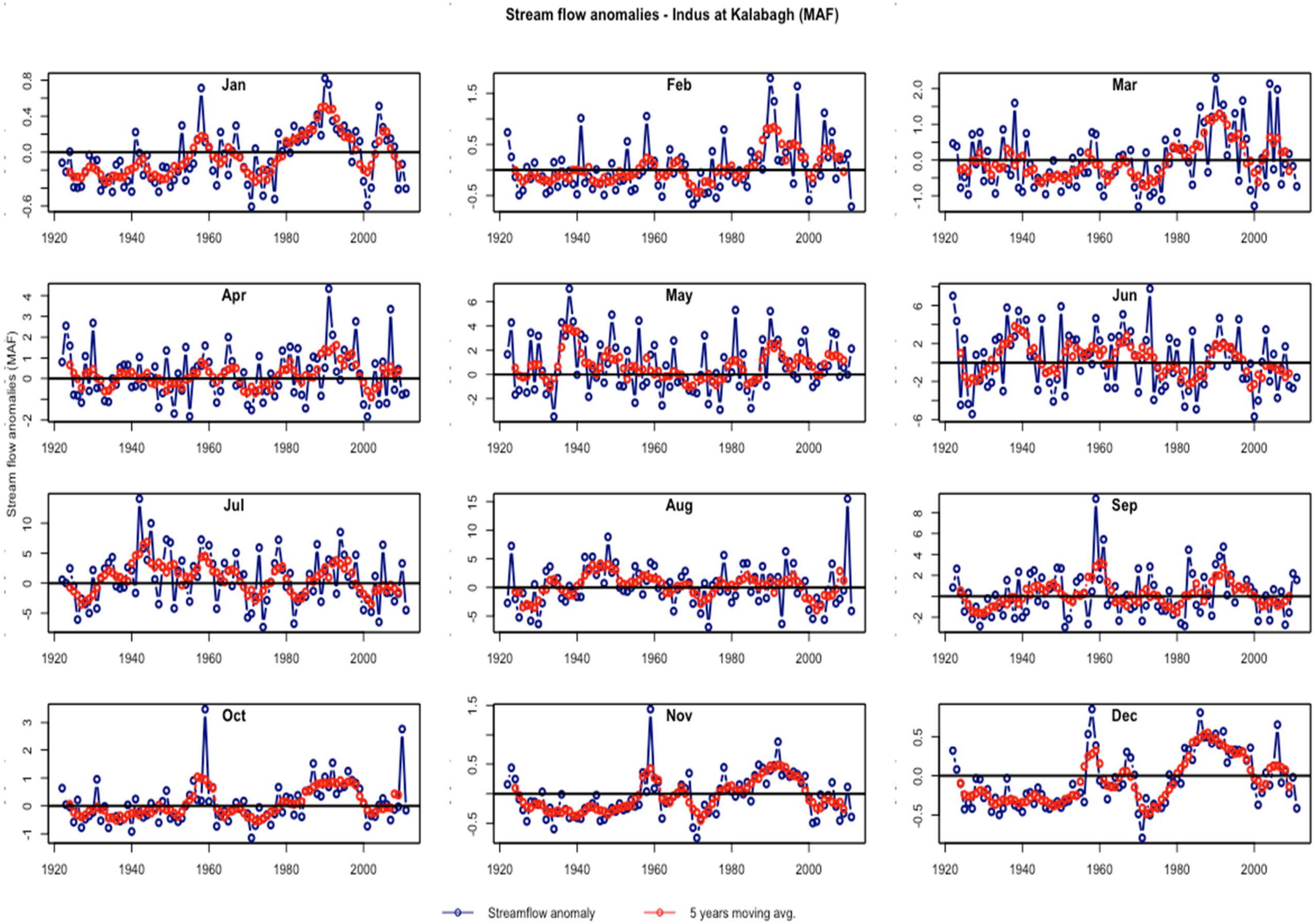
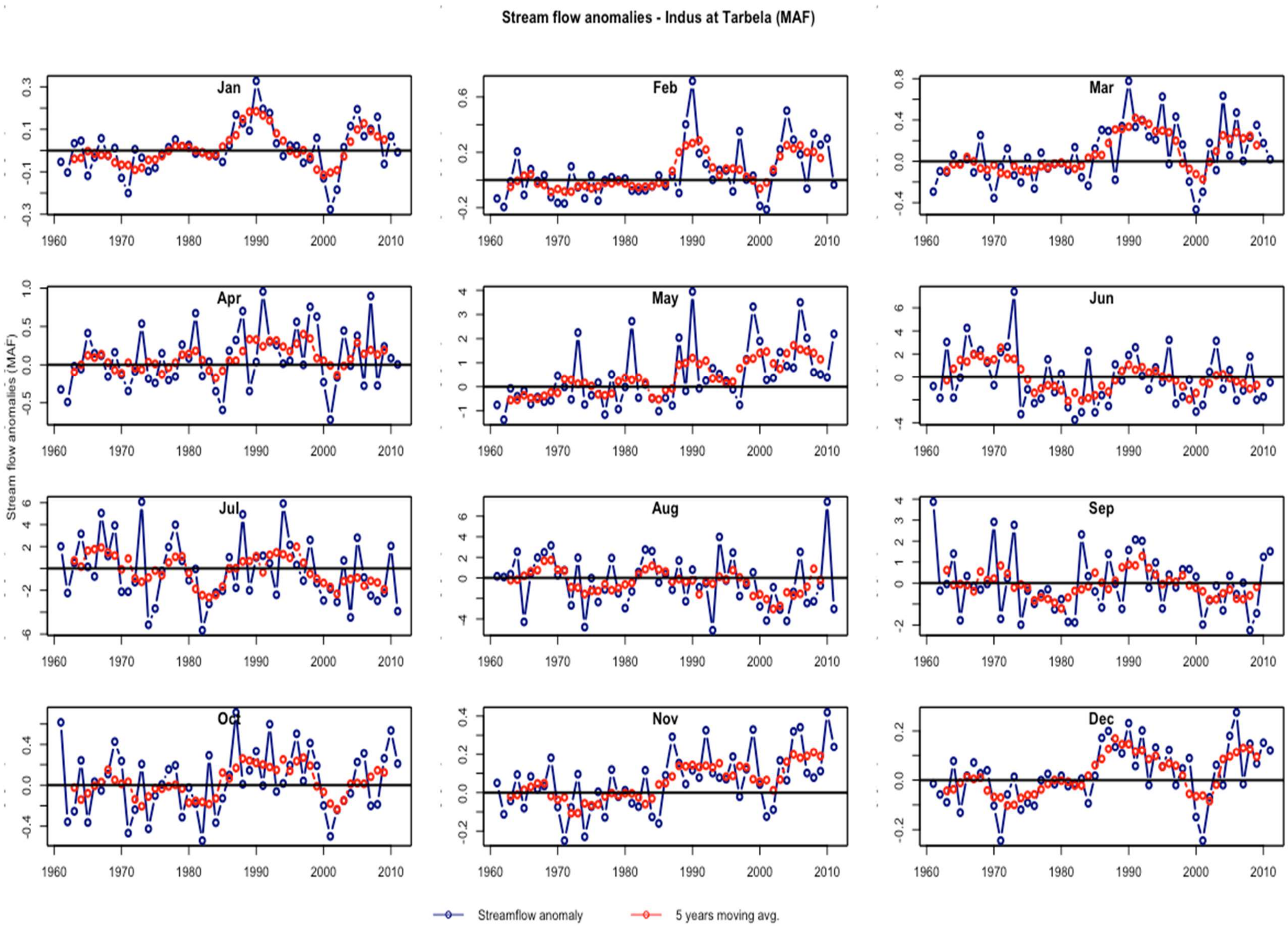
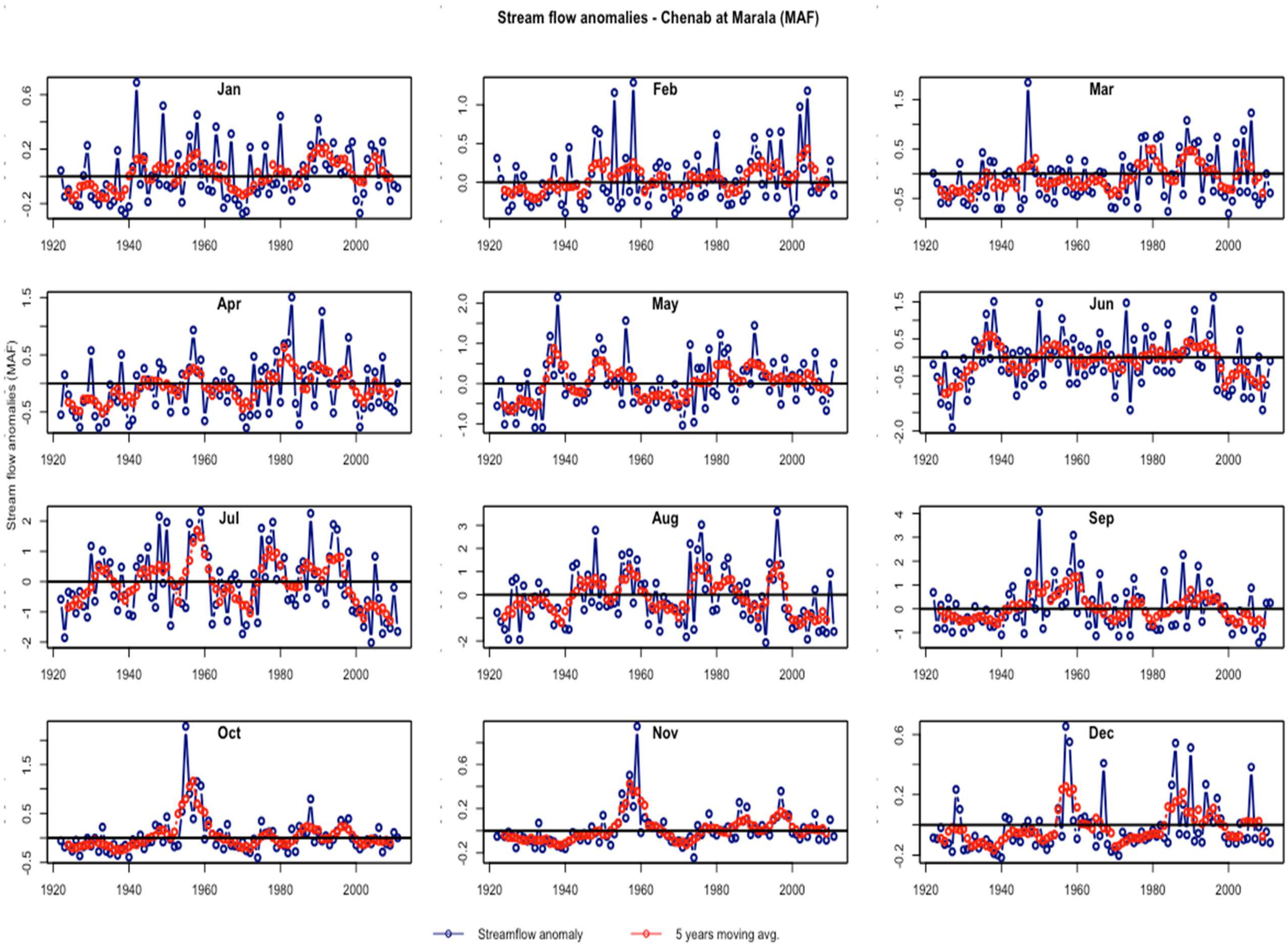

Jhelum at Mangla - Decadal variability (MAF)
Stream flow (MAF)
January
February
March
April
May
June
July
August
September
October
November
December

Fig. 4. 10: Anomaly plots for stream-flows in individual months

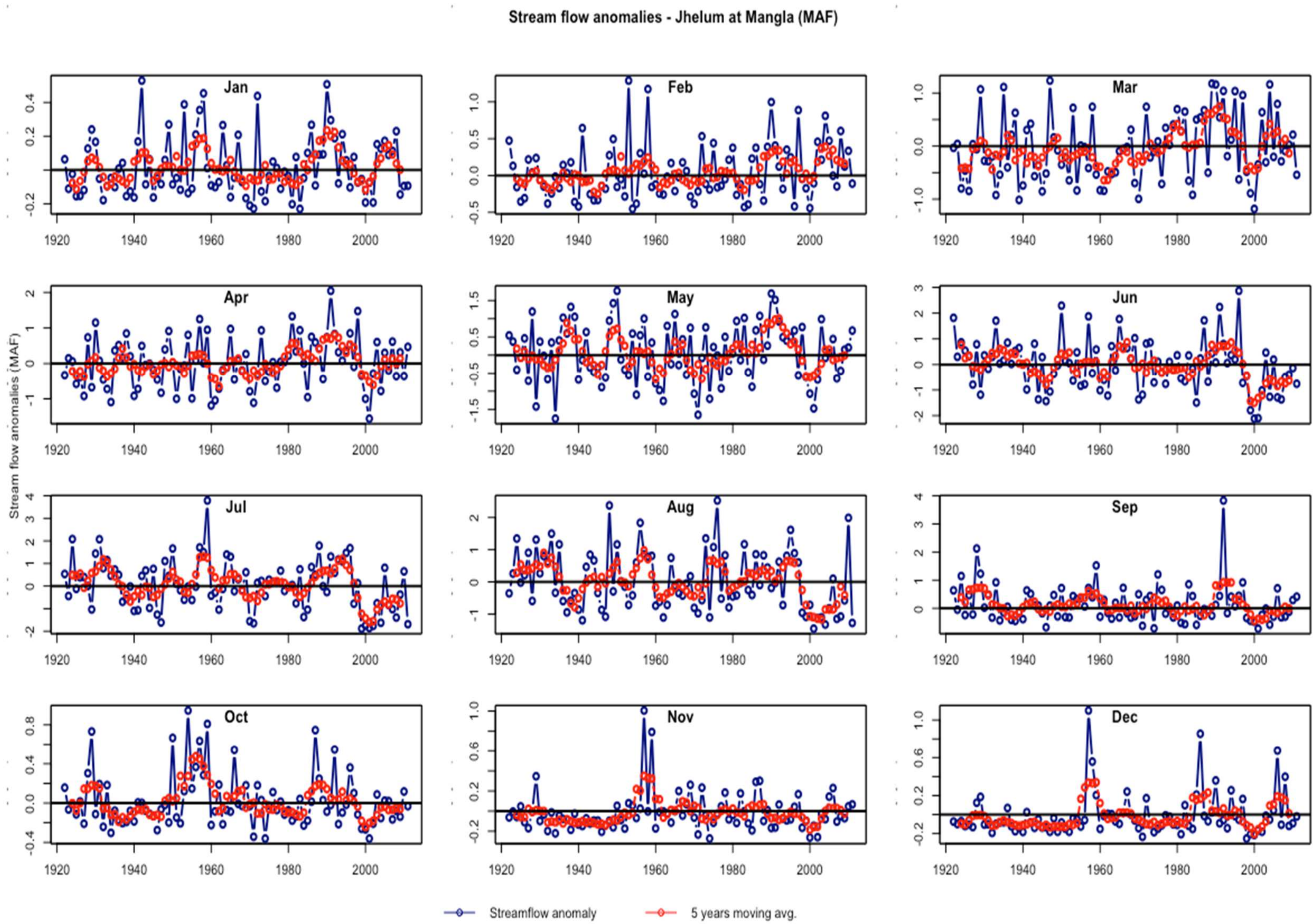




Stream flow anomalies - Indus at Tarbela (MAF)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Stream flow anomalies (MAF)
Streamflow anomaly
5 years moving avg.



Stream flow anomalies - Chenab at Marala (MAF)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Stream flow anomalies (MAF)
Streamflow anomaly
5 years moving avg.


Stream flow anomalies - Jhelum at Mangla (MAF)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Stream flow anomalies (MAF)
1920
1940
1960
1980
2000
Streamflow anomaly
5 years moving avg.

Trends in meteorological variables:

Three meteorological stations in three distinct agro-ecological zones are selected in order to gauge spatial and temporal changes in weather patterns at these locations. The gauging stations are closest to the field interview sites discussed in the next chapter. Three climate variables, Monthly min. temp. (TNTN), Monthly max. temp. (TXTX), and Total monthly ppt. (RRR) are used. The table below lists the names of cities along with time-period for which data are available.

City	Lahore	Bahawalpur	Hyderabad
Monthly min. temp. (TNTN)	1950-2012	1960-2012	1961-2013
Monthly max. temp. (TXTX)	1950-2012	1960-2012	1961-2013
Total monthly ppt. (RRR)	1931-2012	1931-2012	1961-2013

Mean Monthly Minimum temperature (TNTN):

Winter (NDJF):

There is a significant rising trend in minimum temperatures recorded in all three gauging stations in the months of November and December, and points to a warming of winter season. In Lahore (central Punjab), both January and February have consistent increase in minimum temperature. MK values for Bahawalpur (southern Punjab) show a rising trend in minimum temperature in January.

TNTN Mann-Kendall Values												
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lahore	**5.58** (0.00)	**5.41** (0.00)	**4.30** (0.00)	**5.60** (0.00)	**4.33** (0.00)	1.18 (0.24)	0.92 (0.36)	**2.07** (0.04)	**3.60** (0.00)	**5.35** (0.00)	**11.62** (0.00)	**7.63** (0.00)
Bahawalpur	**1.728** (0.084)	0.138 (0.89)	0.057 (0.954)	0.529 (0.596)	**2.678** (0.007)	-1.111 (0.266)	0.488 (0.625)	**-2.78** (0.005)	-0.299 (0.764)	0.844 (0.398)	**1.935** (0.052)	**3.201** (0.001)
Hyderabad	0.71 (0.48)	0.36 (0.72)	0.84 (0.40)	0.08 (0.94)	-1.09 (0.28)	-1.61 (0.11)	**-3.16** (0.00)	**-2.61** (0.01)	0.15 (0.88)	0.75 (0.46)	1.62 (0.11)	**2.2** (0.03)

Table 4. 8: Mann-Kendall results for Mean Monthly Minimum Temperatures (TNTN)

All three cities are located in the wheat-growing regions, and rely on mild to low winter temperatures for wheat cultivation. Increase in minimum temperature in November and December points to warming of the entire region in Punjab and Sindh provinces. Field interviews also confirmed this trend as farmers pointed to warm-winter that has resulted in pushing back of sowing schedule by at least two months (late-November or early December as compared to early-mid October).

Spring (MAM):

Minimum temperatures during March, April and May also show a rising trend in Lahore (central Punjab). There is rising trend in min. temp. in May in Bahawalpur (southern Punjab). In Hyderabad (lower Sindh), decadal variability plots show that temperatures rise in March, but start declining rapidly in April and May, a downward trend that continues into summer.

Decadal variability plots show that temperature variability in Punjab and Sindh is hard to ignore, and affects the two regions differently.

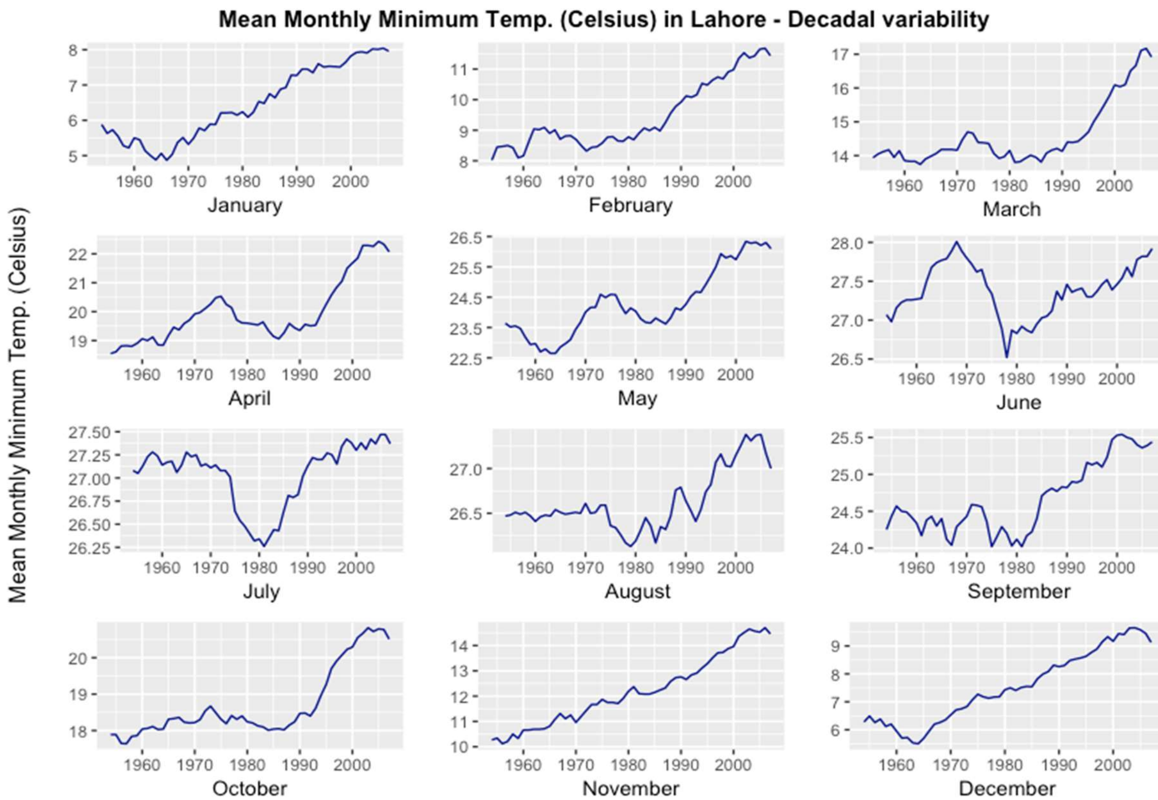
Spring months are crucial for the health of wheat kernels as well as overall yield. Rapid increase in TNTN causes forced maturation of wheat kernels, resulting in lower yield and higher than normal water requirement as evapotranspiration dries up the fields much faster.

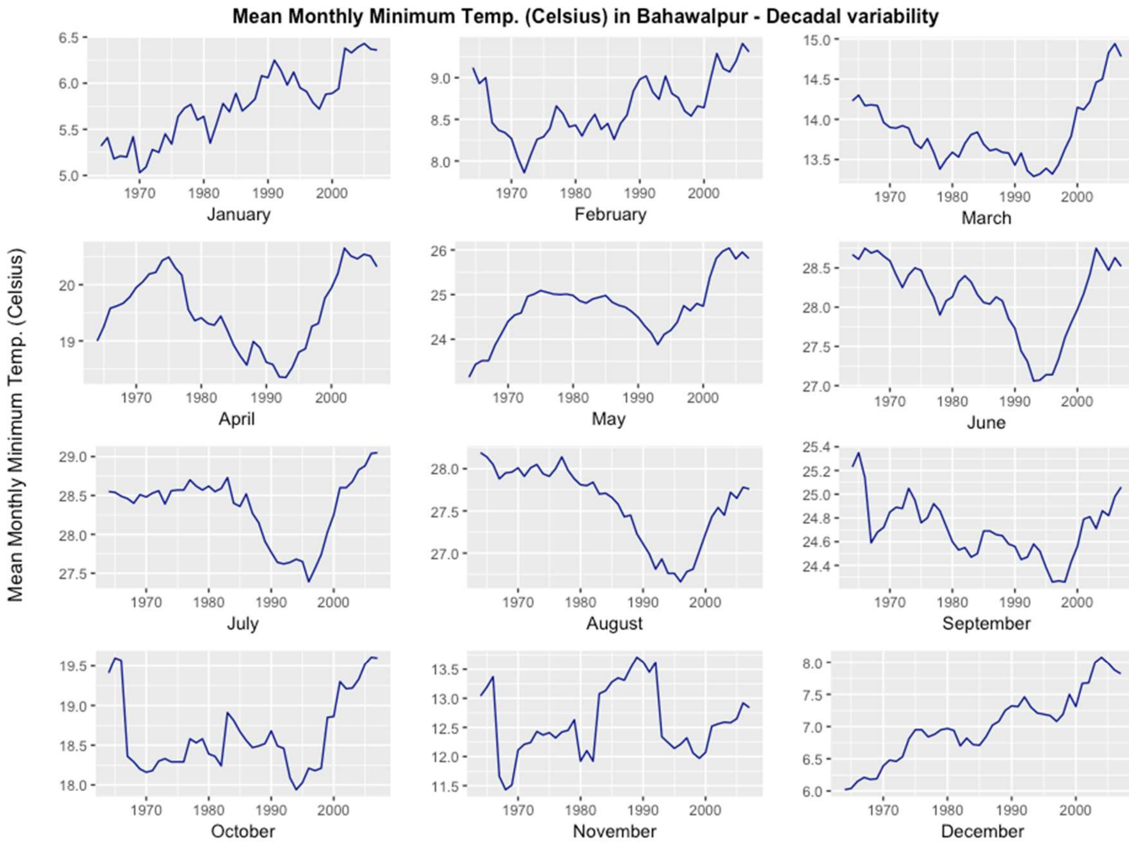
Higher minimum temperatures during winter and spring provide ambient temperature for pests to grow rapidly, forcing farmers to increase the frequency of pesticide sprays per crop cycle, increasing cost of production.

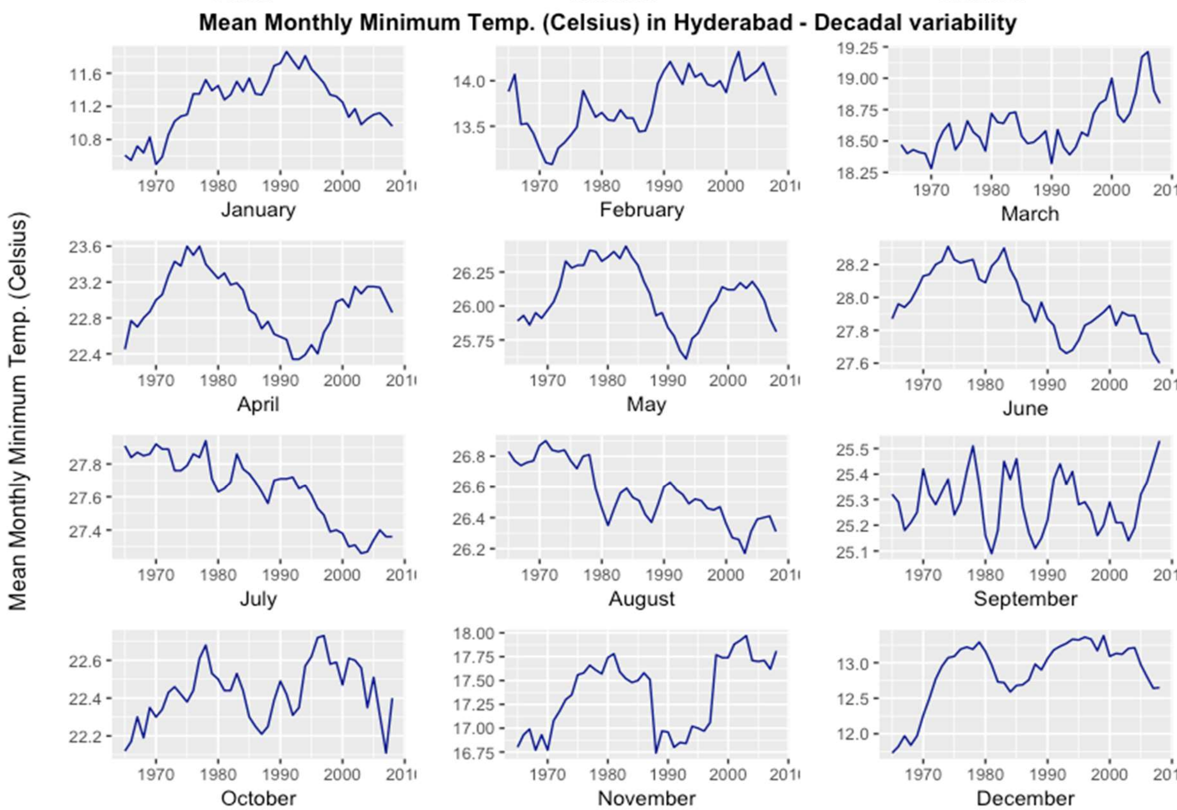
Summer (JJAS):

Minimum summer temperatures in Punjab fell until 1980 but have been rising ever since, albeit not at the same pace as winter and spring temperatures. On the other hand, lower Sindh (Hyderabad) shows a significant downward trend for TNTN. The area is known for historically dry and hot summers – conditions conducive for cotton production. Falling summer temperatures lead delayed harvest, and cut into preparation time for the next cultivation cycle.

Fig. 4. 11: Decadal plots for mean monthly minimum temperatures (TNTN)




Mean Monthly Minimum Temp. (Celsius) in Bahawalpur - Decadal variability
Mean Monthly Minimum Temp. (Celsius)
January
February
March
April
May
June
July
August
September
October
November
December


Mean Monthly Minimum Temp. (Celsius) in Hyderabad - Decadal variability
Mean Monthly Minimum Temp. (Celsius)
January
February
March
April
May
June
July
August
September
October
November
December

Mean Monthly Maximum temperature (TXTX):

Winter (NDJF):

Decadal plots show a declining trend in maximum temperatures in all three cities during winter, particularly in December and January. However, low winter temperatures do not last long and start rising in February again. Sharp change in temperature from one month to the next has catastrophic effects on crops, particularly wheat which is in the very early stage of kernel development at that time, and cannot withstand rapid fluctuations in temperature. Farmers in almost all field interviews brought up this issue as one of the biggest challenges they face during wheat cultivation. Rapid change in temperatures, especially temperature drops in December and January, creates mist on the plants, causing the sapling to shrivel overnight.

Mann-Kendall values show declining trends for all three cities only in January.

TXTX Mann-Kendall Values

Station	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Lahore	-1.55 (0.12)	-0.53 (0.59)	0.23 (0.82)	0.40 (0.69)	0.12 (0.91)	**-5.04** (0.00)	**-2.77** (0.01)	**-1.79** (0.07)	**-2.52** (0.01)	**-2.31** (0.02)	0.69 (0.49)	0.18 (0.86)
Bahawalpur	**-2.95** (0.003)	-1.39 (0.16)	-0.42 (0.67)	0.87 (0.38)	**2.29** (0.02)	-1.80 (0.07)	-0.12 (0.90)	**-3.05** (0.00)	**-3.13** (0.00)	**-1.74** (0.08)	1.08 (0.28)	0.61 (0.54)
Hyderabad	**-1.94** (0.05)	-0.78 (0.44)	-0.04 (0.97)	0.32 (0.75)	-0.81 (0.42)	-0.70 (0.48)	-0.95 (0.34)	**-2.77** (0.01)	**-2.17** (0.03)	-1.10 (0.27)	0.45 (0.65)	-0.33 (0.74)

Table 4. 9: Mann-Kendall results for Mean Monthly Maximum Temperatures (TXTX)

Spring (MAM):

Just like TNTN, decadal plots for maximum temperatures show an increasing trend in the months of March, April, and May. Rise in temperatures in the month of May is going on since 1960 but increase in TXTX in March and April is comparatively a recent phenomenon, and began in 1980s. Spring's importance for wheat cultivation is paramount, as it is around this time when wheat crop gradually ripens under right environmental conditions. Higher than usual temperature in March and April causes forced maturation of wheat kernel and decreases its yield. Plants look healthy from afar but wheat kernels are smaller and lack nutrition that comes with slow/gradual ripening and growth in size. The only way to counter warmer-than-usual springs, field interviews revealed, is to increase the amount of irrigation water to account for higher temperatures and evapotranspiration. Number of watering cycles increase, bringing up the cost of production.

Maximum temperatures in Sindh start declining in May, a trend that continues through summer.

Summer (JJAS):

Summer temperatures are on the decline in all regions in Sindh and Punjab. This downward trend has grave implications for southern Punjab and Sindh, both previously hot and dry regions. Lower TXTX in summer delays the blooming of cotton bolls, thereby pushing forward the sowing window for the next season's crop (wheat). It should be noted that the effect of less intense summers is not as significant in rice/wheat Punjab, as it is on cotton/wheat Punjab and Sindh. Temperate summers are much more acceptable in regions which do not need hot dry weather for their crops.

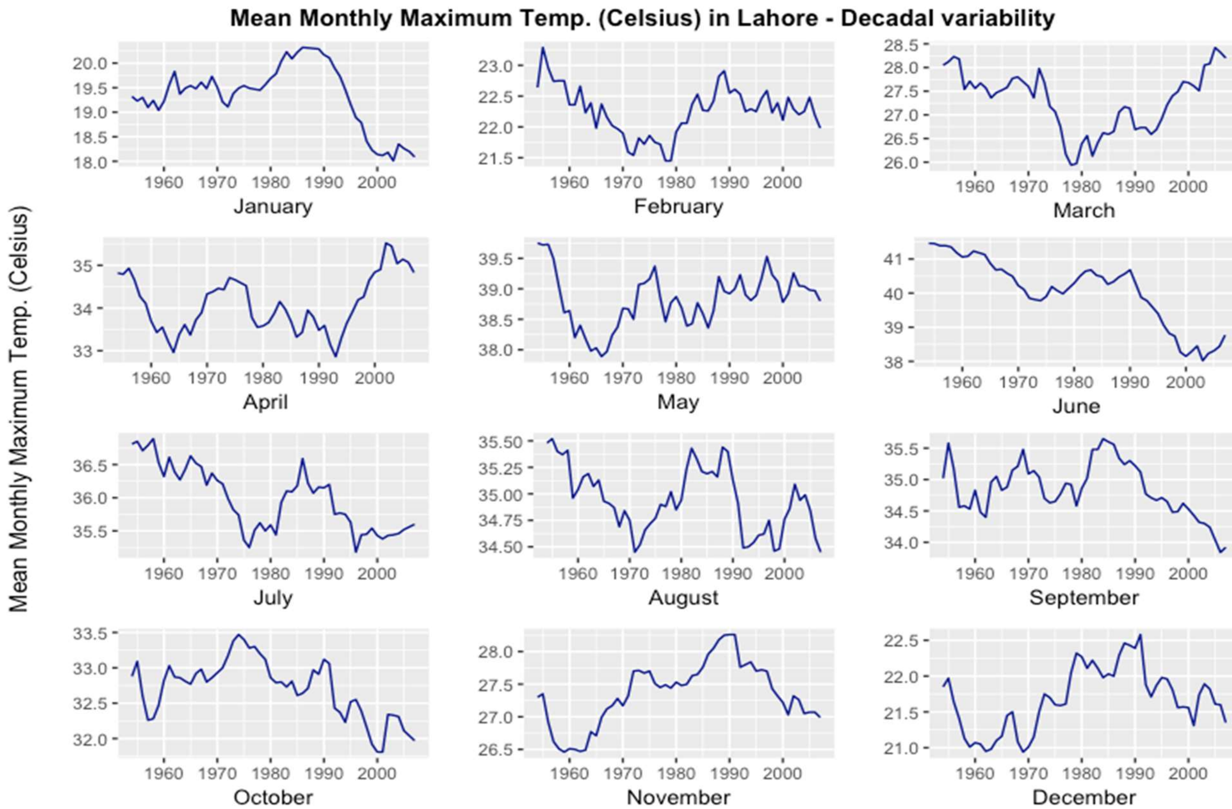


Fig. 4. 12: Decadal plots for mean monthly maximum temperatures (TNTN)

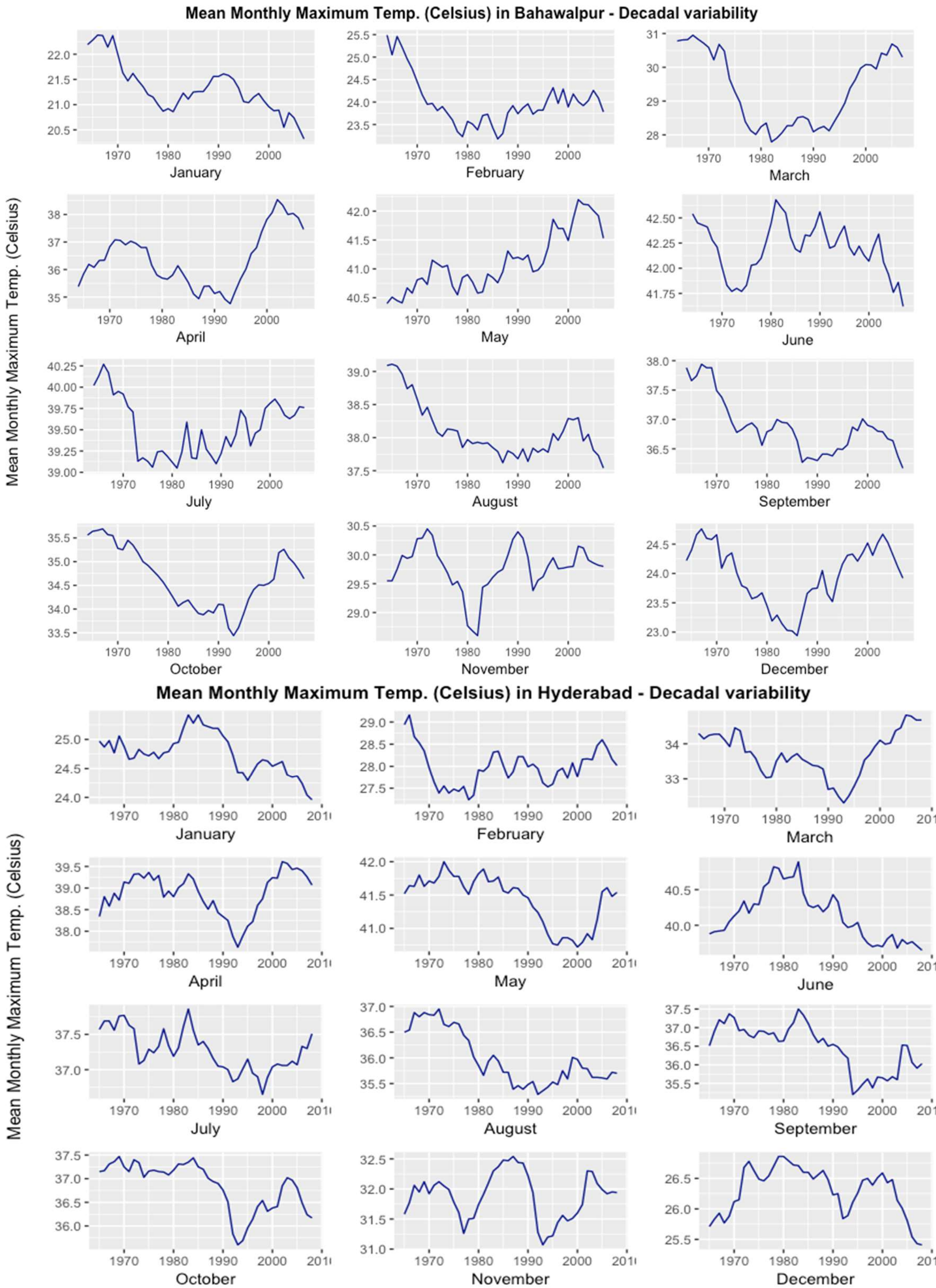


Figure 4.11: Decadal plots for mean monthly maximum temperatures (TNTN) for a) Lahore, b) Bahawalpur, c) Hyderabad

Precipitation (RRR):

Spatial variability is evident in anomaly plots for rainfall (fig. 4.13) in the three gauging stations. Historically, most rainfall takes place in the monsoon months of June, July, and August. MK values for central Punjab (Lahore) show positive trend in May, June, July, August, and September. However, anomaly plots show that although the overall trend may be rising, there is increased variability from one year to the next in these months. Similarly, in Lahore, pre-monsoonal rainfall in June seems to have become more variable in recent years.

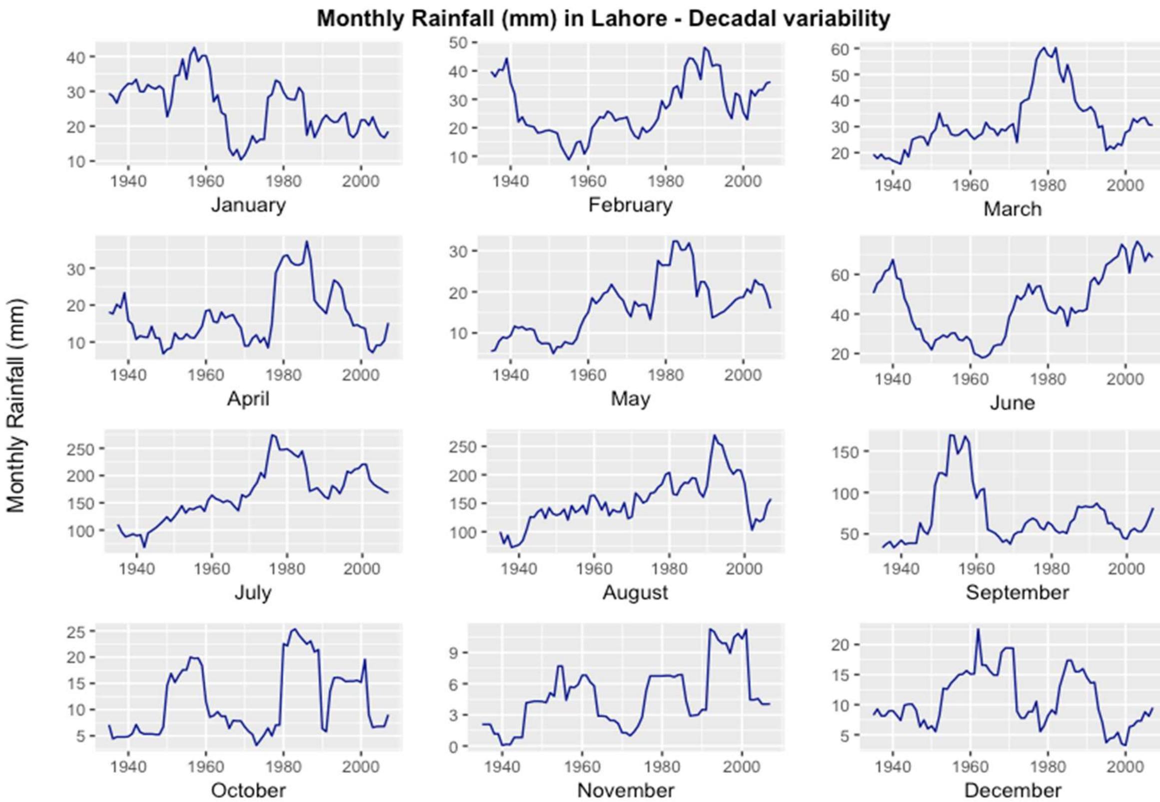
RRR Mann Kendall Values												
Station	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Lahore	**-1.65** (0.10)	0.93 (0.35)	1.06 (0.29)	0.69 (0.49)	**1.94** (0.05)	**2.09** (0.04)	**4.72** (0.00)	**4.11** (0.00)	**2.71** (0.01)	0.55 (0.58)	1.07 (0.28)	-0.07 (0.94)
Bahawalpur	0.90 (0.37)	**5.54** (0.00)	0.50 (0.62)	**3.83** (0.00)	1.00 (0.31)	**2.04** (0.04)	0.30 (0.76)	**1.85** (0.06)	1.28 (0.20)	0.26 (0.79)	0.67 (0.50)	0.50 (0.61)
Hyderabad	1.27 (0.20)	-0.19 (0.85)	-0.58 (0.56)	0.97 (0.33)	-0.53 (0.60)	-0.53 (0.60)	-1.34 (0.18)	0.19 (0.85)	0.13 (0.90)	0.17 (0.87)	0.08 (0.94)	-0.31 (0.76)

Table 4. 10: Mann-Kendall results for Monthly Precipitation

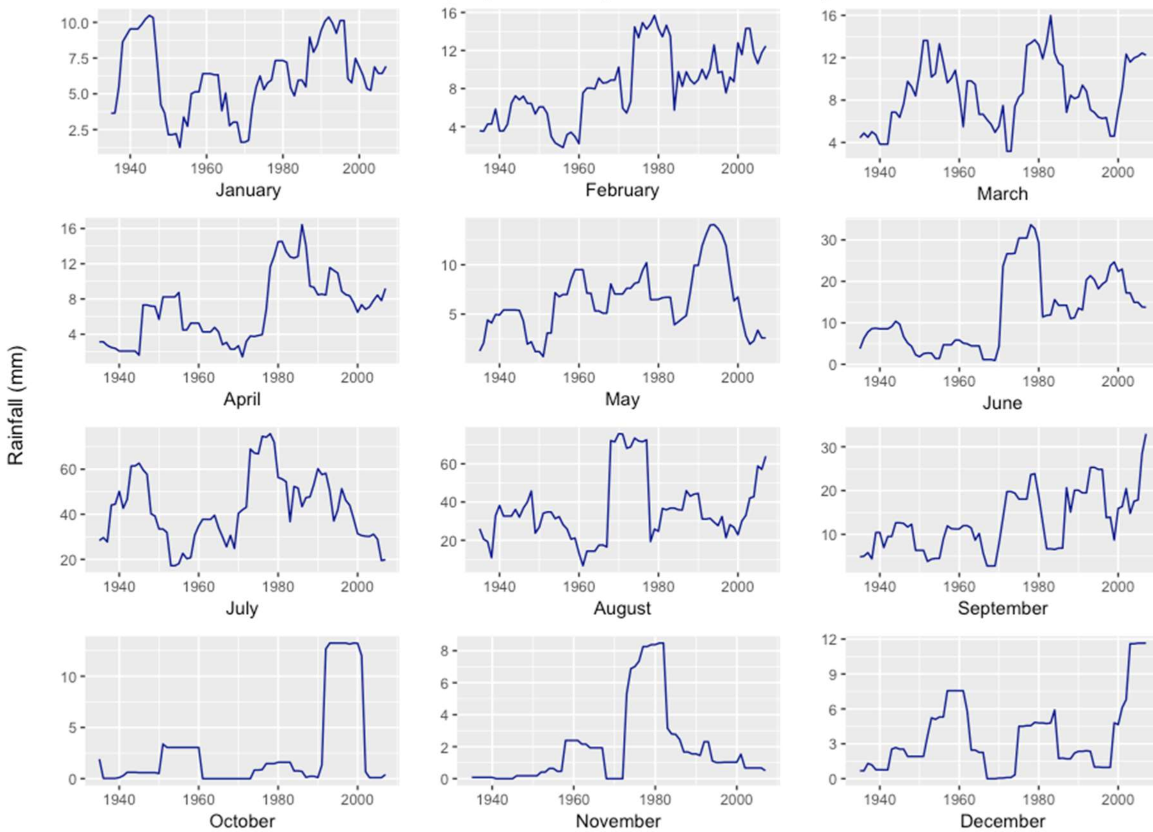
In southern Punjab (Bahawalpur), precipitation has increased in February. There is increased variability in the months of April, May, and June, as well as in August and September. Historically, this region is not known for heavy rainfalls. Famous for cotton crop and fruit orchards, in addition to wheat, it is a dry warm region, but recent increase in variable rainfall patterns has resulted in flash floods, and even hailstorms in spring and summer months.

It must be noted that both southern Punjab and Sindh are comparatively low-lying areas. This means that riverine or flash floods caused due to erratic rains anywhere in the upstream locations drain through this part of the country, often destroying ready-to-harvest crops.

Fig. 4. 13: Decadal plots for monthly precipitation (RRR)



Rainfall (mm) in Bahawalpur - Decadal variability



Monthly Rainfall (mm) in Hyderabad - Decadal variability

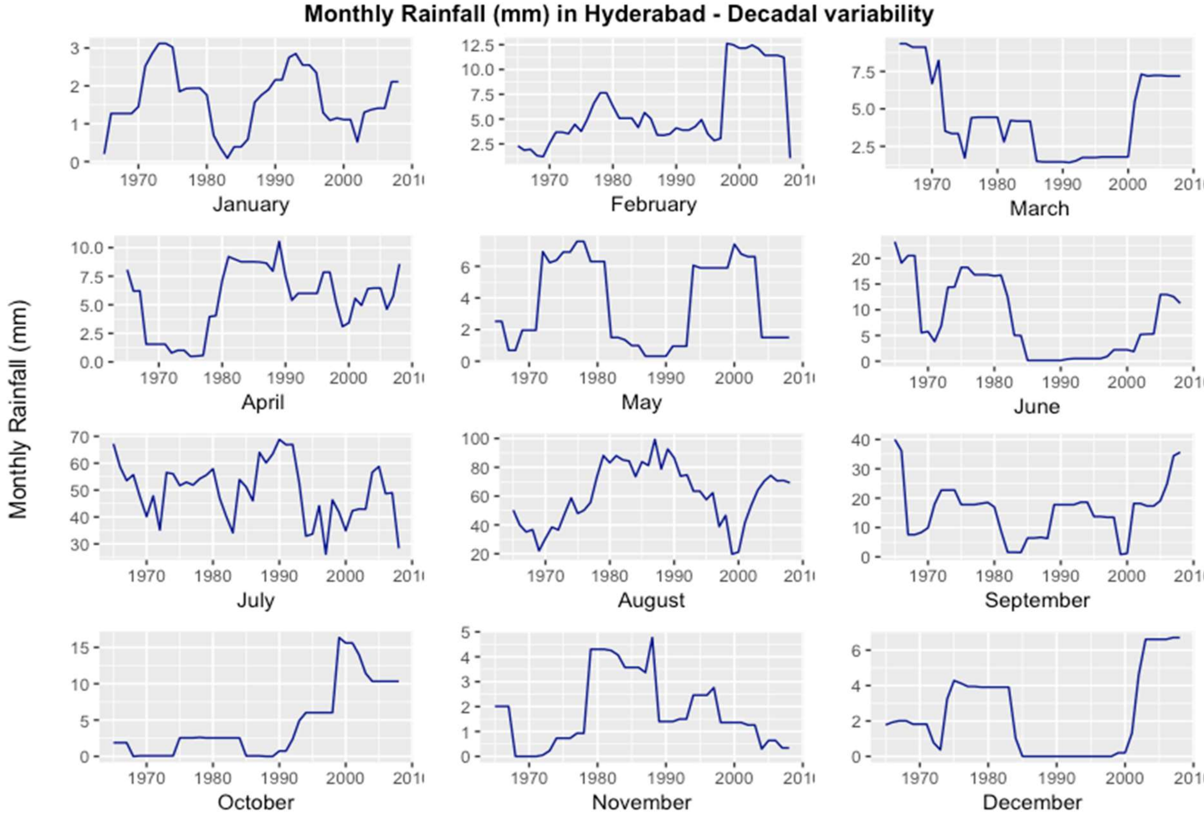
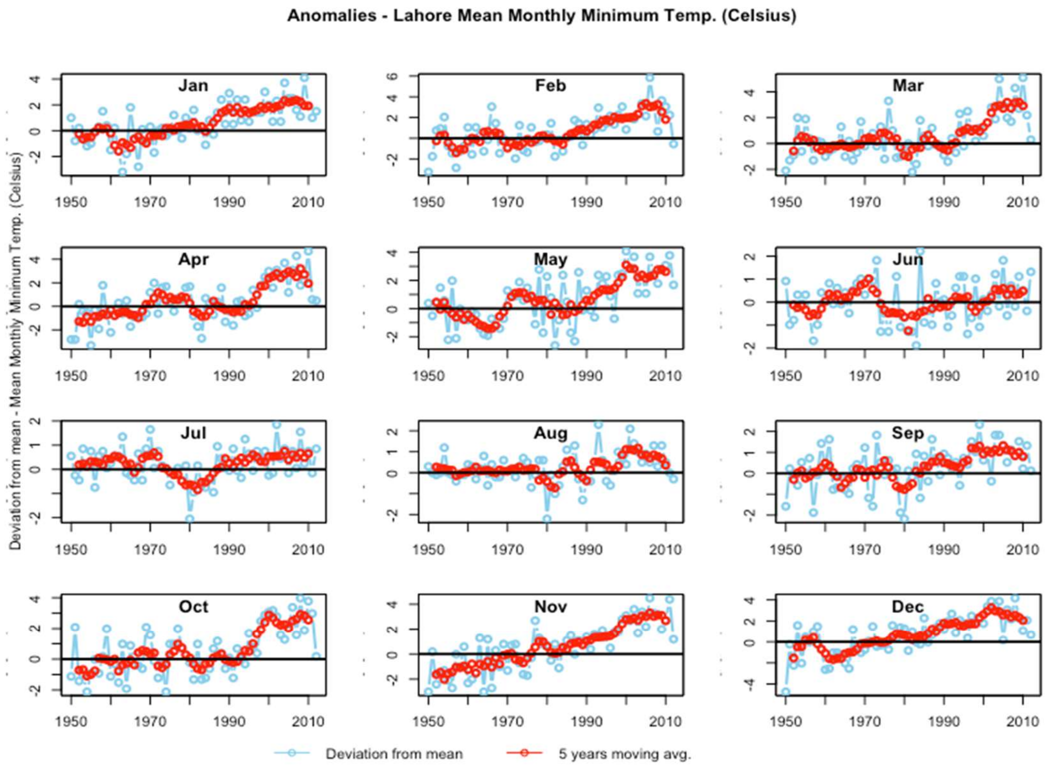
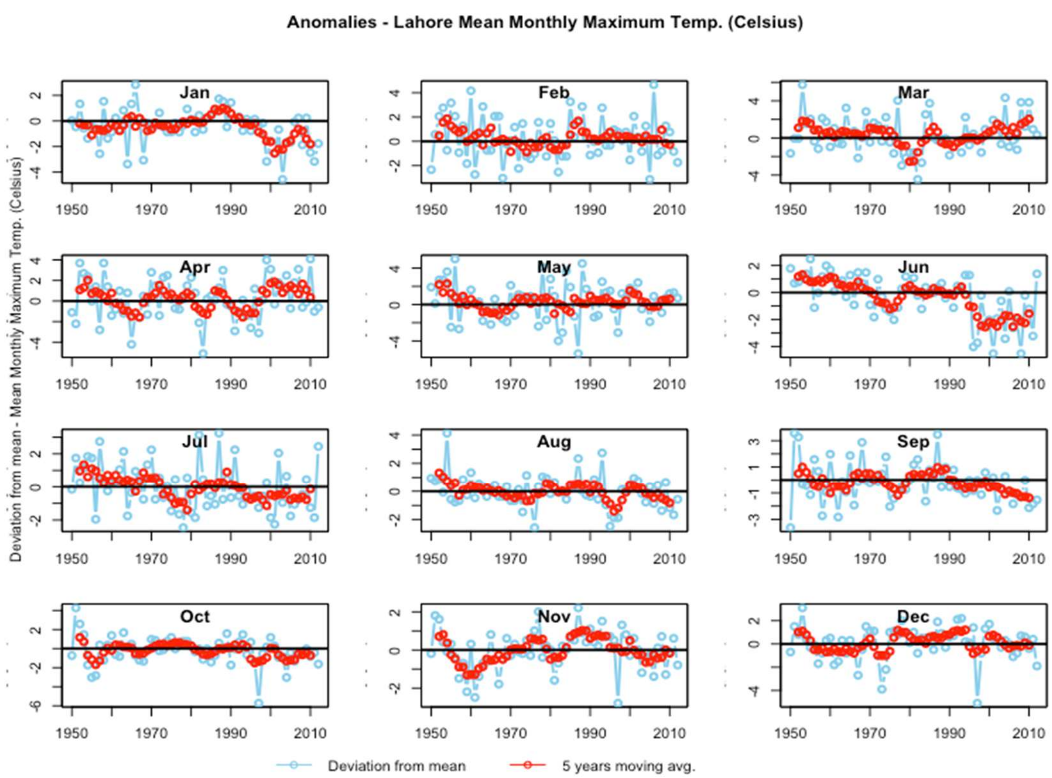
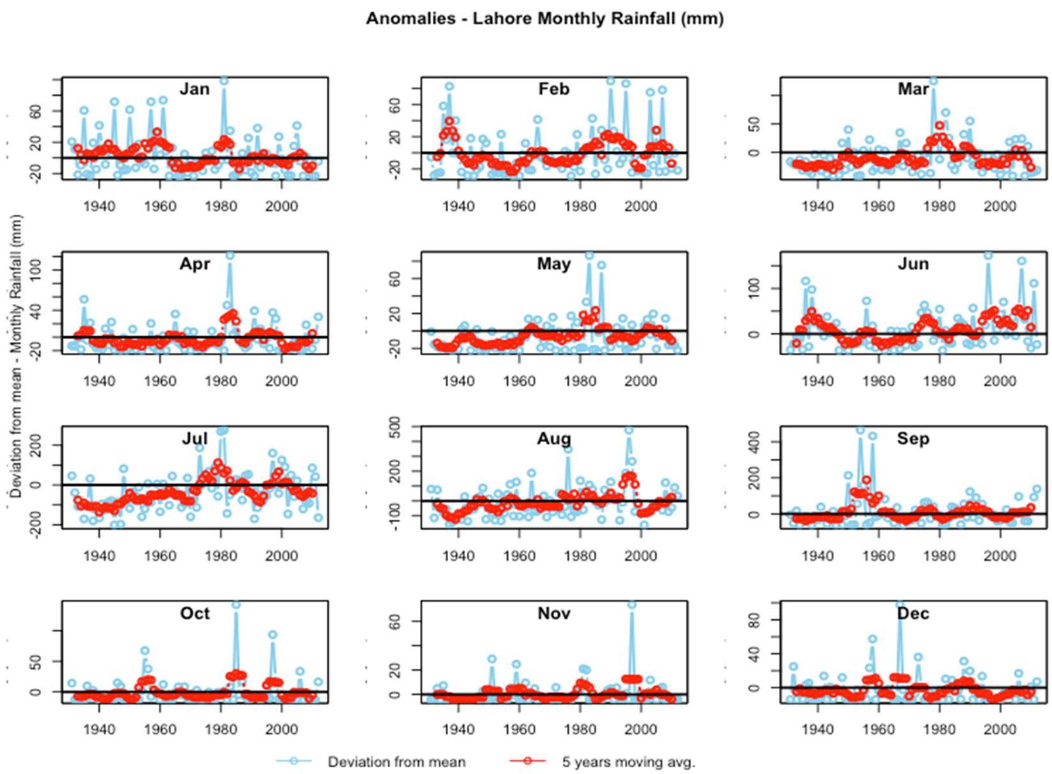


Fig. 4. 14: Anomaly plots for meteorological variables (Lahore)

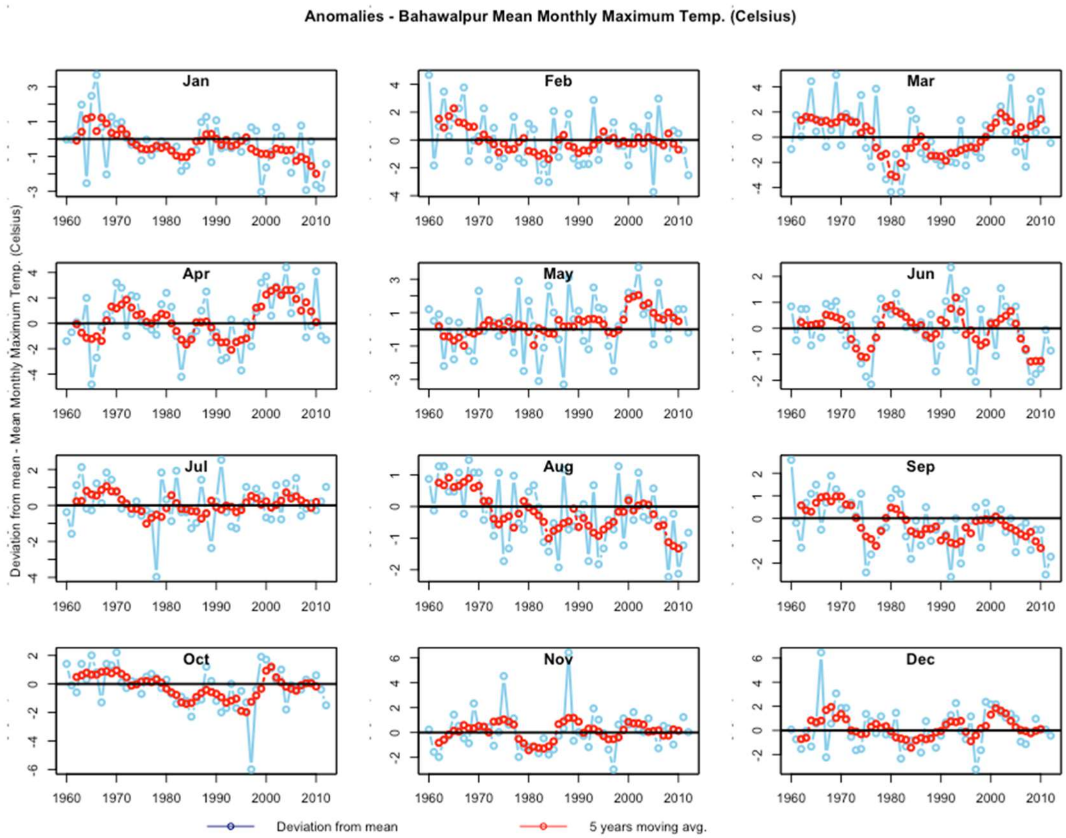




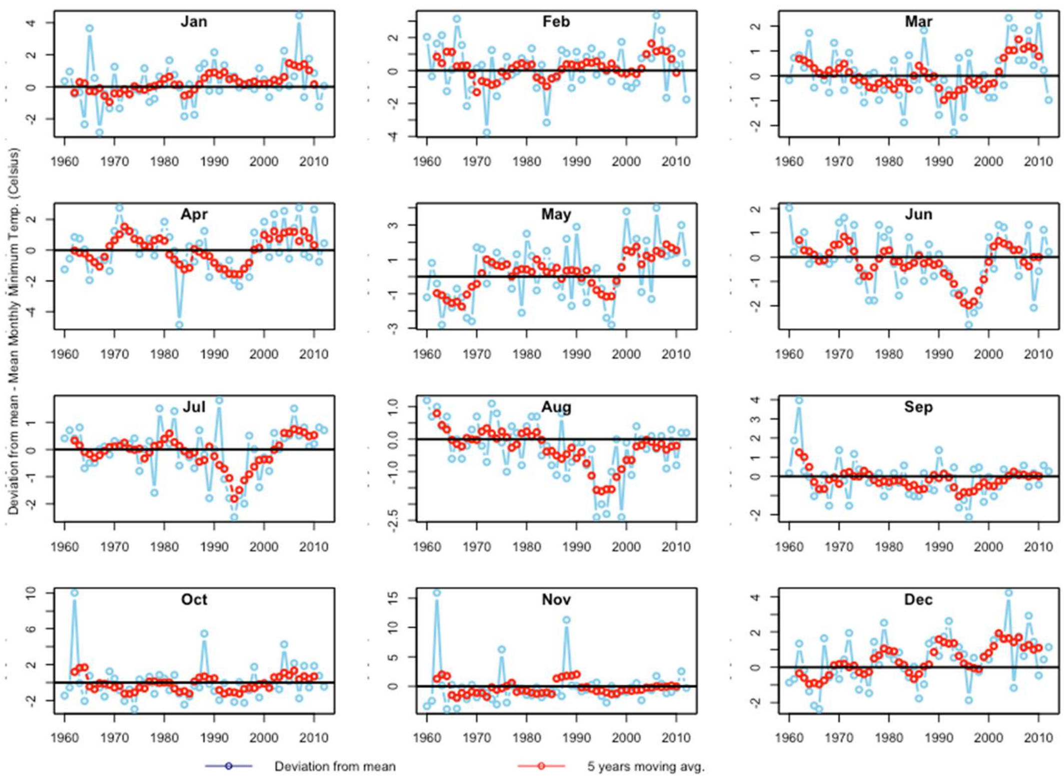


Anomalies - Lahore Monthly Rainfall (mm)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Deviation from mean - Monthly Rainfall (mm)
Deviation from mean
5 years moving avg.

Fig. 4. 15: Anomaly plots for meteorological variables (Bahawalpur)



Anomalies - Bahawalpur Mean Monthly Minimum Temp. (Celsius)



Anomalies - Bahawalpur Rainfall (mm)

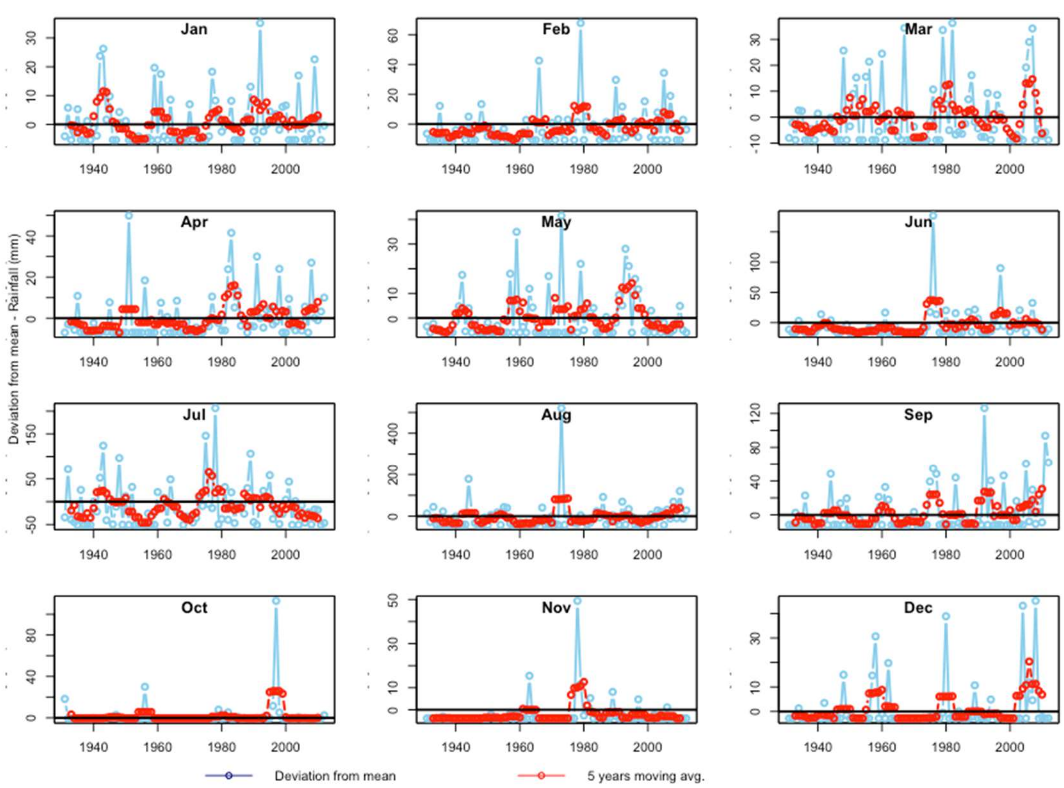
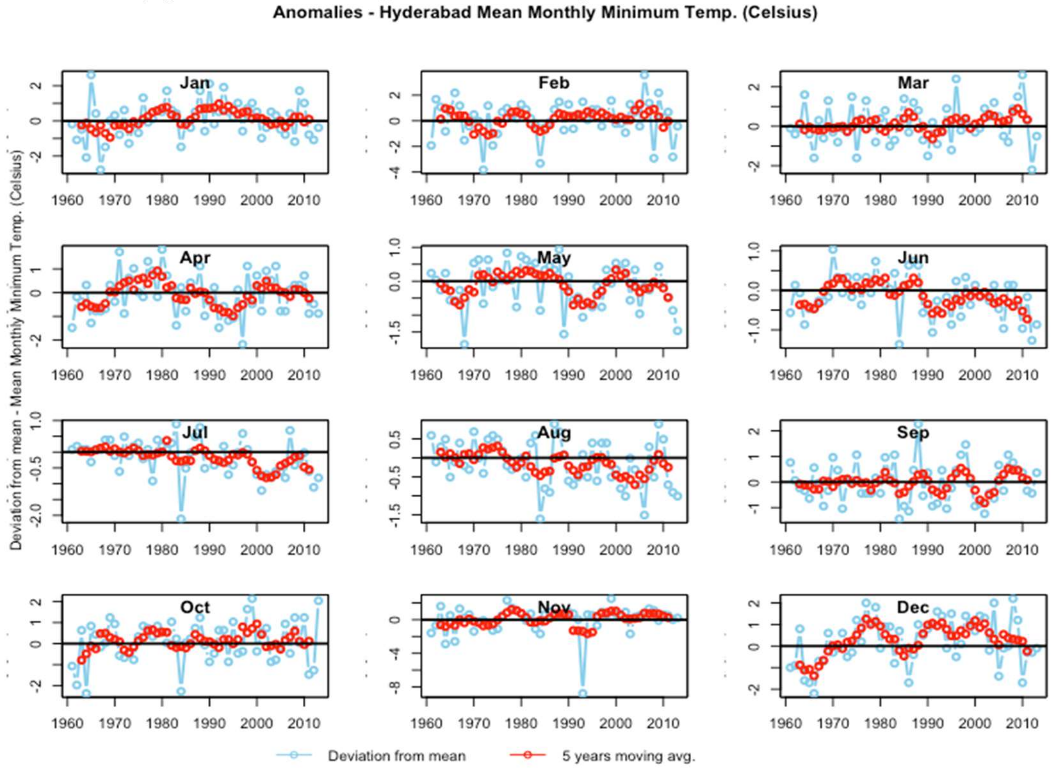
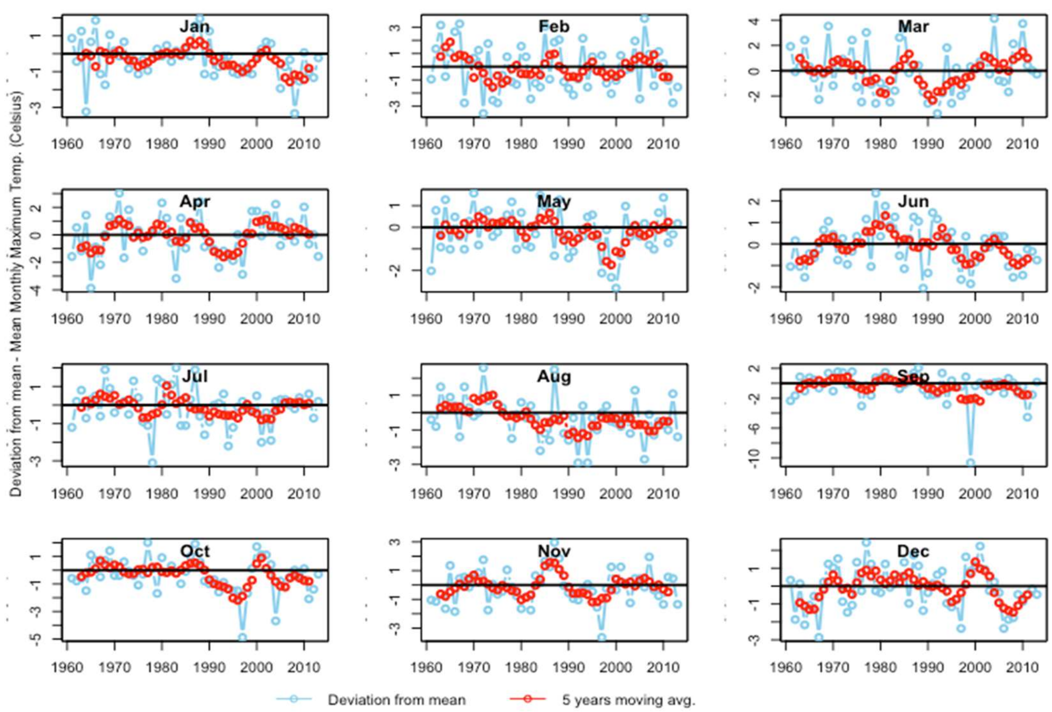


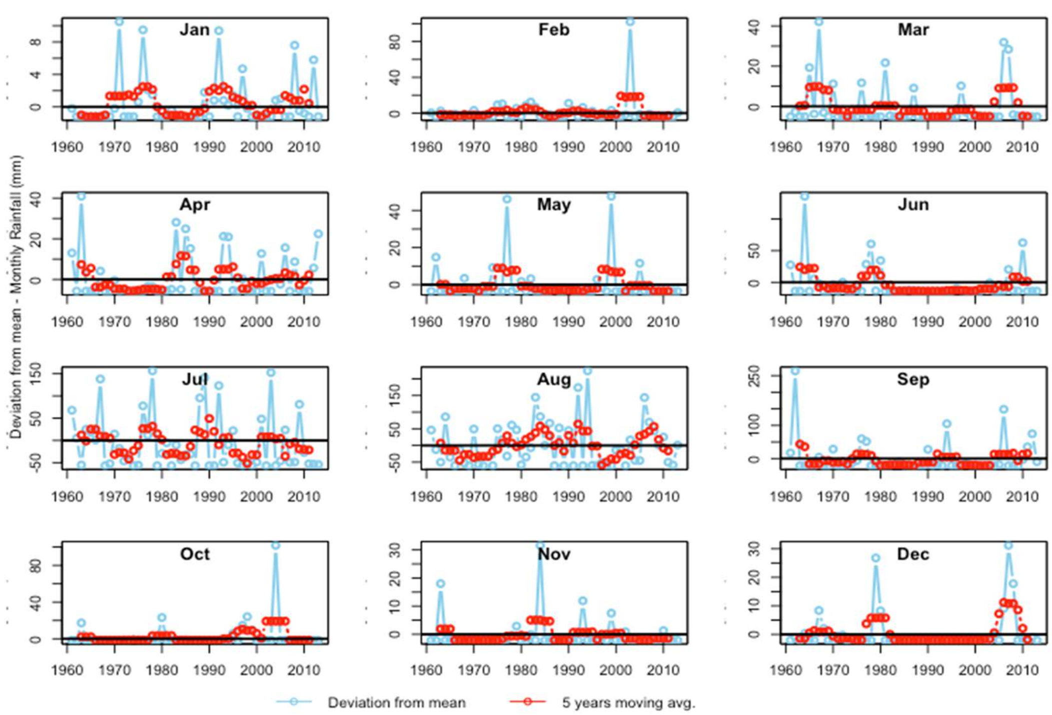
Fig. 4. 16: Anomaly plots for meteorological variables (Hyderabad)



Anomalies - Hyderabad Mean Monthly Maximum Temp. (Celsius)



Anomalies - Hyderabad Monthly Rainfall (mm)



Conclusion:

Meteorological data shows spatial and temporal variability of climate change in different regions of Pakistan. There is an overall trend of warming especially during the winter months (increase in TNTN in NDJF); and cooling of what used to be hot summer months (decrease in TXTX during JJAS). Based on types of crops grown, the effects are non-uniform across regions. For example, in central Punjab where wheat-rice cultivation cycle is prevalent, cooling down of summer does not pose as big a threat to agricultural production as does warming of winters. While in southern Punjab, where wheat-cotton cultivation cycle is well established, cooling down of summer temperatures has devastating effect on cotton – a crop that requires hot, dry conditions for full yield. Similarly, unexpected rainfall in spring, although adversely affects wheat yield in Punjab, it decimates the crop in Sindh where it is almost ready for harvest at that time on account of increased spring temperatures.

Temporal variability in the Indus stream-flows points to the other important insight gleaned from this analysis: stream-flows are shrinking in summer, thereby setting in motion a competition of resource capture among upper and lower riparian populations, irrigation and power generation sectors, and urban and rural communities, etc. Although non-parametric analyses show no trend in the annual average time series, downward trends during summer months (JJAS) are noticed in decadal and anomaly plots.

Reduced flows in the Indus basin, erratic rainfall patterns (both temporal and spatial variability in rainfall), as well as temperature changes throughout the country are generating adaptation response at the local operating level of the society. There is a significant shift in the sowing and harvesting seasons in most parts of the country. Sowing schedules have shifted ahead by as much as two months in the last five to seven years. While early onset of summer and increased winter and spring temperatures have shortened the time required for ripening of crops, forced maturation is resulting in poor quality and lower yield of important crops (wheat and cotton, in particular). Changes in diurnal temperatures seem to have provided ambient conditions for pests to flourish.

Changing weather patterns, shortage of water, and increased cost of production is imposing burdens on vulnerable farmers. The next chapter sheds light on how these changing weather and hydrological trends are changing agricultural practices, and how they can lead to social and political unrest.

Chapter 5: Social and political stresses attributable to climate change in Pakistan

Abstract

The central piece of the framework proposed in this research argues that climatic stresses interact with a society's social, political, and economic processes by way of eliciting responses from vulnerable populations at micro and meso levels. It is this interaction that may determine the nature and severity of these stresses as well as the final outcome. Moreover, since climatic changes are imposing complexity and emergence on vulnerable populations, the framework argues that most of the coping responses can be safely assumed to being taken in real time, and without complete knowledge or understanding of the stressor. The bounded rational coping responses thus taken, if turned out to be maladaptive may in turn exacerbate the situation and engender unrest in vulnerable populations.

This chapter aims to assess the validity of this claim by documenting the phenomenon as it unfolds in Pakistan. The task undertaken in this case study is threefold:

1) Trace the vulnerable population's perception of the original stressor, as well as their coping responses to the stress.
2) Analyze the effect of those coping responses on both vulnerable populations as well as broader political economy.

3) Assess whether the final outcome is attributable to the original stressor, either directly or indirectly.

Whereas the first two parts of the puzzle explain the climate-society interaction, the third part may establish (or otherwise) the link between the original stressor and the outcome of interest.

Culling from field interviews of vulnerable farmers conducted in three distinct locations in the country undergoing environmental changes, the first part of this chapter documents and analyzes farmers' perceptions of the threat, their coping responses as well as the effects of these responses. Themes from content analysis of farmers' interviews, long term time-series records of agricultural production of major and minor crops, as well as respective cultivation patterns show that, for the most part, farmers' agricultural practices in the face of climate change are shortsighted and bounded rational. Aimed at resolving uncertainty from immediate conditions, the coping responses and their effects, in addition to stresses directly imposed by climate change, are generating system effects and resulting in widespread unrest among farmers. The high-resolution insights open a window into the workings of climate change, and the extent of instability it is sowing in the society.

In addition to an incomplete understanding of changing climate trends, the complexity and emergence of climate change is catching local farmers off guard. The coping strategies employed in response are proving to be shortsighted and add to the burdens imposed by the original stressor.

The net result of both climate stresses and their interaction with the society is general unrest among farmers, and manifesting in the form of popular protest by increasingly organized and mobilized farmers across the country. Analysis of collective action events recorded in the Armed Conflict Location & Event Data Project (ACLED) dataset shows an increasing trend of farmers' protest demonstrations, sit-ins, marches, rallies, etc. over the last few years. Detailed reporting of these events, acquired using LexisNexis, directly traces the reasons of farmers' discontent to stresses imposed by climatic changes such as water scarcity, high costs of production, rapidly declining profits, etc., as well as indirect ones such as unstable commodity markets.

When combined, the three pieces of the puzzle, i.e. high-resolution climate trends, accounts of farmers' coping responses as well as their effects on domestic political economy, and expressions of unrest attributable to these stresses, shed light on climate-induced instability in Pakistan.

Introduction

On Nov. 18, 2014, more than 5,000 policemen from six districts in Punjab, Pakistan, launched an armed operation on farmers in Marot, a city district in the southern part of the province, to quell what was described in media reports as a civil disobedience-like situation.[11] The police operation ended with more than 30 farmers severely injured and over 350 booked on terrorism related charges. Police officials burned down houses of suspected farmer leaders, fired tear gas, and baton charged local peasants. By the end of the operation, most men had either been arrested or fled to avoid being captured, leaving

[11] Police-farmers clash; over 350 booked, *Dawn*, November 19, 2014

behind only women and children in the village. Police officials claimed that they launched the operation for arresting defaulters who had not paid electricity bills of their agricultural tube-wells for a long time. According to the police, farmers of Marot owed upwards of PKR200 million (approx. USD 1.4 mil.) in electricity charges. In the days leading up to the police operation, upon serving notices and disconnecting electricity of their tube-wells, local farmers had held the meter-readers hostage and subjected them to torture, snatched weapons from accompanying police guards, and set police vehicles on fire. Farmers maintained that in addition to inflated electricity charges, they were suffering losses in almost every crop, and therefore falling behind in their utility bills payments.[12]

Two years later, the theatre of confrontation between farmers and state officials was the capital of Punjab province. On Sep. 28, 2016, thousands of farmers from across Punjab set off for Lahore. Instead of the usual practice of traveling in the form of a caravan of tractors, buses, motorcycles, etc., most farmers travelled separately, some having slipped into the city a day before in order to bypass policemen deployed to keep them from entering the city. The crowd assembled in front of *Data Darbar* – the holiest sufi shrine in Lahore – and marched toward the provincial legislative assembly building to stage a sit-in demonstration.[13] Protesting against the government for not curtailing input costs and not revising subsidy prices of agricultural products, farmers vowed not to disperse until the government had met their demands. They blamed the government for carrying out an "economic massacre of farmers"– increased costs of production, water

[12] Farmers' future in the balance, *BBC Urdu* (Video report), April 12, 2015 (accessed October 7, 2019)
[13] Farmers protest outside PA against govt's anti-farmer agriculture policy, *Pakistan Today*, September 28, 2016

shortage, and energy crisis had made agriculture financially unviable for many who could not stay in business unless supported by the state. For them, setting crops on fire was more acceptable than selling at a loss. To prove their point, they set fire to large bales of crops that they had brought with them in protest. The sit-in continued for two days as farmers spent the night under an open sky, sang songs, and danced joyously. Leaders from major political parties that were not a part of the government expressed solidarity with farmers by joining in the protest and made speeches against the government.[14] Police officials arrested over 600 farmers from across the province to stop the march.[15] Protestors dispersed only after meeting with the top executive of the province, the Chief Minister of Punjab, who assured them he would look into their demands. Two months later, farmers came back for yet another sit-in as the government failed to follow through with its promises.

A year later, the seat of power - the national capital, Islamabad - became the site for a show down between the protesting farmers and the government. On May 26, 2017, farmers travelled to Islamabad and marched toward the parliament building, demanding to confront the Prime Minister and present their demands in person. They were met with heavy contingents of police and other law enforcement agencies who used tear gas, water cannons, and batons as farmers tried to enter the Red Zone – a virtual perimeter deemed sensitive on account of close proximity to government buildings including the Parliament House, the Supreme Court, foreign embassies and diplomats' residences. The protesting

---

[14] Farmers' protest gets political parties support, *Dawn*, September 29, 2016
[15] '600 detained' across Punjab to stop farmers' march, *Dawn*, September 28, 2016

farmers responded to the police's use of force by pelting stones and altercating with police guards.[16] Eight farmers were hospitalized and scores arrested.

In the last few years, there have been hundreds of such protests led by farmers, each more organized than the previous one. Representative organizations have mobilized growers in almost every district in Punjab and Sindh provinces, set up offices, and even participated in the local bodies elections under their political banner. Mobilization campaigns have resulted in the formation of Pakistan Kissan Ittehad, or Pakistan Farmers' Alliance, the most notable organization representing farmers in Punjab, recruiting hundreds of thousands of card-carrying members across the largest and most populous province in the country. In Sindh, the second largest contributor to agricultural production in the country, and arguably more vulnerable than Punjab to the effects of climate change, a plethora of farmer-led organizations have sprung up that have organized hundreds of protest demonstrations in recent years.

Protesting over perceived injustices is not new in Pakistan. Neither is the heavy handedness of the police, which is often used by the state to quell political expression in the country. The uprising of farmers, however, is a landmark development. For the first time or at least in one of the rarest episodes in the country's history, previously apolitical small and medium farmers, most of them tenant farmers, have taken to the streets in large numbers with increasing frequency.

Contentious performances have also evolved in the process. Instead of impromptu demonstrations in small cities and towns, farmers now advertise their upcoming rallies,

---

[16] Police charges at the farmers' union in Islamabad, *Pakistan Today*, May 26, 2017; Police fires water cannon to disperse protesting farmers in Islamabad, *Dawn*, May 26, 2017

sit-in demonstrations, etc., weeks and months in advance and march toward large cities such as Lahore, Islamabad, Karachi, etc. Out of the fear of being apprehended beforehand, they take extra caution in planning and carrying out rallies and protests, and keep details of their strategies private. Dumping and/or burning truckloads of agricultural produce in public squares, taking out symbolic funerals of agriculture, and burning effigies have become increasingly common sights in such demonstrations. Usually carrying farming implements such as spades, sickles, or even sticks, that could also be fashioned as weapons during altercations with police and the general public, farmers block major highways, railroad tracks, and *gherao* (surround) key legislative or administrative buildings. Disrupting traffic on busy roads and highways in large cities earns them visibility in media as well as government's attention. Police officials have noted that farmers are becoming increasingly violent in their tactics.[17]

What is the connection between this unrest and climate change? It is a big one, if one asks farmers. Although climate change in Pakistan gained international attention due to apocalyptic floods in 2010 and 2014, major climatic changes have been taking place below the radar for quite some time. Intra-annual and intra-seasonal, as well as spatially variable changes in climate and weather patterns have been resulting in crop failures, reduced yields, and increased pest attacks. Shrinkage of the Indus stream-flows caused by climatic changes in the Upper Indus Basin, has imposed severe burdens on irrigation and hydroelectric power generation systems of the country. Cold snaps, heat waves, changes in diurnal temperatures, hailstorms, and shifting of meteorological calendars have thrown

[17] کسانوں کی پرتشدد تحریک (Farmers' violent movement), BBC Urdu, April 15, 2015

farmers off their game as they scramble from one coping strategy to the next in order to remain financially viable.

In addition to varied manifestations and effects of climate change in different parts of the country, interactions between climate change and society are not a straightforward affair either. Ignorant of a fuller picture of the changing climate and weather patterns in the country and region, and with almost no government assistance vis-à-vis dealing with changes in the natural system, local farmers rely on their common sense when it comes to coping with stresses imposed by climate change. These coping measures, taken without foresight or complete knowledge, often result in additional stresses, and may even be unsustainable.

As discussed in previous chapters, the challenge of climate-security research in particular, and climate-society interaction in general, has to do with isolating the effect of climate signal from other confounding stresses that may induce unrest and contention in a society. This is not an easy task - not only because of the complexity and emergence associated with climate change, but also due to its interaction with preexisting mechanisms and processes that constitute a society's political economy, history, and culture. As proposed in the theoretical framework chapter, the best one can do is to identify generalizable pieces of theory in all three processes, i.e. climate change, its interaction with society, and finally contention, which may provide at least partial explanations of salient pieces of this puzzle.

This chapter is organized as follow: The first section provides an in-depth look into climate-society interaction in Pakistan, especially in the agriculture sector. This entails analyzing local farmers' experiences of the changing climate, coping responses to these changes, and finally the dynamics of the resulting social and political unrest. This analysis is based on two sources of data: (i) field interviews, (ii) long-term trends of cultivation patterns.

The second section analyzes the social and political unrest among Pakistan's farmers. Using protests records from Armed Conflict Location and Event Database (ACLED), as well as detailed news reports of these protests from LexisNexis, this section evaluates whether/how farmers' unrest is attributable to effects of climate change in the country.

Climate-society interaction in Pakistan

As discussed in the previous chapter, with the exception of extreme climate events, which are increasing in frequency and intensity, most climatic changes taking place in Pakistan are gradual and therefore comparatively much less conspicuous. Since vulnerable populations lack access to long-term high-resolution hydrological and meteorological data, as well as computational resources and training to analyze it, coping responses, at least at an individual level, have become a function of perception of the nature of the (climate) stress. Given the lack of appreciation in the general public regarding the complexity of the phenomenon, the chances of misperceiving the changing climate trends are higher. This may influence the decision-making calculus in developing coping responses.

Fieldwork:

Fieldwork was conducted in September-December 2014 in three villages located in the *tehsils* (local administrative units) of Muridke, Ali Pur, and Hatri, in Pakistan's Punjab and Sindh provinces. Two of the three villages, located in Muridke and Ali Pur are situated in central and southern parts of the Punjab province, respectively. Hatri is located near Hyderabad district in the southern part of the Sindh province.

As discussed in the previous chapter, the *tehsils* are linked to meteorological stations that were selected randomly from three randomly selected agro-ecological zones. The three ecological zones represent the varied weather and climate patterns at sub-national level. As discussed previously, farming strategies and crop patterns employed by the three populations are dictated by their respective climate and weather patterns, and therefore are different from each other.

Semi-structured interviews were conducted with a total of 63 farmers in the three sites. The number of interviewees was twenty each in Muridke and Ali Pur, while 23 farmers were interviewed in Hatri. The interviewees' age ranged between 25-65. All interviewees were men. Sixty five percent of those interviewed had education level below matriculation (grade 10). Seventy-five percent were tenant farmers with landholdings between 5-50 acres. Twenty five percent owned their lands and had landholdings between 50-100 acres.

The interviewees' sample was based on convenience sampling. The social structure of Pakistan's countryside, especially regions in Sindh province or in the southern parts of Punjab province, is such that locals are skeptical of outsiders and therefore unwilling to talk freely. In order to conduct interviews, one has to go through local elders or local *Chaudhry*, who in turn may make the connection with peasants and small farmers. Initially the local *chaudhrys* were skeptical, but upon learning about the purpose of this research became more cooperative and made arrangements for interviews in their respective sites.

Instead of tilling their own land, most landowners in the areas selected for field interviews had leased their agricultural plots to tenant farmers, and seemed unaware and to some extent indifferent to the problems (attributable to climatic changes) faced by farmers. On the other hand, farmers were acutely aware of changes in weather patterns unfolding in their respective regions, and were excited to share their experiences and coping responses. Almost every farmer shared the frustration about the non-availability of weather forecast from the local meteorological department. They argued that they would have a better chance for preparing for the changing weather conditions if they had access to weather forecast well in advance. Interviews were semi-structured, and each lasted between two to three hours. Interview transcripts were later coded in NVivo - a Computer Assisted Qualitative Data Analysis Software (CAQDAS) - and themes and subthemes identified.

A brief introduction of the three sites is as follows:

Muridke: Located near Lahore in the Rice/Wheat (Punjab) agro-ecological zone in the central Punjab, temperature trends in Muridke are relatively least extreme of the three sites. Additionally, being an upper riparian, it has comparatively easy access to abundant irrigation water. The area is semi-arid, and most rainfall takes place in the monsoon months of July and August. The main crops grown here are wheat (in winter), rice, and sugarcane (in summer). The nearest meteorological gauging station is Lahore.

Ali Pur: Ali Pur is located in the Cotton/Wheat (Punjab) agro-ecological zone near Bahawalpur, and historically has a hot and dry weather during summer season. Low humidity makes it an ideal place to grow cotton, the region's most important cash crop. Rainfall is significantly below that recorded in the central parts of Punjab. In addition to cotton, the region is famous for sprawling mango orchards, a crop that too requires hot and dry summer months for cultivation. Despite cotton being the most important cash crop for local farmers, there is a sense of pride associated with mango cultivation in this part of the country, owed in large part to the fruit's cultural importance. Monsoon rains are comparatively less strong than in the upper and central parts of Punjab. Almost all crops in this region are irrigated, and depend on a timely supply of the Indus stream-flows. Winters are short and temperate, and most commonly grown winter crops are wheat, sugarcane, guava, and citrus fruits.

Hatri: Located near Hyderabad district in Sindh province, Hatri has hot and dry summers, and relatively warm winters, making it an important and fertile part of the "cotton belt" in Pakistan. Rainfall is elusive, and mostly occurs in the months of July and August. Bananas, mangoes, and wheat are important crops in addition to cotton. Reliance on availability of irrigation water is the highest for cotton cultivation, the most important cash crop for the region.

Interview transcripts are analyzed using NVivo 12. Line-by-line coding of semi-structured interviews in NVivo is used to identify important themes and subthemes from respondents' answers to open-ended questions. These themes are discussed at length in this section. Additionally, word-clouds and hierarchy diagrams generated from NVivo graphically depict farmers' perceptions of various manifestations of climate change, as well as key coping strategies employed.

Long-term records of crop production, yield, and cultivation patterns are obtained from the Agriculture Department of Pakistan. These include long-term time series of cultivation areas, production quantities, and yields for major cash and staple crops for the period 1961-2019.

Climate change as perceived by farmers:[18]

Although none of the farmers interviewed explicitly invoked the term climate change, almost everyone noted that something is up with the meteorological calendar: rainfall has both shifted (temporally as well as spatially) and become erratic; springs are significantly warmer; winters have shortened in length; cold snaps, heat waves, and flash floods have increased in frequency and intensity; diurnal temperatures have increased, etc.

Interviewees mentioned water shortage in canals as the most consequential factor affecting their livelihoods, although none of them was certain about what might have caused it. The vacuum left by the lack of information about changes in the hydrological

[18] Information and themes presented in this section are based on farmers' interviews in the three field sites.

Fig. 5. 1: Map of Pakistan with field sites identified

system was filled by conjecture and preexisting ethnic and political rivalries as well as mistrust of the government and corrupt public officials. For example, farmers in Ali Pur (southern Punjab) were convinced that water shortage in their fields is the work of influential farmers in the upper riparian part of the province who dominate the local and national political and administrative institutions, and therefore have influence over irrigation officials to get a larger share of irrigation water. The pejorative term "*Takht-e-Lahore*", the imperial throne of Lahore (Punjab's provincial capital), was used frequently by farmers in Ali Pur to refer to the provincial government of Punjab, who they believe is unconcerned about their troubles.

The roots of this anger can be traced back to historical grievances between the Saraiki-speaking people of the southern Punjab region and the Punjabi-speaking, more affluent and influential elite of the central Punjab (Alavi, 1972). For decades, the Saraiki people have demanded that the province of Punjab be split into two separate administrative units, so that they can have their fair share of resources including renewable fresh water from the Indus. Palpable anger among farmers due to their worsening economic situation has provided political entrepreneurs with an opportunity to utilize preexisting political fault lines, and recruit members to mount a political movement to achieve policy change vis-à-vis farm subsidies and financial handouts for farmers. Although the goals of this movement remain narrow, at least for the time being, identity work is underway where political entrepreneurs invoke historical grievances to motivate their current members and attract new ones.

Similarly, Sindhi farmers in Hyderabad were the angriest about shortage of water in the Indus river, and openly blamed Punjabis for stealing their water. They lamented that the Indus River, once a lifeline of the ancient Indus Valley civilization, has been reduced to the size of a narrow strip of muddy water.

> Punjab has turned our *Sindhu darya* (the Indus River) into a *nullah*. They steal our water in times of our need, but whenever there are floods, they divert floodwaters toward us to protect their cities and lands and destroy ours. They don't even give

> us a warning. Punjab treats us the same way as India treats Pakistan – like an enemy. (A farmer in Hatri)

Using the same logic, farmers in Muridke (central Punjab) vociferously blamed the upper riparian India for stealing Pakistan's waters.

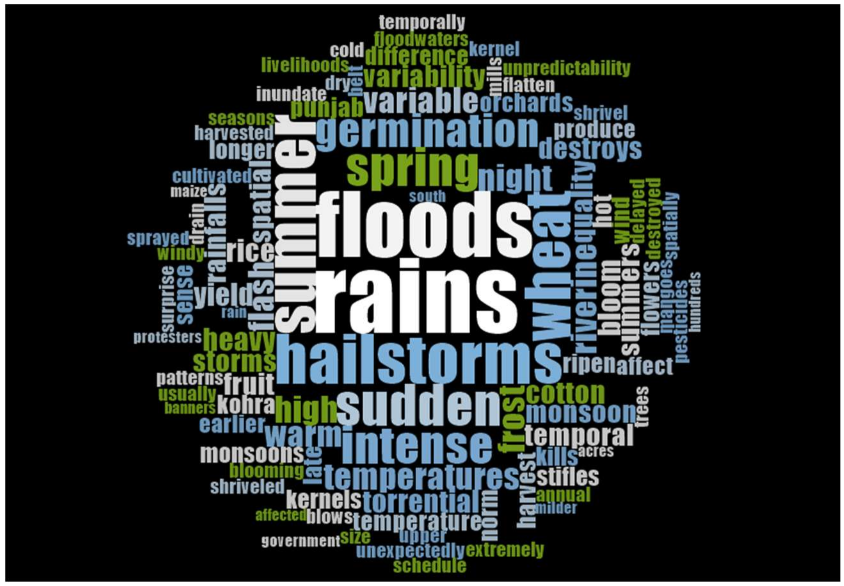
> I have no doubt in my mind that India is stealing our waters. This is the biggest reason why we have water shortage. India is building dams on our rivers in clear violation of the Indus Waters Treaty. (A farmer in Muridke)

Despite the fact that so far there has been no violation of the Indus Waters Treaty, the perception of India stealing Pakistan's waters is widespread among a large section of the population.[19]

From the interviews, farmers appeared to be keenly aware, arguably more insightful than government officials in related agencies, of the nuances of the changing weather patterns and their impact on their livelihoods. Figure 5.2 shows word clouds generated from content analysis of interview transcripts. Varied font sizes represent frequency with which respective words were used by the respondents, and allude to the emphasis placed on certain manifestations of climate change. Whereas erratic rainfall and unseasonal temperatures appear to have dominated their attention, water scarcity is the biggest impact affecting farmers' livelihoods. Almost every interviewee mentioned that water requirements for irrigation have increased substantially in response to changes in weather patterns. Fig. 5.3 graphically ranks, as per farmers' observations/perceptions,

---

[19] India is stealing water of life, says Pakistan, *Independent*, March 26, 2009; Farmers protest Indian water aggression, *Dawn*, September 07, 2009



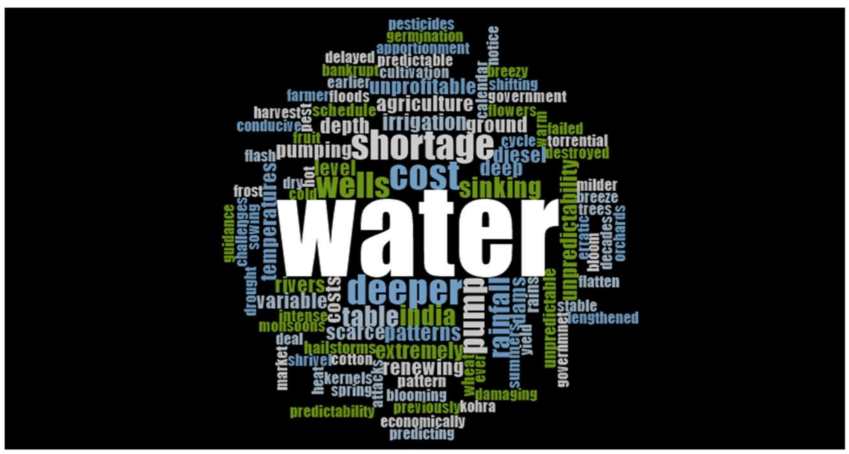


Fig. 5. 2: Word clouds auto-generated from interview transcripts. Above) Varied manifestations of climate change. Below) Effects of climatic changes on society and farmers' livelihoods

varied forms in which climate and weather patterns are reported to be changing in Pakistan's rural areas. These changes as well as their effects on agricultural practices are discussed next.

1. Warm and short winters, cold snaps, and frost

One of the direct effects of climate change that has been witnessed throughout the country, and was brought up by every farmer interviewed for this research, is the early onset of summer and lengthening of its duration. The effect has been a shifting of sowing and harvesting schedules. Winter crops need cooler temperatures in which seeds can germinate and grow into saplings. Since hot weather now extends into late fall, sowing schedule of winter crops, the most important among them being wheat, has been pushed back by up to two months (from Sept. to Nov.). Wheat sowing in central Punjab now takes place at the end of November, instead of mid-September to early-October, as was previously the case.

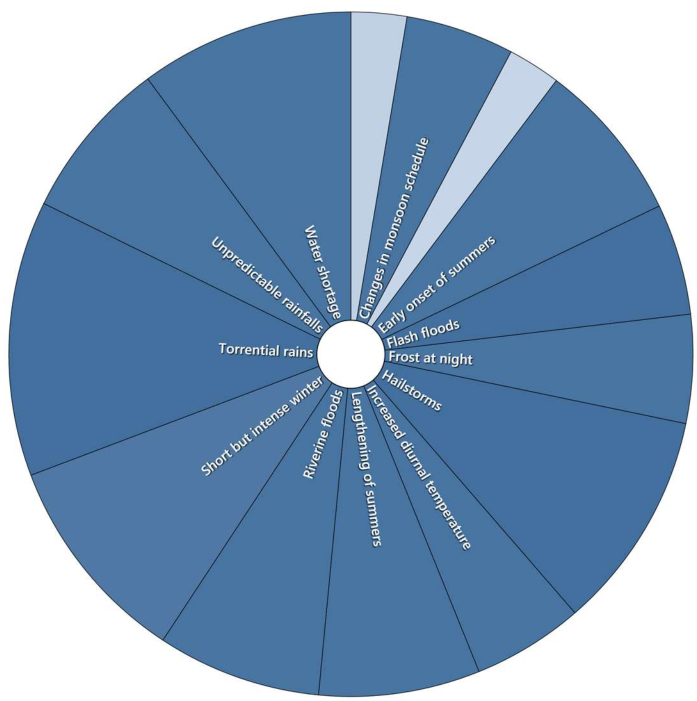


Fig. 5. 3: Varied forms of climate change based on farmers' interviews

In Sindh, where temperatures start to rise earlier in the year, delayed sowing of winter crops translates into shortening of growth duration, which in turn leads to forced maturation, and ultimately a smaller yield. Weaker grains, being smaller in size, are valued less by buyers and result in income losses for farmers.

In both Sindh and Punjab, farmers reported sharp drop in temperatures during winter, especially around the months of December and January when wheat crop is too young to withstand harsh weather. Called *kohra* or *paara* (frost), caused by sudden drop in temperature at night, the phenomenon results in freezing and ultimately shriveling or even dying of the wheat kernel. In sugarcane, it decreases sucrose content by crystallization attributable to freezing at night followed by de-freezing during the day. Fruit trees, too, are highly sensitive to sudden temperature variation. Farmers in Ali Pur reported that several of their crops have been damaged or failed due to frostbite in the past few years alone.

Local agriculture departments advise farmers to create smoke under plants to artificially create warmth. In addition to burning dried cattle-dung for this purpose, farmers in Hatri burn used tires to create a thick sheet of smoke that would envelop the fields and keep plants warm. The same practice is followed by farmers in Ali Pur to protect their crops from frostbite.

Warm and short winters, as well as frost and cold snaps increase demand for irrigation water for winter crops, which are in early phase of growth at that time. However, the hydrological cycle of the Indus River is such that stream-flows are historically smaller during winters. Less water means smaller yield, or worse, crop failure.

In southern Punjab and Sindh, where water scarcity is much greater as compared to the upper riparian central Punjab, most small and medium farmers have abandoned growing wheat due to the unpredictable weather as well as lack of irrigation water to counter the changing climate trends. Of the farmers interviewed for this research, three-fourths in Ali Pur and Hatri noted that they have abandoned growing wheat for commercial purposes. Only the relatively affluent farmers with comparatively large landholdings and better access to irrigation water continue to grow wheat on a commercial basis, although they too reported reducing their cultivation areas. Responses from farmers in Muridke were different, however, due to better access to irrigation water during winter season, and therefore higher capability to withstand vagaries of the changing weather patterns.

2. Warmer spring, lengthier and breezier summer:

Another notable development in local weather trends, as reported by interviewees, is the warming of the spring season. In the lower parts of Sindh and Punjab, there is a recent trend of temperatures rising as early as in February/March. Farmers also reported that the frequency and intensity of heat waves has increased in spring season.

Spring season is critical for farmers as it is when their wheat crop is in the final stages of growth. Historically, a gradual increase in temperatures through spring season would result in proper ripening of wheat kernel and a decent yield for farmers. Now, a sharp increase in temperatures results in higher evapotranspiration, which in turn leads to an increased demand for irrigation water for crops.

Unseasonal heat waves in Pakistan have increased by nearly fivefold in the last three decades (Chaudhry, 2017). They are the most destructive when crops are in the early phase of growth, and when combined with reduced availability of irrigation water.

> We don’t know about climate change. All we know is that seasons have shifted. Summers are longer and stretch well into October. It delays our cultivation schedule. After short winters, weather starts to heat up early in the year. Our crops grow prematurely, resulting in smaller grains and lower yield. From a distance, plants look healthy but grains are much smaller because they don’t get enough time and water to grow fully. (A farmer in Ali Pur)

Spatial variability:

In addition to temporal variability, weather patterns are exhibiting spatial variability as well. Regions of Sindh, and southern parts of Punjab, previously known for hot and dry summers, are now experiencing milder temperatures. Interviewees mentioned that a big part of this change is unseasonal breeze that lowers the temperature. Summer nights are cooler than they used to be. This is a recent phenomenon, as no one among the interviewees had experienced it before.

Breeze not only slows down blooming of cotton bolls and shedding of their protective cover, often it causes cotton bolls to fall off, reducing crop yield.

> Breeze makes us shake in our boots, because we know that it will destroy our yield. This is something we have never had in our region before. All our business runs on credit from local moneylenders. Poor crop in one season is not just a temporary loss that we can recover in the following season; it pushes us further down in the debt spiral. (A cotton farmer in Hatri)

Mild summer is bad not only for cotton, it also affects other crops that require hot climate for cultivation. A banana farmer in Hatri noted that he had lost half of his crop due to lower temperatures in summer, while loss to cotton crop was twenty-five percent. In the same area, an intense heat wave in spring season had destroyed twenty-five percent of wheat crop.

3. Changes in minimum and maximum temperatures:

Another notable change observed by local farmers is regarding changes in daily minimum and maximum temperatures. Interviewees in all three agro-ecological zones observed the phenomenon, albeit in different seasons. A farmer in Muridke observed that pest attacks markedly increase when diurnal temperatures (difference between min. and max. temperatures in a 24-hours cycle) increase in the winter season, while those in Hatri and Ali Pur mentioned the same phenomenon taking place in summer. The effect, as per their observations, is that a change in diurnal temperature provides pests an ambient temperature to complete their lifecycle much faster. If not destroyed immediately, these pests multiply overnight and can infect an entire field in a matter of less than a week.

Farmers in Hatri mentioned that despite more than doubling their pesticide use, they are unable to get rid of the pests.

> We used to have pests before, but they would never go beyond the larval stage. Now, if we saw a pest laying eggs on even one leaf of a plant today, by the week's end it will have spread to the entire field. We spray pesticides but they don't work anymore. Either these pests have developed resistance, or we are

being sold counterfeit drugs. The only way we can get rid of these pests and stop them from spreading to other plants/fields is to uproot the entire plant(s) and bury it deep into the ground. (A cotton farmer in Hatri)

We are at a loss as to what to expect vis-à-vis weather. One year temperatures are normal, rainfall is timely, and we have a bountiful harvest. The next year, temperatures change, or rains don't come, or come at wrong times, and we have these deadly pests that won't go away, no matter how much pesticides we spray on them. (A wheat farmer in Muridke)

Pest attacks have been the deadliest for the cotton crop, resulting in its failure at least four times in the last ten years alone. Farmers in Sindh reported that pests such as whitefly, armyworm, mealy bug, big bollworm, are particularly lethal. Since ambient weather for their growth is now all year long, larval population lurks below dried leaves even after the harvest, or under the soil in pupal stage[20]. Since wheat or other winter crops are sown in the same fields after the cotton harvest, these pests transfer to the next season crops, and cause widespread crop failure and (or) reduced crop yield.

4. Unpredictable rainfall, flash floods, and hail storms:

Rain, if occurred around the time of sowing is usually considered as help from heavens. However, this blessing turns into doom if it arrives at the time of harvest. Conversely, if delayed by even a few weeks at the time of sowing, it stunts growth of saplings, and reduces crop yield.

[20] Threat to wheat crop in cotton fields (2003, December 15), *Dawn*

Unbeknownst to farmers in Punjab and Sindh until recently, unseasonal rains and hailstorms during spring season have become a regular feature in the changed climate of the country. Unseasonal torrential rains damage crops in many ways: for crops ready for harvesting, they dampen the produce, resulting in either shattering of grains, or introducing fungal infection in it; for plants still in ripening phase, rains abruptly stop or slow down the germination process, and cause wilting of wheat kernels, thereby reducing grain quality and yield.

Spatial and temporal variability of rainfall, particularly sudden downpour of enormous amount of rain in just a few hours, has perplexed farmers in southern Punjab and Sindh where heavy rains were not a common phenomenon until recently. Hailstorms in both central and southern Punjab in spring season are not just unseasonal and even unprecedented; they have the most devastating effect as crops at that time are nearing the harvest phase.

In Ali Pur, mango and guava farmers reported that their crops have become alternate-bearing due to weather fluctuations. Since this variability in precipitation patterns is both temporal and spatial, it is impossible for farmers to prepare in advance for the upcoming weather change.

A few examples of spatial variability of unseasonal rainfall and resulting flash floods are as follows: In 2010, flash floods inundated most parts of the southern Punjab and Sindh. Some elderly farmers in Hatri noted that they had never seen as big a flood in their area in their lifetimes. In 2014, heavy rains flooded large parts of southern Punjab, claimed 400 lives, and affected 1.9 million acres of crop area; but there was not a drop of water in Hatri/Hyderabad area.

Being located at the tail-end of Pakistan's hydrological system, southern Punjab and Sindh bear the brunt of heavy rains and flash floods. Regardless of where they originate on the upstream, floodwater and swollen stream flows of Indus river pass through low lying areas of southern Punjab and Sindh and wreak widespread destruction. In order to protect heavily populated urban centers, protective dykes are broken to divert floodwaters towards open agricultural lands, causing massive losses to farmers.

5. Reduced stream flow:

Given the central role it plays in not only agriculture but in the entire political economy of the country, variability and change in the Indus stream-flows is perhaps the most consequential change affecting Pakistan's society. As discussed in the previous section, the Indus flows are exhibiting a downward trend in peak summer months when demand for water is the highest. The effect of this water shortage is a poor yield of major crops such as cotton, rice, wheat, and sugarcane. Farmers in Hatri reported that due to irrigation water shortage and variable rainfall, wheat yield has reduced from 50 maunds (traditional unit of mass equaling ≈40 kilograms) per acre to 30 maunds/acre, and cotton from 40 maunds/acre to 25-30 maunds/acre. The situation is Punjab, especially southern Punjab, is similar; farmers in Ali Pur reported that their crops, especially fruits and vegetables, have become alternate bearing,[21] with a substantial decrease in crop yield.

[21] Alternate-bearing refers to the tendency of trees/crops to produce an average or above-average crop one year, followed by a lower than average crop the next year, and so on.

Despite the fact that changes in the Indus stream-flows are directly attributable to climatic changes in the Upper Indus Basin, farmers did not make the connection between water scarcity and climate change. Whereas they considered change in rainfall and temperature patterns as "God's will," interviewees put the blame for shortage in surface water squarely on either corrupt irrigation officials or upper-riparian influential Punjabi landowners.

One of the important reasons behind this perception, as discussed earlier in this chapter, has to do with historical misgivings between Sindh and Punjab over the use of the Indus River waters. There is a long history of Sindh accusing Punjab of taking more than its fair share of irrigation water at the cost of lower-riparian populations. Additionally, there is a widespread culture in the country where powerful landowners influence irrigation officials through political pressure or bribery in order to get favorable treatment vis-à-vis water allocation (Jacoby & Mansuri, 2018; Mustafa, 2002).

Another important reason behind the lack of knowledge among vulnerable populations about the role of climate variability and change in water scarcity is a poor understanding of climatic changes unfolding in the Karakoram glaciers from where all three rivers of Pakistan originate. Since long-term hydrological and climate data of Upper Indus Basin is not readily available to the general public, there is almost no cognizance among vulnerable populations about substantial changes taking place at higher altitudes, as well as their effects on the Indus stream-flows.

Since water shortages in the Indus stream-flows are not distributed equitably, their effects on vulnerable populations are not uniform either. Being upper riparian, and home to influential landowners, water availability in central Punjab (e.g. Muridke) is higher and cheaper as compared to that in southern Punjab (e.g. Ali Pur), which in turn has comparatively better access to surface water than Sindh (e.g. Hatri), and so on. Based on pre-existing "architecture of entitlements" (Adger & Kelly, 1999) in each of these regions, there are gradations of vulnerability among their respective populations. The result is varying uncompetitive-ness among farmers across and within different regions in the country.

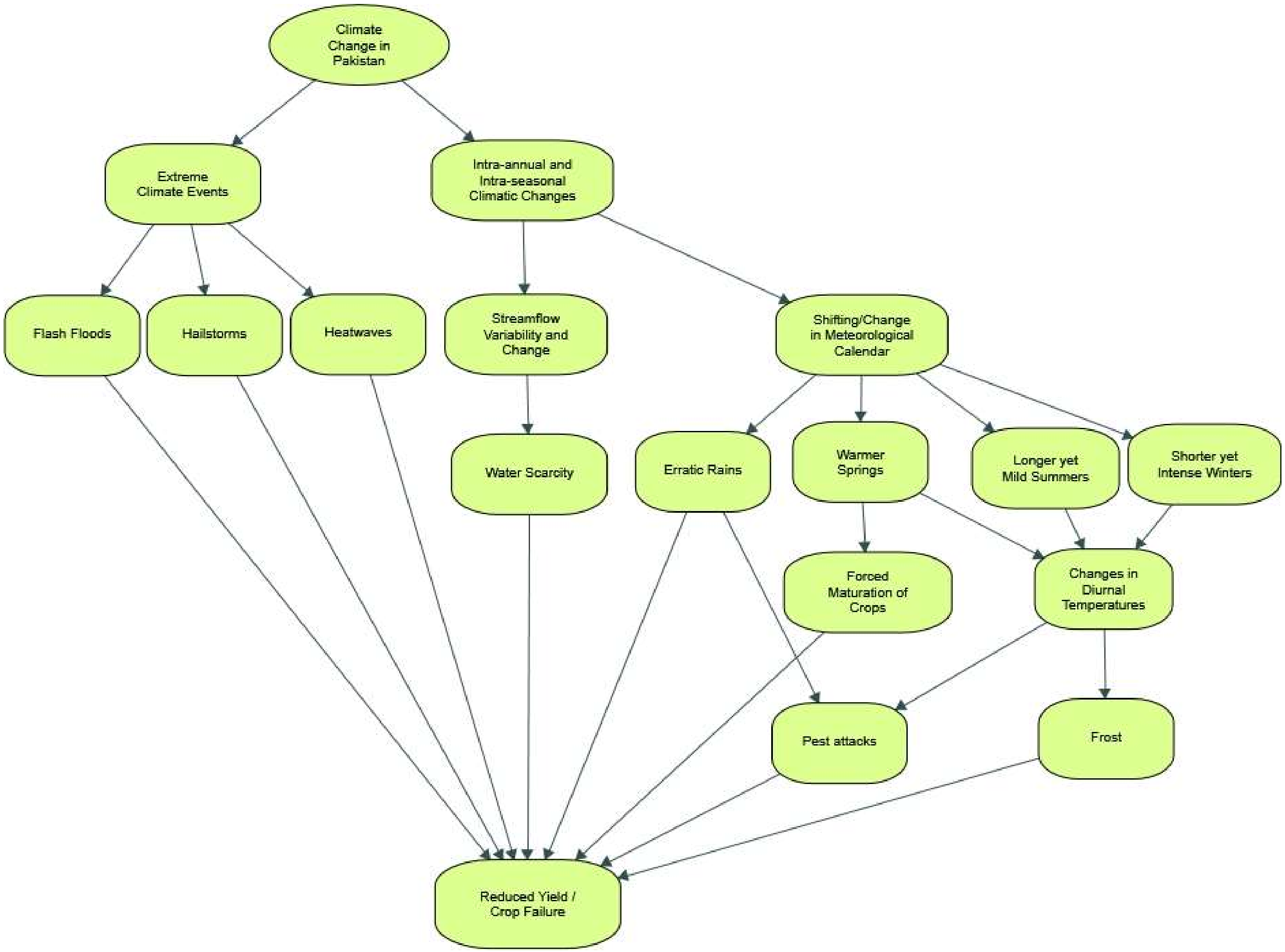


Fig. 5. 4: Climate change and its effects as experienced by farmers in Muridke, Ali Pur, and Hatri

Similarities and differences in climate stresses and coping responses in the three sites:

The purpose of opening the black box of country-year approach in this case study is to shine a light on intra-annual and sub-national variations in climate trends unfolding in Pakistan. Additionally, changing the unit of analysis from country to constituent agro-ecological zones helps in identifying coping responses employed by respective vulnerable populations.

Summarizing the findings discussed above from the three sites, following similarities and differences in climate stresses and coping responses are gleaned.

<u>Similarities</u>:

Climate stress:

One of the most common concerns shared by farmers in all three locations was shrinkage in the Indus stream-flows, especially at the time of sowing for both winter and summer crops. It is notable that the concern gets stronger as one travels from the north of the country to its south - from Muridke in central Punjab to Ali Pur in southern Punjab and Hatri in lower Sindh. The concern is in line with increasingly higher levels of scarcity from the upper riparian regions to the lower riparian ones. As discussed previously, unaware of climatic changes taking place in the Upper Indus Basin from where the Indus river and its tributaries originate, lower riparian farmers blame the upper riparian populations for this shrinkage.

The second commonly held concern had to do with the early onset and lengthening of summer season. Farmers also reported the flip side of the phenomenon, which is short but intense winters that make wheat grains shrivel and cause crystallization in sugarcane, thereby decreasing respective yields. Although farmers in all three AEZs experienced the early onset and lengthening of summer season, the only difference is the intensity of the temperature increase in the three locations and its effects on respective agricultural patterns. For example, farmers in Hatri (Sindh) mentioned that temperatures shoot up as early as in March, resulting in forced maturation of wheat kernels, which in turn leads to smaller grains and lower per acre yield. Although farmers in central Punjab are also noticing unseasonably high temperatures in what used to be spring season until recently, the rise in temperature is not as rapid as in Sindh.

Another similarity in climate stresses being experienced by farmers in all three locations is about the increase in intensity and frequency of extreme climate events. All interviewees mentioned that they are observing an increase in extreme weather events, such as hailstorms, flash floods, heatwaves, unseasonable rainfall, etc. As per farmers' accounts, there is no clear pattern except that spatial and temporal unpredictability of such climate events has increased manifold in recent years.

Coping responses:

The most common coping response observed in all three sites is increased reliance on drawing water from the aquifer for irrigation purposes. The geographical location and the corresponding water stress dictate the degree of reliance, which increases from upper riparian to lower riparian regions. For example, in the upper riparian Muridke, three out of five watering cycles needed for cultivation of wheat crop are sourced from the aquifer. In the lower riparian Hatri, climatic conditions require eight watering cycles for the same crop, of which 7 come from the aquifer. Moreover, the cost of water extraction is higher in lower riparian regions due to a sunken water table as compared to that in the upper riparian parts of the country. Farmers in Hatri reported that the cost of water extraction is one of the main reasons for their having become uncompetitive to the upper riparian farmers of central Punjab.

The second coping response most popular among farmers is intensification of agricultural inputs. As yields have plummeted across the country, farmers have resorted to increasing manifold the use of agricultural inputs to sustain production levels. Effects of longer summers as well as intense winters are countered by an increase in irrigation water. Corresponding to spatial and temporal variations in temperature patterns, water demand is higher in lower riparian Ali Pur and Hatri, as compared to that in Muridke. Since change in meteorological patterns in the country is being exacerbated by shrinkage in the Indus stream-flows, unavailability of timely supply of water, especially at the time of sowing, results in weaker saplings and higher likelihood of pest attacks. Farmers in all three locations noted that their use of both fertilizers and pesticides has increased manifold in recent years.

One of the major effects of climate change reported in interviews is shifting of meteorological calendar. Farmers in all three sites reported that they have been gradually shifting their cultivation schedule in accordance with the changed temperature and precipitation trends as well as that of stream-flow availability. Cultivation windows for most crops have shifted by as much as two months, thereby encroaching on, or reducing next season's cycle's cultivation window.

Finally, another commonality in the coping responses being adopted by farmers in the country is substituting previously profitable cash crops such as wheat and cotton with less risky, albeit less profitable crops. Those crops are considered less risky that take less time to fully grow, and therefore are less exposed to the vagaries of changing weather patterns. There has been an explosion of maize and potato cultivation in the country, especially in the southern parts of Punjab where wheat and cotton cultivation has become much riskier due to unpredictable weather, water shortage, and increased pest attacks.

Differences:

Climate stress:

One of the most notable findings about climate change unfolding in Pakistan is the spatial variability of temperature and precipitation patterns within the country. This means that historically hot and dry regions in the country are becoming wetter and cooler. This is most evident in southern Punjab and Sindh where hot and dry summers have been most important for the country's biggest cash crop, cotton. Farmers in Ali Pur and Hatri noted that cooler and breezier summers have led to the failure of cotton crop several times in the last ten years. This is something that they had not experienced in their respective regions before. In fact, the hot and dry summers had come to define the agricultural practices and crop patterns of these agro-ecological zones, earning the region the nickname, the "cotton belt" of Pakistan. However, in recent years, the downward trend of temperatures during summer season has done significant damage to cotton cultivation. Cool and breezy weather delays and/or impedes cotton bolls from reaching full bloom, thereby reducing the yield of seed cotton.

The other difference in climate stress among the three agro-ecological zones is the change in diurnal temperatures. In Ali Pur and Hatri, farmers reported that the increase in the difference between maximum and minimum temperatures, particularly during the summer months, creates a conducive environment for growth of pests. These pests multiply in days, and appear to have developed immunity against pesticides. The same phenomenon is observed in central Punjab during spring season when difference between minimum and maximum temperature in a 24-hour cycle increases, making it suitable for pests to grow quickly.

Unseasonal rains, hailstorms, as well as heat waves have come to affect the agricultural productivity in southern Punjab and Sindh much more than that in central Punjab. Heatwaves early in the year stunt wheat kernels from attaining full size and nutritional value, at times resulting in crop failure. Also, the two agro-ecological zones, being lower riparian, do not get the required quantity of irrigation water to maintain their agricultural productivity, and are being affected the most due to climatic changes.

Finally, hailstorms and flash floods originating in the upper catchment areas in the country flow through the lower riparian regions and cause widespread destruction.

Coping responses:

Since changed weather patterns are not suitable anymore for cultivating cotton as well as fruits that used to be the mainstay of their economy, farmers in southern Punjab and Sindh have resorted to switching to “less risky” crops. These crops, however, are not as profitable as cotton, and have led to a disproportionate decrease in farm incomes of lower riparian farmers. Additionally, there is a big push toward replacing cotton cultivation with that of sugarcane and rice, the major cash crops in central Punjab. Overproduction of sugarcane results in price crash, and has led to a rift between farmers and sugar mill owners. Hundreds of protests have been taken out against sugar mill owners in recent years where farmers demand higher rates for their sugarcane produce. Violent altercations between growers and sugar mill managers have become a frequent occurrence.

Changing temperature and rainfall patterns have also led to farmers in lower riparian regions of Ali Pur and Hatri abandon growing wheat for commercial purposes. However, in central Punjab, wheat remains an important crop and is grown commercially.

Effect on agricultural production

Due to an intuitive link between agricultural and natural systems, as well as popularization of the overly simplistic scarcity argument, it has been widely hypothesized that the effects of spatial and temporal changes in climate trends would be readily observable in a society’s overall agricultural production. This is hardly the case in Pakistan, at least for now. In fact, a macro-level look at the effects of climate change on agriculture shows a sustained increase in agricultural production and its share in the country’s GDP from one year to the next (Fig. 5.5). Agricultural Production Index Number, a metric used by the Food and Agricultural Organization (FAO), shows a steady increase in relative level of aggregate (price-weighted) volume of different agricultural commodities produced each year in comparison with the base period 2004-2006 (Fig. 5.6).

This does not mean that climate change has no effect on agricultural production. In fact, the effect is much more disruptive and systemic than is commonly imagined. However, understanding the full effect requires looking deeper than the surficial analysis of abstract macro indicators that mask the dynamics of both the natural and agricultural systems. This is where the interactive nature of climate change as well as the analytical challenge to study its effects comes in full view.

The current formulation of climate-security problem, as discussed in the literature review chapter, is based on the neo-Malthusian premise that climate change may cause resource scarcity, which in turn may threaten agricultural production (and therefore food security), and induce vulnerable populations to join violent insurgencies. Although sustained climate stresses such as extended drought or degradation of renewable water resource(s) may ultimately lead to such an outcome, Pakistan's case shows an intermediate picture that may lend insights about how climate change *process* degrades agricultural systems and dispossesses vulnerable populations of their livelihoods even before the final stage of total resource scarcity and food insecurity is reached.

In addition to the problematic extant formulation, there are a few risks involved with relying on macro indicators when it comes to analyzing the effects of climate change on agriculture. These risks are explained below, and may provide a backdrop for a high-resolution analysis of climate effects on agricultural productivity in Pakistan.

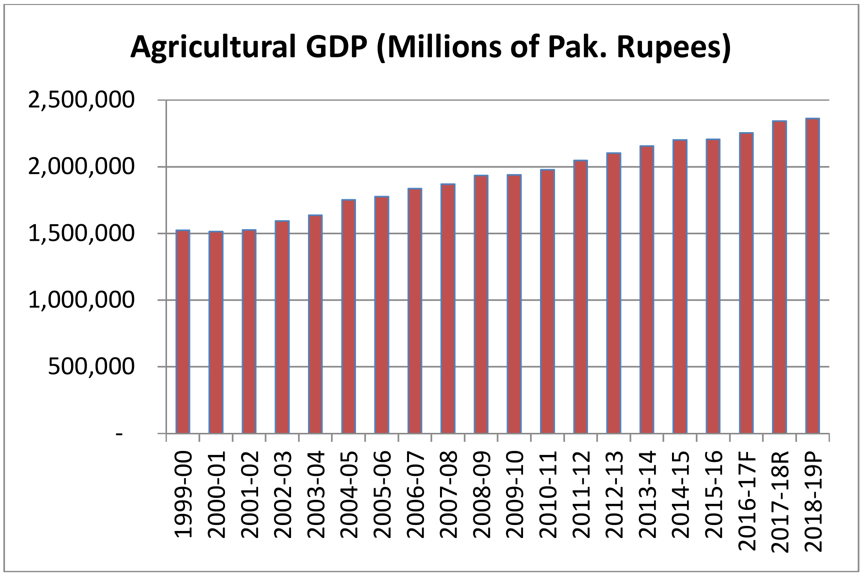


Fig. 5. 5: Agricultural GDP of Pakistan
Data source: State Bank of Pakistan

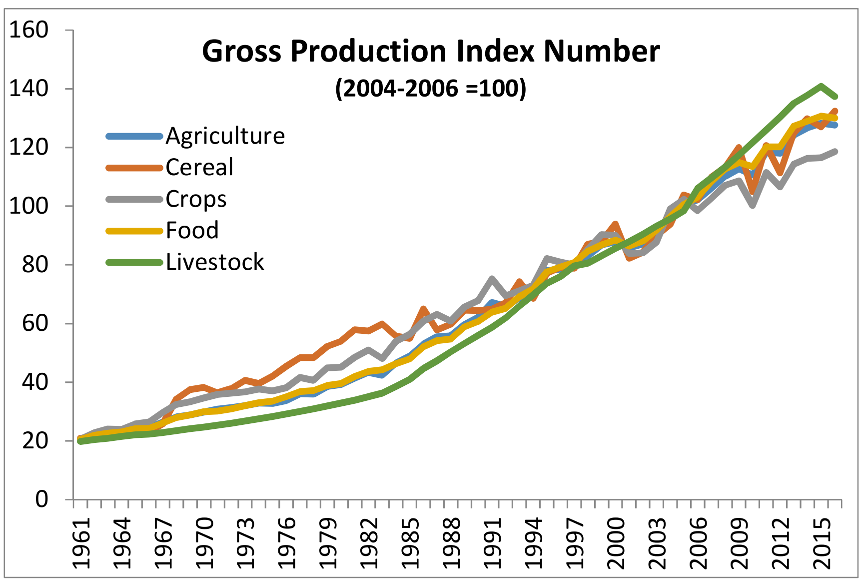


Fig. 5. 6: Gross Production Index Number
Data source: FAO

Firstly, agricultural GDP, agricultural growth rates, etc. do not take into account direct or indirect subsidies or related protectionist interventions that may influence agricultural production in a society, and even result in price distortion in global markets. In other words, the "pure" effect of climatic changes on agriculture can be adulterated or even obfuscated by protectionist agricultural policies, thereby undermining the overly simplistic neo-Malthusian logic.

Secondly, the aggregate trends of agricultural production may mask the effects on "losers" of climate change. As discussed earlier, climate change perpetuates preexisting structural inequities in a society, and its burdens fall disproportionately on the poor and vulnerable sections of society. "Winners" on the other hand, may benefit, and give the illusion that adverse effects on agriculture in a society are minimal or even non-existent.

Another risk in using macro agricultural trends as indicators of climate-induced stresses is that they do not lend insights about imposed changes in the makeup of the agricultural products as well as their effects on larger political economy of a society. Not all crops are the same when it comes to their importance in a society's political economy. In the case of Pakistan, for example, cotton is perhaps the most important crop because of the country's reliance on domestic textile industry for not only exports but also for absorption of workforce in the country. As climatic changes have disturbed agricultural patterns in the cotton growing regions of Pakistan, the effect has reverberated through the textile sector. Thousands of textile manufacturing units have either shutdown or moved elsewhere in the world, leaving behind hundreds of thousands of unemployed factory workers, not to mention the lost revenue in cotton and textile exports. As for the overall trend of agricultural production, cotton has been replaced by heavily-subsidized sugarcane and rice crops, which although make up for total agricultural production lost by cotton, are responsible for a massive sugar and rice glut in the country. In fact, since Pakistan is one of the major sugar producing countries in the world, overproduction of sugarcane has contributed to a global sugar glut, and depressed prices of sugar in the international market. Moreover, since agricultural GDP does not include subsidies provided to agricultural sector, or reports the preferential treatment (as well as distributional conflicts) with regards to renewable resource allocation, such as irrigation water, it may obfuscate the true effects of climate change in a society.

In order to avoid these risks, this research argues in favor of looking at yield and production of individual crops at a subnational level. Being one of the top producers in the world for wheat, rice, cotton, and sugarcane, Pakistan's entire agrarian economy as well as its political stability rests on predictable and sustained yield and production of these crops. Figure 5.7 shows long-term records of yield and production of the country's major and minor crops. Aggregated at provincial level, these records provide a clearer picture as to where vulnerability lies in the country regarding climate's effects on agricultural production.

Findings from data are in line with farmers' accounts about reduction in yield, increase in cost of production, and disturbance in crop pattern. From data it can be seen that yield and production of all four major as well as minor crops have languished in recent years, particularly in the past two decades. This reduction in yield coincides with the time period when climatic changes as well as stream-flow variability in the Indus river and its tributaries became pronounced, as shown in the time series analysis earlier in this chapter.

Perhaps the biggest impact on yield as well as production can be seen in cotton where farmers reported changed climate trends and meteorological calendar affecting their cultivation cycles. Similarly, the yield for rice, sugarcane, and wheat has dropped significantly, although sugarcane production shows spikes with production falling in one year and picking up in the next only to fall back again in the subsequent year, and so on.

The overall rising trend of wheat and sugarcane, despite their falling per-acre-yields, can be explained by Pakistan's massive subsidy program aimed to provide relief to farmers of the two crops. Wheat being a staple crop is essential for food security and therefore political stability, and enjoys special treatment. Sugarcane, on the other hand, has the backing of a powerful lobby that includes political elites who are also in the sugarcane crushing business.

By looking at the sub-national trends it becomes clear that although production and yield have declined in all four provinces, the effect is more pronounced in smaller provinces of Sindh, Khyber-Pakhtun-Khwa (KPK) and Balochistan. This is in accordance with preexisting structural inequities in the country with respect to resources available for adapting to the climatic changes. Punjab, Pakistan's biggest province in terms of population, wealth, resources, as well as dominance in the country's politics, has a lot more sway over resource distribution than all the other provinces combined. Moreover, Punjab's geographical location as an upper riparian of the Indus system of rivers gives it higher control over dwindling Indus stream-flows and to offset the effects of a changing climate on agricultural production.

Figure 5.8 shows a similar picture of falling yields of an array of minor crops of fruits and vegetables. Falling yields are an unmistakable sign of the country's agriculture taking a thrashing at the hands of changing climate trends as well as water scarcity in the

Indus Basin. As will be discussed in the next section, this reduction in yield is being offset, primarily, by input intensification and haphazard crop switching; both of which are in turn exacerbating farmers' vulnerability instead of ameliorating it.

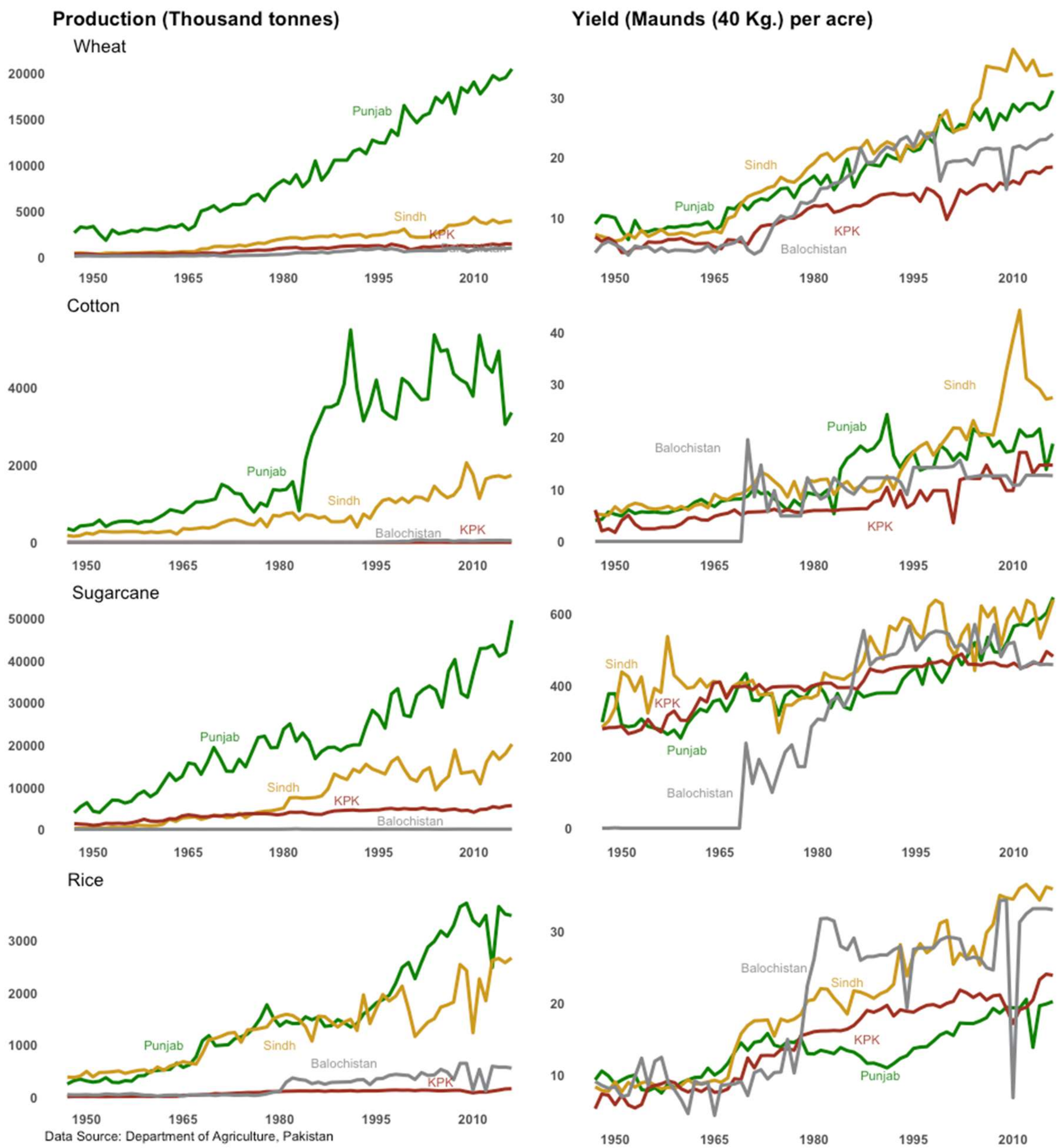


Fig. 5. 7: Production and Yield of major crops
Data source: Department of Agriculture, Pakistan

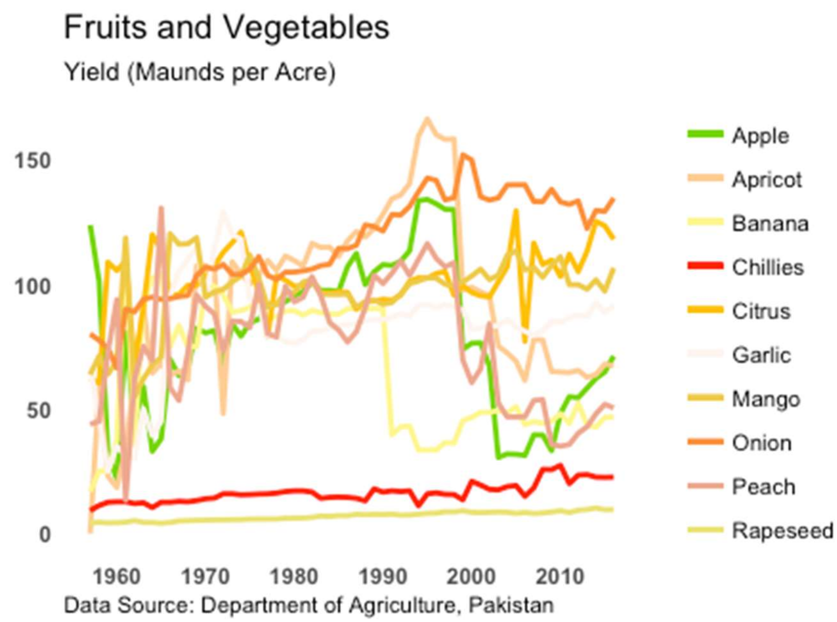


Fig. 5. 8: Production and Yield of minor crops

Data source: Department of Agriculture, Pakistan

Localized adaptation measures taken by farmers:[22]

The most noteworthy result of climate change is its effect on human behavior, specifically coping strategies employed in response to changes in the natural system. In what follows, some of the coping measures recorded in field interviews are discussed.

Groundwater overdraft and input intensification:

One of the most common responses to variability and change in the Indus stream-flows, as well as early onset and lengthening of summer season, is harvesting water from aquifer to fulfill irrigation needs. Being the low-hanging fruit in the face of shrinking and variable Indus flows, reliance on groundwater has increased exponentially in the last couple of decades.

[22] Based on interviews

The share of groundwater for irrigation use rose from 8 percent in 1960 to more than 50 percent in 2010 (Qureshi, McCornick, Sarwar, & Sharma, 2010), and to over 60 percent in 2014 (Qureshi, 2015). Withdrawing over 9 percent of the total global groundwater withdrawals, Pakistan is the fourth biggest extractor of groundwater after India, China, and the United States (Margat & Van der Gun, 2013). According to Döll et al. (2014), average annual groundwater depletion (GWD) in Pakistan between 2000 and 2009 was 3.61 km^3/yr. Since the rate of extraction in the Indus Basin region is higher than the rate of recharge (ibid), the water-table has plummeted in the last two decades to such an extent that underground water extraction is becoming financially unviable for farmers (S. Khan, Rana, Gabriel, & Ullah, 2008).

All the farmers interviewed in all three locations noted using underground water as their main source of irrigation in the face of surface water scarcity. Farmers in Muridke rely on underground water extraction for at least half of their irrigation needs. Of the five watering cycles for wheat cultivation, for example, three come from tube-wells, while the rest comes from surface stream–flow through canals. However, as one travels south in the Indus Basin Irrigation System, dependence on the underground water increases for two reasons:

The first is the location. Being at the tail-end of the irrigation system, the quantity of surface water decreases as it reaches the southern parts of Punjab and Sindh. Canal water, by the time it reaches Hatri is reduced in quantity to such an extent that it takes 5 hours to irrigate one acre of land as compared to 2.5 hours in Muridke. For wheat cultivation, farmers in Hatri reported that out of 8 watering cycles, 6-7 watering cycles are dependent on water extracted by using tube-wells. Resultantly, the cost of agricultural production there is much higher than Punjab and is directly attributable to higher cost of water extraction from the aquifer.

Second, climatic conditions in southern Punjab and Sindh are such that the role of precipitation in irrigation is negligible. Additionally, rainfall schedules have become variable, further diminishing whatever little reliance farmers had on precipitation before.

The necessity of chasing down the aquifer:

Every farmer interviewed for this research mentioned the “necessity” of using tube-wells to make up for reduced stream-flow in canals and rivers. There are over 1.2 million tube-wells in Punjab and Sindh (Qureshi, 2015), of which 0.8 million are in Punjab (ibid). In the face of the shrinking Indus flows, there is a sense of urgency among farmers regarding resorting to pumping underground water to meet their needs.

Since most electricity-operated tube-wells are rendered useless due to acute energy shortage in the country, farmers use diesel-operated Petter engines for pumping underground water. Those who do not have access to these engines attach their tractors or even motorcycles to small centrifugal motors for the same purpose. In 2015, Pakistan’s government announced a soft-loan scheme to help farmers switch to solar-powered tube-wells, but the program was shelved as the country’s economy languished. Recently, some farmers in Muridke have begun replacing their diesel-operated tube-wells with solar-powered ones, but the high initial cost is prohibitive for a large number of small and medium farmers.

The most striking observation was the disconnect between farmers' grave concern over increasing water scarcity, and their lack of understanding about the need for conserving water or using it in an efficient manner. Despite water shortage and increase in the cost of harvesting water from the aquifer (Qureshi, 2015), flood irrigation remains the most popular technique. Not a single farmer among the interviewees used efficient irrigation techniques such as drip or sprinkler irrigations.

Farmers lamented that water extraction is their single biggest expense. The only recourse in the face of falling groundwater tables is to dig deeper and deeper, which in turn drives up the energy requirement for pumping the water. Also, since renewing the tube-well boreholes requires significant upfront cost, only affluent farmers can afford to extract water from higher depths.

During interviews, farmers in Muridke reported relatively higher water table (>160ft), as compared to that in Ali Pur (>200ft). All of them noted its rapid sinking, and the need to renew boreholes every season.

Given the fact that recent studies have found extensive Arsenic contamination in Pakistan's groundwater (Podgorski et al., 2017; van Geen et al., 2019), rapidly increasing reliance on underground water for irrigation and drinking needs is nothing short of a public health hazard for a vast majority of population of the country.

Input intensification:

Just like the dropping of water table, input intensification takes place in a gradual manner over a period of time, until it becomes ineffective and (or) economically infeasible. Farmers noted that the use of water, fertilizer, and pesticides has increased manifolds in recent years as a result of variability and change in the country's weather trends. Water requirement has increased due to both, increased evapotranspiration due to hotter spring season as well as reduced growth period for crops. In cold snaps and frost, additional irrigation water helps saplings fight rapid temperature change. Fertilizers are used to compensate for water shortage at the time of sowing. Fertilizers provide nutrients to saplings whose growth may be stunted due to shortage of water in the early phase of plant growth. Finally, pesticide use has increased manifolds in response to increased pest attacks. The combined effect of the three has been an inordinate increase in the cost of production.

Impact:

1: Loss of competitiveness:

The combined effect of scarcity of irrigation water in canals, additional cost of groundwater extraction, and input intensification is the loss of competitiveness in vulnerable populations vis-à-vis agricultural production. This loss in competitiveness is not equitably distributed, and overlays preexisting inequities in Pakistan's society. Those who can afford to access cheaper state-subsidized surface water, either through political influence or by bribing irrigation officials, or just by virtue of their geographical location, have comparative advantage over others. Similarly, those who can extract underground water comparatively cheaply can produce agricultural products efficiently as compared to those living in areas where the water table has sunk too low to render extraction economically feasible.

Although inequitable access to scarce water may appear to be creating winners and losers among farmers, Pakistan's agriculture sector as a whole has become less competitive due to an increase in the cost of production. Selling locally produced agricultural products is becoming increasingly difficult and is one of the key reasons of social unrest among farmers. Local farmers losing their share of domestic commodity markets is resulting in traders importing cheaper agricultural goods from elsewhere in the world.

> No one buys our wheat at the government's set-up price. We are forced to sell it at a loss to middleman. Government says its stocks are already full. Procurement centers are always closed. It is easy to sell dirt, but more difficult to sell our wheat. (A farmer in Muridke).

> It is a shame that our government allows importing of cheap wheat, cotton, as well as minor crops such as tomatoes, potatoes, onions, etc. from India, while we grow the same crops here at home. Instead of helping us, the government is carrying out our economic massacre. We are bearing losses in every crop. Very soon farmers will have no other option but to commit suicide. (A farmer in Hatri)

> I cultivated twenty acres of sugarcane this season in the hope that I'd be able to generate enough money to marry off my daughter. But sugar mill owners have refused to buy my produce at the support price set up by the government. I am forced to sell it at a loss just so I can pay the rent to the landlord. I am already under a pile of debt from losses in other crops. (A sugarcane farmer in Ali Pur)

The net effect is that agriculture has become economically infeasible for a large number of farmers. Farmers, who for generations have relied on certain agricultural practices and cultivation patterns, now suddenly find them unprofitable. Since almost all of Pakistan's agro-based industries rely on cheap (locally produced) agricultural commodities, increase in the cost of agricultural production has translated into an increase in the cost of manufacturing, and ultimately increase in consumer prices.

2: Unstable crop patterns:

Another impact of instability brought about by climate stresses and the resulting loss of competiveness is manifesting in the form of unstable crop patterns. Approx. three-fourths of farmers interviewed in Hatri and Ali Pur reported that they have abandoned growing wheat on commercial basis due to water shortage and increased cost of production. The situation is not very different for other major crops, and the effect is visible in cultivation patterns across the country. Growth rates of major agricultural products have declined in the last few years (Spielman, Malik, Dorosh, & Ahmad, 2016a).

However, since there are not a lot of high-value alternative crops that would yield enough income to support their families, farmers play it by ear when it comes to making decisions for cultivation for the next season. Figure 5.9 shows that cultivation areas of major crops have hit a plateau. The jagged spikes in the graph in recent years depict the yo-yoing of cultivation areas in four major crops. These trends are consistent with findings from field interviews where farmers noted that their decisions regarding cultivation have become highly dependent on weather conditions.

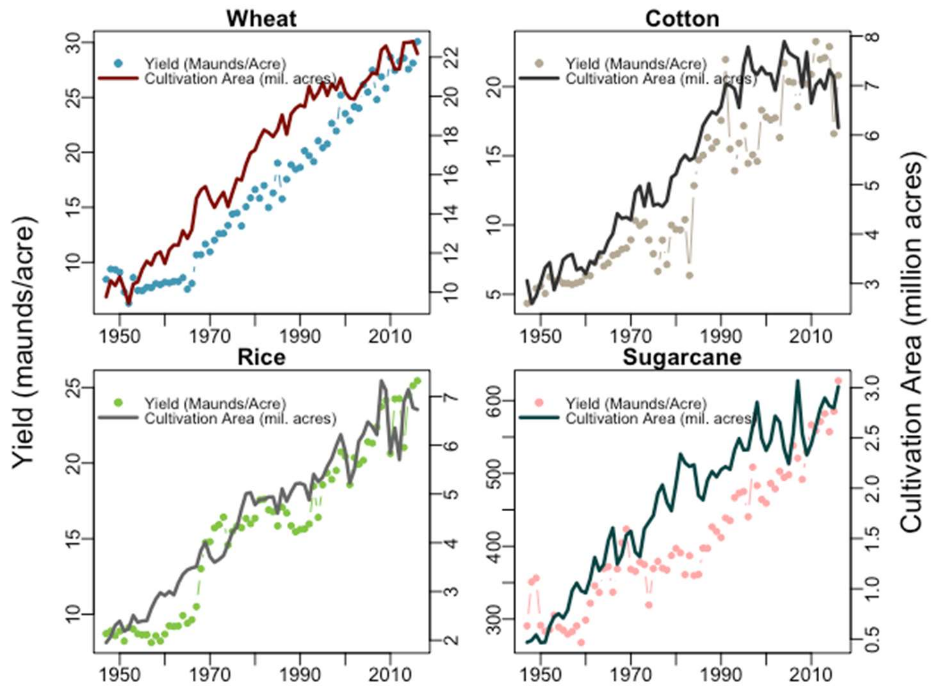


Fig. 5. 9: Change in cultivation areas for major crops

Data source: Agricultural Statistics of Pakistan, Ministry of National Food Security and Research

> Most of our agriculture is now based on guess-work. When rains are good and there is abundant water for our crops, we have better yield and more area is under cultivation. Most of our crops have become alternate bearing. (A farmer in Ali Pur)

> My family has been growing wheat for generations. Wheat used to be the easiest and the most risk-free crop to grow. One could get average yield with only a smaller amount of water and relatively stable weather. Now, even after spending double the amount in water, pesticides, and fertilizers, we barely get to touch average (yield). Other crops such as rice or sugarcane have been underperforming too and consistently bring less and less income. I am at a loss as to what to grow anymore. Instead of thinking about making a profit, now I spend most of my time

thinking as to which crop to grow that would result in the smallest amount of loss. (A farmer in Muridke)

Cultivation of major cash crops such as cotton, wheat, sugarcane, and rice increases when weather for relevant seasons is somewhat normal, or when water is abundant due to rainfall, or stream flows are relatively higher due to glacier melting in the Upper Indus Basin, etc. However, the flip side of this coin is that in times of better weather and higher water availability, although harvests are bountiful, excessive supply results in price crash, causing financial losses for farmers and discouraging them from cultivating the crashed crop in the next season. Shortage in the next season results in an increase in commodity prices, drawing in more farmers for cultivation and resulting in yet another glut, and so on.

Shifting of sowing schedule:

One of the most straightforward on-farm management techniques is shifting the sowing schedule to match the changing weather patterns (M. Burke & Lobell, 2010). In the face of erratic rainfalls, and change in schedules and durations of meteorological seasons, the original cultivation schedule appears to be no longer useful. For example, in most parts of Punjab and Sindh, wheat sowing has been pushed back by up to two months due to the shortening of winter season (or the lengthening of summer). The early onset of summer forces farmers in Sindh to complete their harvest by March 1. Farmers in Hatri noted that due to mild and breezy summer, their cotton harvest schedule has been pushed to mid-October as compared to early-September, which was previously the case.

Change in weather patterns is a slow process that takes place over a long period of time. Although farmers pay attention to changes in weather in the short-term, in the absence of long-term records of climate variables, the trend is not self-evident to most farmers as they deal with climate's effects in real time. It is only after considerable time has passed that they realize the magnitude of change that has already entered the system. In that regard, shifting of sowing schedules is not as much a deliberate attempt to adapt to changes in the climate. Instead, it is a coping mechanism that is practiced out of habit, and its effects sneak up on farmers when it begins encroaching on cultivation cycles of other crops.

Farmers mentioned two reasons for adopting this coping strategy:

The first reason has to do with the habit of following a particular crop pattern. Used to following a particular pattern (e.g. Rice/Wheat in Punjab, or Cotton/Wheat in southern Punjab and Sindh) with their lifestyles and agricultural practices built around it, farmers have been gradually adjusting to the new meteorological schedules almost instinctually in order to maintain their existing crop patterns and agricultural practices. It should be noted that agricultural practices and crop patterns are a function of climate and weather patterns that constitute a particular agro-ecological zone. It is not as easy to entirely abandon an existing crop pattern, and switch to another one, as it may appear to non-farmers. Moreover, since every crop pattern has a commodity market(s) built around it, changes made in farms reverberate throughout the society. As will be discussed later, depending on the level of integration in the global market, changes in local crop patterns may have implications at the global level.

The second reason has to do with the value of a particular crop for which weather patterns may have become unstable. Farmers mentioned that for high value crops, such as cotton, rice, sugarcane, etc., their tolerance level for climate variability and change is higher, as compared to low-value crops, because one good harvest may generate enough profit to cover their losses.

Impact:

For most farmers, these adjustments in cultivation schedules may have worked in the past but now they have reached a point where negative effects appear to have become dominant. For example, farmers noted that the weather suitable for cotton cultivation has shifted forward by at least two months, and has begun encroaching on the cultivation schedule of other crops that are grown in the same fields after the cotton harvest. This has affected the wheat crop as cultivation period in most wheat growing areas has shrunk considerably. Delayed or erratic rains during the sowing period, and higher temperatures in spring season, result in higher irrigation and fertilizer demand to sustain average yield. Higher temperatures in spring, if not offset by additional irrigation water supply, cause forced maturation and lower yield of wheat crop.

Similarly, the sowing schedule of cotton has been pushed back mainly in order to match water availability at the time of sowing. The Indus stream-flows have become variable with a downward trend during summer months, a time when water is needed the most for cotton planting. Since cotton-growing regions rely on surface water for irrigation, planting cannot be done until there is enough water available for irrigating the cotton fields. On the other hand, delaying cotton planting by even a few weeks affects germination and results in poor fibre quality and lower yield. Cotton prospects have dwindled in Pakistan in recent years, and there is a downward trend in cotton cultivation areas (Fig. 5.8).

Crop switching

Variability and change in climate and weather patterns has left farmers confused. Whereas keeping with agricultural practices that they have employed for decades has become difficult, adopting new ones is not coming easily either. The concepts of "efficient adaptation" (Mendelsohn, 2000) and "crop switching as an adaptation strategy" (Kurukulasuriya & Mendelsohn, 2008) are being put to test in real time as farmers struggle to adapt and switch from one crop to another.

An important consideration in this regard has to do with the process of selecting substitute crop(s). Field interviews revealed that although economistic cost-benefit calculations are a starting point in deciding whether or not to continue with extant crop patterns, choosing substitute crops for cultivation is not necessarily a result of an exhaustive analysis of alternative scenarios. Farmers were although quick to share their rationale, which entailed back-of-the-envelope cost-benefit calculations as to why they abandoned cultivating a particular crop(s), the answers regarding choosing substitute crop(s) were not very sophisticated. In the absence of complete information about climate trends and weather forecasts, unsurprisingly, most crop switching decisions were not based on an exhaustive analysis of all possible alternative scenarios. Instead, the single most prevalent concern shared by struggling farmers was to minimize risk and resolve uncertainty imposed by weather unpredictability, pest attacks, water availability, or surprise floods, etc.

Farmers in Ali Pur and Hatri appeared to be more vulnerable due to much less access to resources necessary for adaptation; and mentioned the risk of changing climate and weather trends to be the biggest factor in their decisions regarding crop switching. Almost everyone in both these locations reported to have replaced wheat with maize cultivation, not because maize cultivation maximized profit, but because the cultivation time is significantly less as compared to wheat or other cash crops that take longer to grow and require much more resources for successful cultivation. Shorter cultivation time, farmers explained, means less exposure and therefore less risk of being disrupted by unpredictable and unseasonal climate effects.

> We get two or even three harvests of maize in the same time required for a single harvest of wheat crop. Profits are low, but it is less risky given the unpredictable rainfall and water scarcity, as well as pest attacks that don't seem to go away. (A farmer in Ali Pur)

Another crop that has recently become popular among farmers as a substitute crop is potatoes, whose cultivation has skyrocketed in recent years. Since both maize and potatoes are grown all year long, their production has increased manifolds in a short amount of time.

As profits have dwindled in agriculture, an increasing number of farmers have begun switching to cattle farming. There is an increasing trend in southern Punjab where cattle rearing, primarily for the purposes of exporting meat has become widespread in recent years. Since maize is used primarily as fodder for cattle, an increase in its cultivation can be explained by the corresponding increase in cattle production. Figure 5.10 shows long-term trends for potatoes and maize cultivation as well as cattle rearing and meat exports.

Spatial change in crop patterns:

In addition to switching to alternative crops, changing weather trends, especially spatial variability of rainfall and temperature patterns in southern Punjab and Sindh, have led to an increase in sugarcane cultivation in regions which were previously known for growing cotton. The same is true of rice cultivation in previously hot and dry areas that have become prone to erratic rainfalls and humidity in recent years. An increasing number of previously cotton farmers in Sindh have resorted to growing sugarcane and rice in order to exploit the spatial variability and change in weather trends, as well as to avoid uncertainty and risk involved with growing cotton in the changed environment.

Impact:

1: Low profits

Although switching to low-risk crops, such as maize and potatoes has helped reduce exposure to the climate stressor, it has resulted in significant reduction in farmers' income. Pakistan's export-oriented agro-based industry is designed around high-value crops such as cotton, rice, and sugarcane, or staple crops such as wheat. Demand for potatoes and maize is comparatively much smaller, and their production barely profitable.

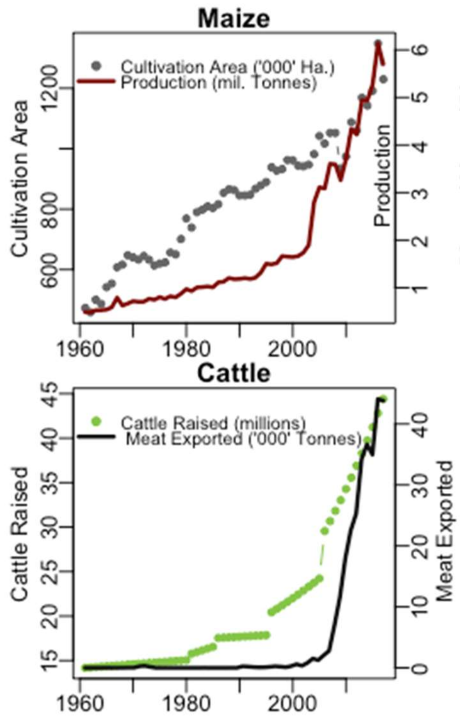


Fig. 5. 10: Crop production trends in Pakistan
Data source: FAO STAT

Additionally, since all famers in a village, town, or agro-ecological zone are faced with similar climatic uncertainty, their thinking regarding crop switching converges by interacting with each other, thereby resulting in widespread adoption of the same substitute crop by a large number of farmers. This behavior, although achieves farmers' short-term goal of avoiding the immediate risk (of unpredictable weather), it often results in a glut and price-crash in local commodity markets. In the last few years, prices of sugarcane, potatoes, maize, rice, cotton, and wheat have crashed several times due to overproduction, and bankrupted a large number of small and medium farmers.

Farmers in Punjab have been struggling to get even a breakeven price for their crops. Frustrated farmers set their crops on fire, both as an expression of frustration as well as a cost effective way to clear the field for next cultivation cycle.

> I once grew maize as a replacement for wheat, only to find out that everyone in my village had done the same. The result was that market price crashed due to oversupply. It was so bad that harvesting the crop did not make economic sense, and I had to clear the land by running tractor through ready-to-harvest plants in order to prepare for next season's cultivation. (A farmer in Hatri)

2: Unstable commodity markets:

The combined effect of climate change, uncompetitive-ness attributable to climate stresses, and uncoordinated (haphazard) crop switching has resulted in unstable commodity markets. As farmers try to switch away from previously profitable crops on account of climate risk and (or) increased cost of production, the shortage of those crops in local markets raises the price just enough to lure them back in the next season. This instability is evident from cultivation trends in recent years where a sharp drop in cultivation areas of major crops is followed by an equally sharp increase in the following year, and so on.

> When we have bumper crop (above average yield), the price in the market drops and we can't get even a break-even price for our produce. The same thing happens to whichever other crops we switch to in order to cover our losses. We are bearing losses in all crops. It is as if we are caught in a trap and can never escape. (A farmer in Ali Pur)

Although the supply-demand principle is usually used to explain fluctuations in commodity markets, such fluctuations in Pakistan have become too frequent to render crop patterns stable. This instability affects Pakistan's agro-based industries as well. As discussed earlier in this chapter, most of Pakistan's manufacturing units were built around consistent and predictable supply of locally produced agricultural goods. As a result of changing crop patterns due to climate stresses as well as commodity market volatility, agro-based industries in Pakistan have been struggling to stay in business by importing cheaper agricultural inputs from elsewhere in the world.

Interaction with global commodity markets

At the same time that intermittent crop failures, increased pest attacks, falling yields, rising cost of production, etc., have thrown local agriculture industry into disarray, they have also exposed Pakistan's already vulnerable farmers to international competition on the other. As local farmers struggle to plant their crops on time due to shifting weather patterns, and (or) face an increase in the cost of production due to input intensification and water scarcity, etc., Pakistan's government allows the import of foreign agricultural goods to ensure food security as well as to keep food prices in check. Similarly, Pakistan's agro-based industry, facing an existential crisis due to an increase in the cost of local agricultural raw material, in addition to other problems such as acute energy shortage in the country, has begun importing cheap raw material from elsewhere in the world. Import of cheap cotton, for example, has become a lifeline for the country's textile industry that finds locally produced cotton much too expensive, not to mention its unreliable availability due to frequent crop failures as well as fluctuating cultivation trends. The situation is no different for other crops such as sugarcane, wheat, rice, etc., as well as vegetables, whose high cost of production, lower yield, and fluctuating cultivation patterns have rendered them unaffordable.

Importing of cheaper agricultural products through international trade has helped keep food prices from spiraling out of control, and kept local agro-based industries afloat. However, it has also increased vulnerability of local farmers who find it hard to compete against highly competitive and efficient agriculture sectors in other countries in the world.

> How can we compete against the outside world when we have no water for irrigation, no electricity, no crop insurance, and very high costs for fertilizers and pesticides? If provided subsidies on agricultural inputs, we will prove that we can outperform any nation in the world. (A cotton farmer in Hatri)

> Instead of supporting our own farmers, our government has allowed importing of cheap commodities from India where agriculture is highly subsidized, irrigation water is plentiful, and electricity always available. We demand that import of sugar, cotton, potatoes, onions, tomatoes, and all other agricultural items be stopped and an agricultural emergency imposed immediately. (A farmer leader in Ali Pur)

Exposure of local agriculture to international competition is only a part of a complex process unleashed by interaction of climate change and international trade. It is important to keep in mind that this interaction between local and global commodity markets is not always one-sided. Just as is the case in Pakistan, extreme climate events as well as variability and change in long-term climate trends have increased in almost every part of the world, and resulted in disruption/change in cultivation patterns, yields, production, etc. Similarly, the effects of coping/adaptation responses taken by respective vulnerable populations in those societies do not stay local, and are transferred to the rest of the world through international trade. These effects translate in the form of price differential between local and global prices, which, in turn, has an effect on cultivation trends.

Interaction of individual commodity markets with each other through international trade is not new. Agricultural countries have been trading their surplus produce with each other for a long time. The only difference now is that all societies, in addition to being exposed to dynamics of international trade, have become vulnerable to changes in their respective natural systems as well.

Consider two scenarios: In the first, drought (or any other extreme climate event for that matter) wiping out an entire harvest of a crop C in a country X, for example, is not local news anymore. In proportion to the market share X commanded in the global market prior to drought, the price of C may increase globally. This price increase may lure commodity traders to purchase it cheaply from farmers in other countries and pocket the difference after selling at higher price to international buyers. The outflow of crop C from these countries may even create shortage in their respective domestic markets, which in turn may lead to social and political unrest. Anticipating the demand for C to linger for some time, farmers in some countries may consider growing more of C in the next season, thus changing their crop patterns in anticipation of future earnings.

In the second scenario, there may be a bountiful produce in one or more countries that may be major producers of C. The overproduction may in part be due to good weather, cultivation of climate-resilient crop varieties, input intensification, or policy changes such as agricultural subsidies, cash handouts, etc. The result in such a situation would be an oversupply and therefore a depressed price of the crop in the international market. This lowering of price is at least as disruptive as the scarcity scenario discussed above, because depressed prices in the international market may render local farmers uncompetitive, and force them to sell their products at a loss. In fact, vendors in some domestic markets may resort to importing cheaper agricultural products instead of buying expensive ones from local farmers. Financial loss that local farmers may experience will result in some of them losing their livelihoods, while others may feel discouraged from growing C in the next season.

In the face of fears of climate change disrupting global food supply (Schmidhuber & Tubiello, 2007), international trade is hailed as an important contributor of food security, for example by transferring excess supply toward food scarce societies (FAO, 2018, p. xii). Global trade of agricultural commodities has increased rapidly in the past few decades with “a rapidly increasing disconnect between trajectories of land under production and trajectories of land associated with national consumption” (Kastner, Erb, & Haberl, 2014). However, little has been said in the literature about its effects on local agriculture sectors, especially those in poor agrarian societies. In what follows, the two scenarios introduced above are explained from the viewpoint of Pakistan’s society as they roil its political economy:

Scenario 1: Global commodity prices increased, local prices stayed the same

The first notable example of this phenomenon attributable to climate event(s) can be traced back to the first global food crisis of this century in 2007-2008, when extreme climate events in Australia, India, Myanmar, and the United States created an unprecedented shortage of food items in the global market. Extended drought between 2006-2008 in Australia – the second biggest exporter of wheat after the United States – depressed agricultural production to such an extent that the pre-drought wheat production of 25 million tonnes fell to 9.8 million tonnes in 2006.[23] The drought caused the annual rice harvest in Australia to fall by as much as 98% from pre-drought levels.[24] In the United States and Canada, the North American Heat Wave of 2006 crippled grain production in most of the region. The heat wave was so intense that it not only destroyed crops, but also killed hundreds of people as well as hundreds of thousands of animals on farms across the two countries.[25] In Kerala, India, unseasonable rains in 2008 washed out the summer rice harvest by destroying thousands of acres of standing paddy crop.[26] In 2008 in Burma, cyclone Nargis – the worst natural disaster in the recorded history of the country – devastated the society by claiming 138,366 lives (Guha-Sapir, Hoyois, Wallemacq, & Below, 2017), decimated the country's agriculture, and forced the otherwise rice-exporting nation to import vast quantities for local consumption.

The second wave of extreme climate events disrupting global food supply took place between 2009-2010. Record high temperatures in Russia in 2010 resulted in several

[23] Australia's food bowl lies empty, *BBC World,* March 11, 2008
[24] A drought in Australia, a global shortage of rice, *The New York Times,* April 17, 2008
[25] In California, heat is blamed for 100 deaths, *The New York Times,* July 28, 2006
[26] Rs. 393.33 crore in crops lost due to Kerala rains, *The Economic Times,* April 8, 2008

hundred wildfires, and destroyed vast swaths of farmland across the country. Fearing food insecurity and unrest, the Russian government imposed a ban on export of all grain. In 2010-2011, a historic drought hit eight provinces in the wheat producing parts of China, and exacerbated an already strained food supply across the world.

The effect of the global food shortage was a massive increase in producer-price in Pakistan, i.e. the price received by local farmers for their goods in a given season/year (Fig. 4.23). Traders offered lucrative sums to local farmers for their produce,[27] and exported/smuggled it to international buyers. All the farmers interviewed for this research remembered selling their respective harvests to informal traders/agents who offered them prices higher than those being offered in the local market at the time.

> We didn't even have to transport our produce to procurement centers as we usually do. Traders purchased our crops even before we could harvest them, loaded the harvest on their tractor-trolleys, and drove away. (A farmer in Muridke)

The net result of the outflow was a dire shortage of wheat, sugar, rice, pulses, etc., in the domestic market. Sudden disappearance of sugar from local stores led to a record increase in its price, and created near panic situation in the country. People waiting in long lines for sugar rations often erupted into fights with each other over bags of sugar, flour, or rice, etc., or took out their frustration against the government,

[27] Agents offering lucrative prices to wheat growers in Sindh, *The News International,* April 24, 2008

hoarders, black marketers, and especially wealthy sugar mill owners who dominate Pakistan's lucrative sugar industry and politics.[28]

As Pakistan's agricultural products found their way out of the country in order to meet global demand, Wheat shortage in 2008-2009 led to food riots in various cities in Pakistan. Paramilitary forces were called in to restore law and order situation across the country. Thousands protested after the price of wheat flour doubled in less than a week (Schneider, 2008). The military guarded flourmills and wheat storage centers, and a ban of inter-city and inter-provincial transport of wheat was imposed to curb smuggling of wheat and other commodities out of the country.[29]

Sudden price increase of agricultural items had a notable effect on planting decisions in Pakistan. Higher than usual prices for food items encouraged farmers to bring more area under cultivation to grow additional quantities of wheat, sugar, rice, pulses, etc. Wheat production grew and resulted in bumper crop in 2009, 2010, and 2011.[30]

As extreme climate events have increased in frequency and intensity around the world in the past several years, the phenomenon has repeated itself several times in Pakistan since then. An informal trading sector thrives in the country, with smuggling routes operating through Pakistan's porous borders with Afghanistan and Iran, and

[28] In Pakistan, sugar shortage sours public mood, *Washington Post,* November 28, 2009
[29] Pakistan army guards scarce grain, *BBC,* January 14, 2008
[30] Crop prospects and food situation, *Food and Agricultural Organization*, 2009; Pakistan sees at least 25 million tonnes wheat from 2010/11 crop, *Dawn*, April 8, 2011

connects their respective markets by seamlessly trading commodities from one society to the other.[31]

Scenario 2: Global commodity prices decreased, local prices increased (or stayed the same)

The alternative scenario of interaction between local and global commodity markets unfolded in the aftermath of the global food crisis. In fact, it turned out to be much more disruptive for Pakistan's domestic agriculture, and had widespread and long-lasting effects on farming practices and planting decisions as well as the local political economy.

As climatic changes, especially extreme climate events disrupted agricultural practices, productivity, and crop patterns in countries around the world, the effect was a widespread disruption of global supply chain of agricultural commodities. In response, agricultural societies took aggressive measures to safeguard their respective communities from food insecurity, and to protect their farmers by introducing a wider array of interventionist policies and farmer support programs. These interventionist programs, in turn, generated system effects such as price distortion and overproduction in the global market, thereby depressing production in small agrarian economies such as Pakistan.

China, the world's biggest consumer of rice, for example, became the net importer of the grain, in addition to starting a multi-year support program for its farmers. The result of massive imports as well as boost in local grain production was a rapid

---

[31] Wheat smugglers bring high prices, and hunger, *Inter Press Service News Agency,* June 4, 2014; Smuggling from Pakistan to Afghanistan tripled, *Tolo News,* March 13, 2017

expansion of its strategic rice stockpile.[32] In Thailand, the government, under political pressure to provide support to its struggling rice farmers, began a similar multiyear rice procurement program offering its farmers prices as high as 40 percent above world market prices.[33] Similar farmer-support programs and subsidies were initiated in other major agricultural countries such as India, Vietnam, and South Korea. Production of wheat, corn, and sugarcane exploded too in the years since the global food crisis,[34] and set off one of the longest global glut of cereal and related crops in the world (FAO, 2019). Prices fell in the global market, and in some cases even triggered "price war" as countries tried to clear off their stockpiles. [35]

Overproduction and price distortion did not remain limited to food crops alone. Price of cotton, for example, plummeted due to overproduction, owed in large part to bountiful harvest in the United States as well as a multi-year support program operated by China for its cotton growers.[36] Similarly, spells of good weather, government subsidies, use of flood (drought)-resilient crop varieties, crop insurance, etc., resulted in unprecedented stocks of major agricultural commodities in other major agricultural countries of the world.

---

[32] Eyeing an end to Asia's rice glut, *Gro Intelligence,* January 24, 2019

[33] U.S. challenges Thailand to explain rice subsidies, *Reuters,* November 9, 2012; Thai rice-subsidy loss set at $15.7 billion, *The Wall Street Journal*, November 13, 2014

[34] Drowning in grain - How Big Ag sowed seeds of a profit-slashing glut, *Reuters,* September 27, 2017

[35] Thailand tries to unload mountain of rice amid world glut, *Bangkok Post,* January 28, 2015; What sugar glut means for Mondelez—and your grocery bills, *Crain's Chicago Business,* March 17, 2015; Unprecedented sugar glut expanding as world output soars, *Bloomberg,* March 17, 2015*;* Global sugar glut to grow as India prepares to flood the market with the sweetener, *The Telegraph,* August 5, 2015; The world is dealing with a massive sugar glut, *Bloomberg,* July 9, 2018

[36] Cotton slides on bumper US harvests, *Financial Times,* August 19, 2014; Cotton farmers hit hard as prices drop to lowest since 2009, *Financial Times,* December 09, 2014

The effect of global glut and depressed price of commodities was nothing short of devastating on Pakistan's farmers who already struggled from reduced yields, crop failures, pest attacks, and water scarcity. Reduced prices in the global market did not just make them uncompetitive in the international market, it decimated their livelihoods locally too because local manufacturers abandoned them for cheaper imported commodities. Agricultural growth, especially that of major crops, dropped significantly. Crop production in the country declined by 6.25 percent in 2016, pulling down the overall agricultural growth to a negative 0.19 percent.[37]

In addition to slowing down the agricultural growth, it also affected crop patterns. Confused by climate change as well as depressed prices in the global market, farmers lurched from one crop to another in order to keep their farms financially viable. Haphazard crop switching and bandwagon effect led to even more price crash and chaos. The price for wheat crashed in 2011, 2012, 2017. As farmers switched to cotton, it tumbled in local markets in 2012, 2015, and 2017. Global rice glut (combined with local overproduction) led to market crash in 2015. Price for potatoes in local commodity markets fell in 2015, 2017, 2018, and so on.

[37] Agriculture pulls down GDP growth, *Express Tribune,* June 3, 2016

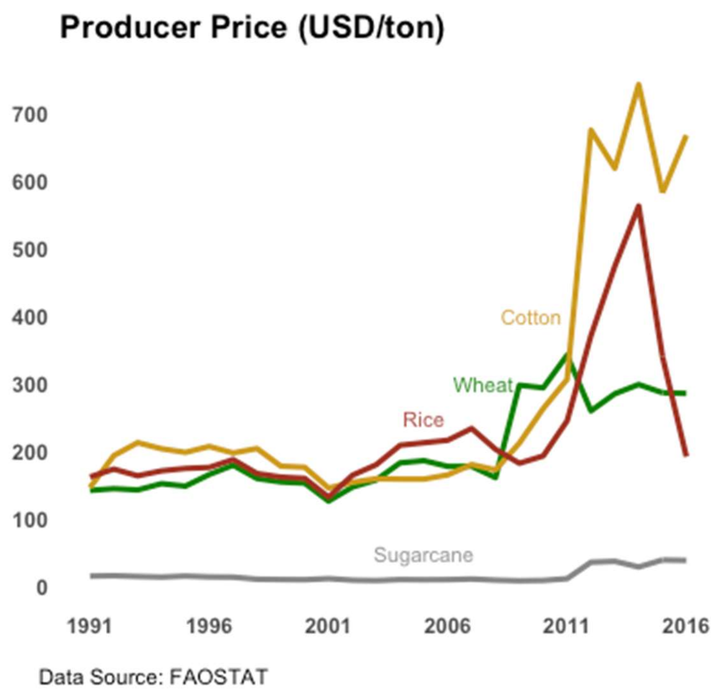


Fig. 5. 11: Producer Price for the four major crops
Data Source: FAO STAT

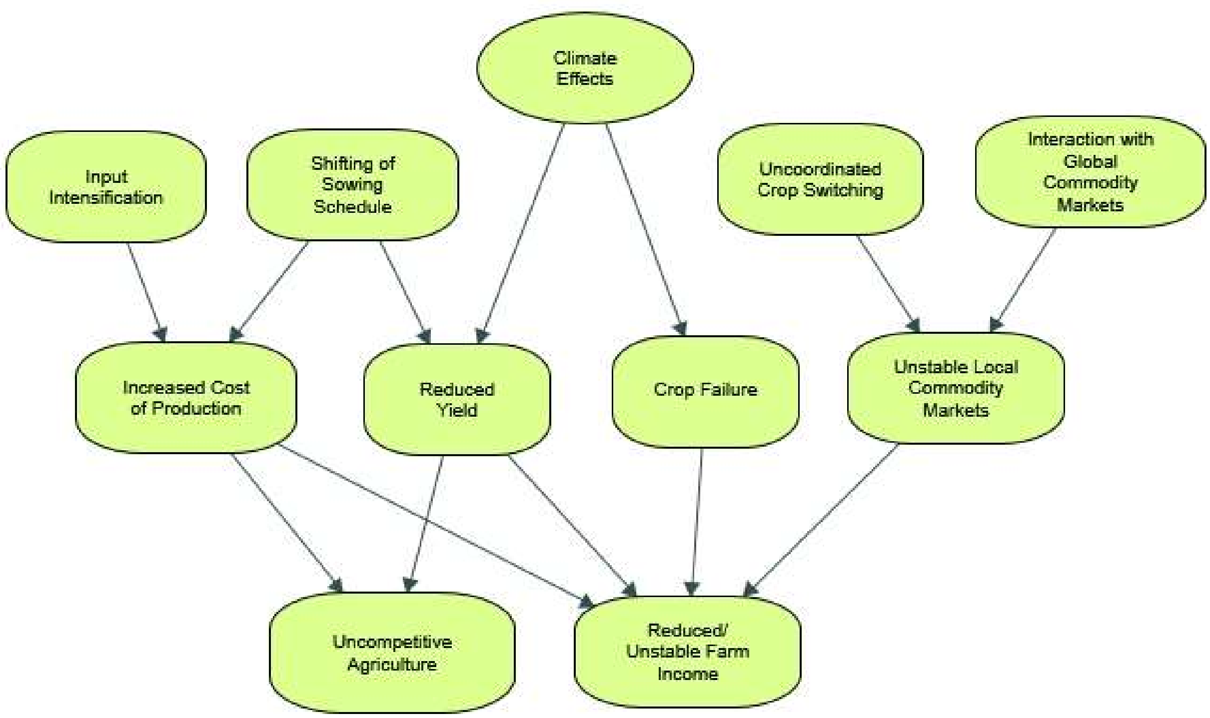


Fig. 5. 12: Concept diagram – Interaction of climate change and Pakistan's society

Mechanisms of climate-society interaction in Pakistan:

Reading through the farmers' accounts of their perceptions of the climate stressor and their rationale for choosing coping responses reveals the interactive nature of climate change at micro and meso levels of the society. Contrary to the assumptions of the adaptation framework discussed at length in the literature review chapter, most coping responses in this case study appear to fall short of the criteria for "efficient" and "effective" adaptation measures. In fact, the single key factor behind most coping responses appears to be farmers' motivation for what Steinbruner (1974) calls "uncertainty resolution". Shifting of meteorological calendars, spatial and temporal variability of previously stable climate trends at intra-annual and sub-national levels, and decline in the Indus stream-flows seem to have confused Pakistan's farmers. The unpredictability introduced in the system has rendered impossible selecting the most optimal coping response(s) based on economistic cost-benefit calculations, as the rational model of decision making implies.

As discussed in the theoretical framework chapter, instead of following the commonly used practice of constituting collective social actors consisting of all the individuals within a category – in this case all the farmers in Pakistan – this dissertation has chosen to identify coherent social action taking place at the level of individual farmers. This means that most relevant mechanisms to understand climate-society interaction are assumed to be unfolding at both the individual level – or cognitive mechanisms (Hedström & Swedberg, 1998), as well as are a result of interaction among individuals – or relational mechanisms (McAdam et al., 2001). According to this conceptualization, the macro-level phenomenon of climate change elicits responses and triggers mechanisms at the micro-level of society. Since these micro-level or individual responses take place in the social meeting-place where "transactions, interactions, social ties, and conversations constitute the central stuff of social life" (Tilly & Goodin, 2006, p. 11), the final outcome is the result of interaction between mechanisms operating at micro- and meso-levels of society (J. S. Coleman, 1987; T. Schelling, 1998).

What follows are micro and meso level mechanisms identified from farmers' interviews discussed earlier in this chapter.

Cognitive rationality:

Boudon (1998) traces the motivation of individual decision-making in "cognitive" reasons rather than economistic cost-benefit calculations. Giving his mechanism the name "cognitive rationality", he explains that social actors make decisions based on what they believe to be true: "He did X because he believed that Z is likely or true, and had strong reasons for believing so" (p. 191). In Pakistan's case, cognitive rationality is at play in most coping responses being employed by farmers. For example, farmers seemed convinced that they can counter the effects of high temperatures on their crops by increasing the amount of irrigation water. From a utilitarian cost-benefit standpoint, the logic leads to sub-optimal results. Not only does it increase the cost of production and makes farmers less competitive, the increased demand of already scarce water sets in motion distributional conflicts among vulnerable populations and economic sectors. However, farmers have strong reasons for employing this coping response. Given that they do not have access to complete information about the nature of climatic changes unfolding in the region, long term trends of climate variables, or forecasts of weather trends, etc., following their tried and tested practice of intensifying agricultural inputs is a justifiable cognitive logic from their perspective.

Another example of cognitive rationality can be observed at the meso level of society. In recent years, during times of reduced stream-flows, successive governments in Pakistan have preferred irrigation to hydroelectric power generation. From the social and political unrest that acute energy shortage has caused by way of shutting down tens of thousands of industrial units, not to mention the increase in cost of agricultural production for farmers using electrical tube-wells, the decision can hardly be explained from the economistic rationality principle. However, the cognitive logic of preferring food production - a public good, as well as an important factor for political stability - provides a better explanation for the policy decision.

Similarly, interviews revealed that input intensification, chasing the cultivation windows, and crop switching are motivated not by exhaustive analyses of all the possible alternative scenarios, but by farmers' need to minimize risk as well as to adhere to the agricultural practices that they have used for decades.

Some of the cognitive reasons are psychological in nature, such as value separation, tunnel vision, and belief formation, and are discussed next.

Value separation:

The human mind uses value separation to resolve computational challenges imposed by complexity and emergence during times of uncertainty (Steinbruner, 1974).

For example, during times of climate variability and change, when faced with two negatively associated values, such as conservation in times of scarcity and chasing down the aquifer to make up for scarce surface water, the mind pursues both tasks as if they are separate from each other. As explained in farmers' accounts listed above, farmers in all three sites are "battling" water scarcity by depleting the aquifer.

In addition to aquifer depletion, input intensification can be explained by value separation. Farmers appear to be keenly aware that adding more inputs to maintain crop yields results in an increased cost of production and makes them uncompetitive. Yet they pursue the practice anyway, instead of looking for "efficient" and "effective" coping responses.

Rational imitation and belief formation:

The interrelated social mechanisms of rational imitation and belief formation can partially explain the crop-gluts and price-crashes that have marred Pakistan's agriculture sector in recent years. Both mechanisms are forms of cognitive rationality.

Rational imitation – an individual or micro-level mechanism – may explain the decision-making process of individual farmers in the three agro-ecological zones replacing the crops that have either failed, or are rendered unprofitable due to the changed weather patterns. Farmers' interviews reveal that such decisions are hardly based on an exhaustive analysis of all the alternative choices. In fact, the selection of alternative crops is almost always a result of interaction with, or imitation of, fellow "successful" farmers whose crop-substitution resulted in maintaining or even increasing their farm incomes. It is important to note that although the main driver behind selecting an alternative crop may be benefit maximization – however one may define it, for example, an increase in farm incomes, less exposure to climate stressor, etc. – the decision-making analysis does not take place in an individual's mind in isolation from the rest of society based on "a utility schedule and a set of assets, which interact to generate choices within well-defined constraints" (Tilly & Goodin, 2006). In fact, it is a result of interaction with other social entities either through direct observation or indirect interaction through social media, newspapers, television reportage, etc.

Belief formation is the widespread adoption of the mechanism of rational imitation by a large segment of (vulnerable) population. As discussed in farmers' interviews above, the price-crashes and crop-gluts are a result of overproduction of a crop by a large number of farmers switching to the same crop while struggling to replace unprofitable crops in order to maintain their livelihoods. As climate trends in previously hot and dry regions of southern Punjab and Sindh have become cooler and wetter, farmers have switched, in large numbers, cotton with rice and sugarcane cultivation, thereby resulting in overproduction and resultant price-crashes. As shown in Fig. 5.9, back-to-back yo-yoing in cultivation areas of all the major crops represent farmers switching between crops back and forth from one year to the next, most likely in response to overproduction, followed by shortage and so on. In recent years, prices of almost all major and minor crops have crashed due to overproduction, and led to commodity market instability and widespread economic downturn for farmers in the country.

Rational imitation and belief formation can also explain the widespread approach of pumping water from aquifer to make up for the reduced Indus stream-flows. As surface water has become scarce in recent years, farmers have come to believe that pumping underground water is essential for them to stay in the agriculture business. As discussed earlier, the total number of tube-wells in the country has skyrocketed such that the rate of extraction has surpassed the rate of recharge, and is resulting in a rapidly sinking water table in most parts of the country. As water extraction has become more energy intensive due to the ever-dropping underground water levels, the cost of pumping the aquifer has consistently risen as well, and added to farmers' financial woes.

Double exposure:

The direct and indirect effects of climate change on agricultural production, haphazard crop-switching to counter the stresses being imposed on farmers' livelihoods, and their combined effects on Pakistan's domestic commodity markets partially explain the climate-society interaction in the country. However, as discussed in the theoretical framework chapter, social and ecological systems are coupled not only at the local level, but are also connected with the rest of the world through the global process of international trade. This means that stresses imposed on a society by climate change may not stay local, but travel to other geographically remote societies that may not be experiencing climate change themselves. The phenomenon has become evident in Pakistan where crop patterns as well as domestic commodity markets have become extremely vulnerable to commodity price fluctuations in the global market.

The meso-level mechanism termed as double exposure has not only led to price crashes and bankrupting of local farmers in Pakistan, it has also become an important factor affecting agricultural patterns in the country. Pakistan's farmers now base their decisions regarding crop patterns not only on their respective local climate trends, but also keep an eye on climate events taking place elsewhere in the world. However, since information about climate stresses (other than extreme climate events) affecting political economies of countries of the world is not easily accessible, not to mention their respective climate-society interactions, uncertainty and vulnerability has increased manifold for Pakistan's farmers. As discussed in the previous section, the phenomenon has been observed in the country several times in the past few years alone.

Contention attributable to climate change in Pakistan

All the frustration of water scarcity, increased costs of production, extended power outages, successive crop failures and price crashes, manifested in the form of a massive public demonstration on March 02, 2013 when thousands of farmers descended on *Okara Bypass*—a major intersection merely 100 kilometers from Lahore on the National Highway that runs through the length of the country. Farmers blocked the highway as well as a nearby railroad track for 17 hours using trucking containers. Thousands of passengers, which included women and children, were stuck in the blockade and spent the night without food and water under open skies. Trains were sent back, as farmers, armed with farming implements such as sticks, axes, and reapers, threatened to attack them. Government officials, caught unawares by the sudden outpouring of a large number of belligerent farmers, nervously negotiated terms for a peaceful dispersal of the mob. The crowd dispersed after issuing an ultimatum that the government either address their demands within two days, or get ready for an even larger procession to march towards Islamabad, the national capital.[38] These demands included subsidies on agricultural inputs, revision of support-price of major crops, waiver of arrears of electricity bills, and resumption of tube-well connections that had been cut off due to non-payment of dues.

Blocking the highway proved to be an effective strategy for farmers as it gave them prime airtime on national media. Major news channels as well as newspapers covered the incident in one form or the other, thereby bringing into focus the plight of

[38] Farmers end 17-hour sit-in, *The Nation*, March 03, 2013

farmers and the vulnerability of the government. Political parties in opposition of the government issued press releases expressing solidarity with farmers and criticized the government for its neglect of agriculture – the backbone of the country's economy.

The successful contentious performance of disrupting traffic flow in urban centers of the country, and more importantly, the resultant capitulation of the government emboldened farmers who sensed a political opportunity to put pressure on the government for policy reforms. Since then, over seven hundred large and small protests have been reported in newspapers in the last five years alone, in which farmers travelled to big cities, blocked highways or laid siege to important city squares in Punjab and Sindh, and staged multi-day sit-ins in front of key government buildings. Dumping truckloads of produce in public squares, burning effigies, surrounding important government buildings, and *jail bharo*[39] movements, have also become common practices employed by farmers. This is in addition to countless public meetings, recruitment campaigns, press conferences, and rallies, aimed at mobilizing farmers as well as raising public awareness about their economic woes.

The *Okara Bypass* protest in 2013 was unprecedented in the history of Pakistan as previously apolitical small landowners and tenant farmers mobilized, took to the streets and staged a massive public event. It marked a political victory for them not only for successfully wresting attention from competing newsworthy issues, but also because it was the first time when farmers emerged on the national scene as a political force. Although Pakistan's ruling class has historically consisted of landed elite and big agriculturists, of late, a large majority of them have rented out their agricultural lands to

[39] Wholesale voluntary arrests offered to overwhelm the system

tenant farmers. As agricultural production and farmers' incomes have declined precipitously in recent years, farmers have struggled to maintain their livelihoods, and pay rents to landowners to keep their leases. A political platform solely organized and run by hitherto unrepresented small farmers represented a political awakening at the grass roots level.

The farmers' movement in Pakistan is interesting on two counts:

Firstly, it demonstrates the process through which individual (or localized) grievances evolve into regional and national level movements. Like any social movement, the farmers' movement in Pakistan is episodic, with each episode going through phases of "emergence, development, and decline" (Aminzade & McAdam, 2001), only to be followed by the emergence of the next episode, and so on. Each new episode has attracted new participants, broadened the framing to include other aggrieved groups, and forged alliances with, or gained support of major mainstream political parties. Although their movement has not reached the final stage of a full-blown conflict yet, Pakistan's farmers have emerged as a potent political force capable of causing or contributing to political turmoil in the country.

Secondly, and perhaps more importantly, even if it is established that unrest among Pakistan's farmers has manifested in the form of an organized movement aimed at policy reforms, the challenge lies with (dis)proving that it is in fact attributable to (effects of) climate change. As discussed at length in the previous section, the disruptive effect of climate change on Pakistan's agriculture sector is unmistakable. How (whether) that disruption is manifesting in the form of a budding movement is a task undertaken in this section. By coding the causes of individual contentious gatherings, acts of claim-making, and contentious performances employed by farmers, this case study provides a granular high-resolution picture of unrest and dynamics of political contention.

Data sources:

This analysis is based on two sources of data:

The first is the Armed Conflict Location and Event Database (ACLED) (Raleigh, Linke, Hegre, & Karlsen, 2010), that provides a comprehensive, peer reviewed, on-going survey of protests and political violence in Pakistan based on English language news sources. Using the query tool provided by ACLED, only those records are included in this analysis that contain farmers as central actors. ACLED, as of now, is the best dataset that provides coverage of social and political unrest in countries around the world that may not have reached the stage of full-blown civil conflict yet.

The rationale for using ACLED as a data source is twofold:

First: ACLED catalogs different types of conflict events that range from violent events such as battles, bombings, IED or mortar attacks, riots, protests, or violence against civilians, etc., to non-violent events such as rallies, peace talks, transfer of territory, etc. In comparison, other popular conflict datasets, such as UCDP-GED [40] only record state-based, non-state or one-sided violent events which have at least one direct fatality. Since farmers' movement in Pakistan is in its early phase, and violence has not

[40] Uppsala Conflict Data Program – Georeferenced Event Dataset

reached a level where fatalities have commenced, a dataset such as ACLED is more suited for the purposes of this research.

Second: Unlike other conflict datasets, ACLED recognizes a wide variety of actors ranging from governments, to ethnic and political militias, to ethnic groups, to political organizations, to unidentified civilians, etc.

ACLED provides all the essential (structural) information about geo-referencing contentious events, such as time and place of event, actors involved, outcome, etc. However, more information is needed for deeper analysis about cause(s) of contention, as well as nuances that may have been lost during coding of contentious events in the database.[41] This dissertation tries to circumvent this shortcoming by getting detailed accounts of the events listed in ACLED from LexisNexis, the second data source used in this analysis. In-depth reporting of contentious gatherings listed in ACLED helps identify cause(s) of aggrievement, repertoires of contention employed, processes of contention such as alliance formation, identity shift, framing and aims of political struggle, etc. These detailed accounts are then coded in NVivo, and themes regarding farmers' grievances identified. These themes are discussed later in this section.

[41] Records saved in ACLED appear to be subject to the same constraints of space as faced by any other database. Discussing the dynamics of event-coding (from newspaper reports) as a research enterprise, Franzosi (2017) argues that in order to keep news records index-able, and therefore searchable, coders parse and summarize each news item by extracting information about the 5Ws + H of journalism (When, What, Who, Where, Why, and How). As straightforward as the task may appear, it is fraught with challenges, especially when the phenomenon at the root of a contentious event is too complex to reveal its "real" cause in a news report. In other words, putting a finger on the 'Why' of a contentious event may be a bit of a challenge if the underlying cause of social unrest is masked from the onlookers (news reporters), although it may be clear to those participating in the event. Moreover, as social movements mature, and disparate actors with varied reasons of unrest join in, cause(s) of protests/contentious gatherings/contentious performances become muddled and difficult to untangle. Summarizing a news report to fit the space constraints of a database field as well as related coding requirements is sure to result in even more loss of information. Alternatively, there may be too many stated causes of a contentious gathering for a reporter (or a coder) to pick the most important or the core reason for the purposes of coding.

In addition to protest data from ACLED, this analysis is based on detailed news reports published in local newspapers, retrieved from LexisNexis for the last twenty years.[42] The logic behind using this second source of data is to partially correct the reporting biases (noted below) in newspaper reporting on which ACLED is based. Coding over 1300 news items about farmers' contentious politics in NVivo, this analysis presents a sketch of their mobilization campaign, and includes accounts of public claim-making, forging of alliances with mainstream political parties, press conferences, local organizational meetings, etc. Themes and sub-themes identified during the analysis reveal insights about the evolution of one of the most vocal and politically active farmers' movements in the country's history.

Caveats:

Reporting bias is a problem inherent in all analyses that rely on news reports as a primary source of data (Rafail, McCarthy, & Sullivan, 2019). Data used in this research is not immune from this potential shortcoming. In national and local reporting, news about farmers' issues are crowded out by other stories considered more pressing by the media, such as news about terrorism, domestic and regional politics, etc. Farmers have lamented that their events do not get media coverage unless they travel to big cities and disrupt everyday life in major urban centers. Furthermore, protest events must generate certain amount of attention before national media outlets pick them up.

[42] Farmers' problems did not begin gaining news media's attention until the early 2000s when successive crises caused by sugar and wheat shortages in the country led to riots in 2002, 2003, and 2004. Later, as the global food crisis engulfed the entire world in 2007-2008, farmers' news gained prominence in the country's politics, and have been covered regularly since then.

> When we began our struggle, we started by organizing protests in small cities across Punjab. In one instance, we coordinated simultaneous protests in 23 districts across the province. The plan was to choke key highways in these districts at the same time on a set date. We had envisioned that the effect would be massive and we will get media and therefore government's attention. However, not a single journalist even made a phone call to inquire, let alone covered our demonstrations. It was then that we realized that media covers our news only when we disrupt the everyday life in big cities like Lahore. *Shehri baboos*[43] pay attention only when their own lives are affected. (A farmer leader in Punjab)[44]

Another manifestation of reporting bias in ACLED is its reliance on English language news sources. Such publications usually cater to urban populations, and therefore focus on news more relevant to their readership. Protest events taking place in locations far away from big cities may never get reported, and therefore not included in the dataset. Alternatively, events taking place in smaller cities may be lumped up with bigger contentious event(s), making it difficult for coders to extricate distinct contentious gatherings and retrieve data values of their respective causes, actors, number of participants, outcomes, etc.

Reproduced below is an example of such a news report published in *Dawn*, a leading English language daily newspaper in Pakistan:

> In Hyderabad, scores of Sindh Taraqqi-pasand Party (STP) activists held a protest demonstration against injustices being faced by sugar cane growers. Carrying

[43] Urdu for urban elite
[44] Phone interview

banners and party flags, they chanted slogans against the Sindh government and "Zardari league" outside the local press club…. Similar protests were held in many districts of Sindh, including Tando Mohammad Khan, Tando Allahyar, Matiari, Jamshoro and others.[45]

This news story, although provides information in reasonable detail about a contentious gathering in Hyderabad, a big city in Sindh province; it is hazy regarding details about events in smaller cities, for example total number of events, causes of unrest, actors, number of participants, outcome, exact date or place where events took place, etc.

These distortions should be kept in mind and are reflected in the analysis. However, since this dissertation has more to do with tracing the link between effects of climate change and farmers' uprising rather than mapping every single contentious event, the effect of potential distortions in ACLED is marginal at best on the analysis produced below.

Farmers' livelihoods in the balance

Data from ACLED traces the beginning of the transgressive phase of farmers' uprising to 2010 when public gatherings of disgruntled farmers became too big to be ignored by the local and national media. However, just like any other social or political movement or episode of contention, processes of instability were afoot much earlier. News reports from LexisNexis provide clues about both, the causes(s) of

---

[45] STP holds protests in favour of sugar cane growers, *Dawn*, Dec. 15, 2017

instability/farmers' unrest, as well as the processes of mobilization and organization that culminated in the form of a budding movement as it stands today. In order to understand the link between the stated causes of farmers' protests and effects of climate change, before the temporal and spatial trends of contentious gatherings are presented, at least a preliminary understanding of the events leading up to farmers' uprising is imperative.

Climate change as a process of social change

The effects of changes in Pakistan's hydro-meteorological system had already become observable in the mid-late 1990s and early 2000s. Spatially and temporally variable spells of unprecedented rains in 1992, 1994, and 1996 confused farmers and non-farmers alike. Flash floods caused by these historic rains flooded millions of acres of cropland, caused hundreds of millions of dollars in losses in agricultural production, and displaced millions of people in the country (Akhtar Ali, 2013; OCHA, 1996). Successive catastrophic floods were followed by even more destructive extended drought, the worst in the country's history, which lasted for four years from 1998-2002, and decimated the agriculture and livestock sectors. Hundreds of thousands of small and medium landowners and tenant farmers lost their entire livelihoods as a result of drought alone (FAO/WFP, 2001). In addition to extreme climate events, inconspicuous intra-annual changes in temperature and precipitation patterns had also become noticeable to local farmers, and significantly affected their livelihoods. Moreover, changes in the intra-annual stream-flow trends, particularly shrinkage during the peak summer months of June-August, gave rise to major disturbances in the country's energy sector, with effects disarraying the entire political economy.

Changes in cultivation patterns and agricultural practices:

Changes in spatial and temporal trends of temperature and precipitation, and shifting of seasons had three noteworthy effects on agriculture sector in the country. The first is the change in crop patterns. As discussed previously, this effect was most notable in the southern region of Punjab province where successive failures of cotton crop in the 1990s and 2000s bankrupted a large number of cotton farmers and forced them to switch to sugarcane cultivation. As hot and dry summer weather, suitable for cotton cultivation, became comparatively milder, it provided pests with a conducive environment for fertilization. The following news reports capture confusion of farmers at changing weather patterns.

> 'We have harvested only a couple of maunds of phutti[46] from the fields which used to yield 25-30 maunds in the past,' he says…. The farmers report that they had used double quantity of pesticides this year to vainly control the pest flare-up which has eventually increased their input costs.
>
> Initially the crop was exceptionally good. Everything was just fine and the growers expected a bumper crop and regularly sprayed pesticides. "Then it so happened that we'd rains in the last week of August and first week of September. Pests, especially American worms and Army bollworm, that were though already there got ideal humid conditions for growth, and developed strong defence against pesticides. As a result, the normal schedule of spraying pesticides was also disturbed. Panicked by the flare-up, everyone rushed for pesticides that were already short in supply as soon as rains had subsided. The sudden growth in the

[46] Urdu for seed cotton

demand resulted in the shortage of pesticides needed to cope with the worms," a farmer, Nisar Ahmad, says…. "By the time some farmers obtained the right quantity of right pesticide, it was too late. The pests had already attained an age (of over four days) where you can't kill or contain them," says a scientist working for a government research institution.[47]

Another news story read:

The crop is under attack of Cotton Leaf Curl Virus (CLCV) and Mealy Bug at various places in Punjab.… The current situation reminds one of similar mealy bug attack last year, which largely contributed to country missing the cotton output target by a hefty 800,000 bales.… Mealy bug was spotted on the cotton crop for the first time in 2005, but It did not cause much damage to the crop that year. None of the research institutes in Pakistan could identify the pest or suggest measures for its elimination. The insect was sent to England for identification.… The insect lays eggs and hatches them in a natural basket attached to its body. It multiplies rapidly as eggs are hatched in 6-10 hours. Its occurrence not only curtails the crop size, but also increases the production cost as the farmers are required to apply 3-4 sprays of insecticides to kill it and control the damage…. As the spinners are making hectic efforts to somehow keep down the price of their main raw material, the growers are crying for a better price for their product. "The farmers are getting only Rs1,250 per maund for their crop at this time against their input cost of Rs1,500," claims Mughal. He says the mealy bug attack has increased the farmers' costs on account of their huge spending on pesticides,

[47] Cotton growers lose hope for better crop, *Dawn*, October 19, 2003

which are short in the market and are available only at more than double the actual price.[48]

The switch from cotton to sugarcane cultivation attracted investors who rushed at an alarming pace to set up sugar mills in the erstwhile "cotton belt".[49] Substituting cotton, a profitable cash crop, with sugarcane resulted in financial squeeze for not only cotton farmers, it also adversely affected Pakistan's textile industry which found itself being elbowed out by powerful sugar interests.[50]

In Sindh, a similar situation (of changing weather patterns) resulted in replacement of cotton with rice cultivation as unseasonal rains became frequent in a previously hot and dry region.[51]

In addition to changes in long-term temperature and precipitation trends, unpredictability of climate events (floods, heatstroke, frost, storms, etc.) forced farmers to switch from profitable crops to less risky yet much less profitable ones such as maize, potatoes, fodder, etc. The effect was more pronounced on small farmers, who, unable to absorb vagaries of climate stopped growing on commercial basis the crops, such as wheat and cotton, that the changed weather trends had rendered riskier. In the southern parts of

[48] Cotton Crop and the textile industry, *Dawn*, August 27, 2007
[49] Sugarcane slowly replacing cotton crop, *Dawn,* November 12, 2006; Sugar mills reduce cotton production, *The News*, February 14, 2017
[50] Textile industry being destroyed by promoting sugar industry in cotton belt areas, *The News*, March 5, 2016; Recounting a conversation with former prime minister of Pakistan Nawaz Sharif, Javed Hashmi a notable agriculturist and senior political leader from the 'cotton belt' of southern Punjab said on the parliament floor: 'Nawaz Sharif asked me to set up a sugar mill, but I said I couldn't run a sugar mill. This was not a bribe from Nawaz Sharif, but rather he said your political arena is Multan and, in the coming era, only those having sugar mills would do politics.' (Javed Hashmi continues spilling the beans, *The News*, September 4, 2014); Sugar is muscling out cotton in Pakistan, *Bloomberg*, July 17, 2019
[51] Cotton pays the price as farmers grow rice, *Express Tribune*, July 20, 2010; Sindh's big farmers prefer rice crop, *Dawn*, June 09, 2014

Punjab, a large number of small farmers resorted to abandoning agriculture altogether and took up cattle-farming as a livelihood. The contribution of livestock in agricultural GDP rose from approx. 30 percent in 1990s to 56 percent in 2013-2014. In the same time period, the share of combined crop subsectors (major and minor) declined from over two-thirds of agricultural GDP to 38 percent (Malik et al., 2016, p. 51).

The second big change in agricultural practices attributable to climatic changes in the country is the shift toward aquifer as a source of irrigation. As stream-flows reduced during the peak summer months, farmers switched wholesale to pumping water from the aquifer to meet their needs. The number of tube-wells grew exponentially from approx. 200,000 in 1990 to over one million in 2005 (Watto & Mugera, 2016). This increase was not uniform across the country. The number of tube-wells installed in Punjab was orders of magnitude higher than that in the rest of the country (ibid). Even within Punjab, upper riparian landowners had an unfair advantage not just due to their location and wealth, but also due to their influence on state's administrative and policymaking institutions.

The third notable change in agricultural practices had to do with input intensification. Changes in weather patterns, water scarcity, pest attacks, etc. took a toll on agricultural productivity and crop yield. To resuscitate yields and to curtail damage from the changing weather trends, farmers leaned heavily on using fertilizers and pesticides respectively. To cope from unpredictable rains, extreme temperatures, and reduced stream-flows, they pumped more water from the underground reserves to maintain crop production levels. All of this meant increase in the cost of production. The more crop yields flagged due to effects of climatic changes, the more farmers intensified their agricultural inputs, and costlier became agricultural production. Moreover, as demand for inputs increased, their prices rose disproportionate to farmers' income (Salam, 2017).

Stream-flow variability and acute energy shortage:

Soon after the Water Apportionment Accord of 1991 was signed to ensure its equitable distribution among all four provinces of Pakistan, shrinkage in the Indus waters started to be felt by the lower riparian populations.[52] As the Indus flows receded or became variable during the peak summer months, the downstream populations blamed the upper riparian Punjab of not sharing the water shortfall.[53] Punjab, on the other hand, argued for building a large reservoir to regulate river flows during times of shortage or stream-flow variability.[54] The proposal drew instant and vociferous rejection from vulnerable lower riparian populations who feared even more "usurpation" of their fair share of irrigation water by Punjab.[55] The ethnic faults lines between Punjab and the three other provinces have only sharpened over the use of the Indus waters in recent years (Kazi, 2003; S. R. Khan, 1999; Mustafa, 2007; Rizvi, 1999).

---

[52] Development-Pakistan: Water war looms between thirsty provinces, *Interpress Service*, August 11, 1999; Sea's intrusion into Sindh coastal belt, *Dawn*, December 09, 2002; Water flows downstream Kotri, *Dawn*, April 18, 2005; WB calls for overhauling of 1991 Indus water accord, *Dawn*, March 24, 2004

[53] Punjab illegally pumps water out of Indus, *Dawn*, February 22, 2012; Irrigation decisions: Punjab reneges on sharing water supplies with Sindh, *The Express Tribune*, April 12, 2011

[54] PML-Q seminar calls for Kalabagh dam construction, *Dawn*, November 07, 2014; Kalabagh dam on list of 'ready for construction' projects, *Dawn*, October 01, 2016; Construction of Kalabagh dam critical in fight against water scarcity, says Wapda chief, *Dawn*, August 28, 2017

[55] Infeasibility of the Kalabagh dam, *Dawn*, November 01, 2004; Kalabagh dam over our dead bodies: ANP, *Dawn*, March 07, 2005; Protest in Pakistan against dam, *BBC News*, December 29, 2005; Sindh PA passes four resolutions against Kalabagh dam, *Dawn*, December 08, 2012; Kalabagh dam case: KP wants suo moto notice by SC, *Dawn*, December 01, 2012; MPs of 3 smaller provinces oppose Kalabagh dam, *Pak Tribune*, January 29, 2014; Resolutions against Kalabagh dam submitted in Sindh, KP assemblies, *ARY News*, September 17, 2018;

One of the notable effects of this shrinkage manifested in the form of a shift in Pakistan's energy policy. It was the first time that changes in the Indus stream-flows had brought policymakers to a point where distributional conflict between irrigation and hydroelectric power generation had become evident. As lower riparian and vulnerable populations rejected proposals for developing large reservoirs and hydro-electric power projects, successive governments faced the challenge of an energy shortfall in the country.[56] In a bid to diversify Pakistan's energy mix, in light of fluctuations in the Indus stream-flow trends, the 1994 energy policy (Pakistan, 1994, p. 2) invited bids from local and international business to invest in the country's energy sector and set up thermal power plants:

> The investors are free to propose the site and opt for the technology and fuel including residual furnace oil, diesel oil, natural gas, LPG, etc., for the project.… However, hydro power projects on the main river Indus will not be open to private sector because of water regulations and flood protection functions.

In order to quickly cover the ballooning energy shortfall, lucrative subsidies were offered to private investors, later termed as Independent Power Producers (IPPs), to invest in thermal power generation sector (F. Ali & Beg, 2007). Thermal power, being disproportionately expensive in comparison to hydro-electric power, was to be heavily subsidized by the state at both ends, i.e. production as well as distribution (ibid). However, as successive governments faltered in their payments of these financial incentives, a mountain of debt, commonly referred to as "circular debt," began to pile

[56] Power crisis: Who is responsible, *Business Recorder*, October 20, 2011

up.[57] By the end of fiscal 2012, Pakistan owed 9 billion USD to power producers (USAID, 2013; Zhang, 2018), forcing the latter to take the matter to court.[58]

The combined result of both, distributional conflicts over the use of the Indus waters and non-payment of charges to IPPs resulted in an acute energy shortage in the country. The latest energy crisis started in 2006-2007, and between 2007-2010 total energy production had reduced by ten percent.[59] The energy shortfall grew to 8500 megawatts – more than 40 percent of national demand – in 2012 (Kugelman, 2013). In 2017, the overall power generation reduced by 16 percent as compared to the same in 2016 mainly "due to weather condition and less flow of water in rivers" (Pakistan, 2017, p. xx). Power blackouts lasting up to twenty hours a day became a norm in most parts of the country, at times resulting in riots and demonstrations.[60]

Although the resolution of distributional conflict over the use of Indus waters favored the agriculture sector, farmers did not remain immune to the fallout of energy

---

[57] Pakistan's real power problem: Failed privatization, *Financial Times*, June 22, 2012; Lights out: 'Circular debt' cripples Pakistan's power sector, *Al-Jazeera*, May 24, 2019; Agreements with IPPs are a noose around our necks, Geo TV, January 09, 2019

[58] Court summons officials over Rs8bn IPP dues, *Dawn*, September 04, 2012; Govt loses to IPPs in British Court, *The Express Tribune*, October 22, 2018

[59] Is circular debt the real issue? *Dawn*, October 10, 2011

[60] NWFP Assembly slams power and gas loadshedding, *Business Recorder*, February 03, 2005; Power cuts test Pakistani patience in election year, *Reuters*, July 1, 2007; Protests in Karachi against loadshedding, *Samaa TV*, May 5, 2010; Anti-loadshedding protestors paralyze Sialkot transport, *Samaa TV*, October 3, 2011; Pakistan's power crisis may eclipse terrorist threat, *Washington Post*, May 27, 2012; JI protests power outages in Upper Dir, *The News*, December 24, 2012; Tribesmen block road to protest loadshedding in Mohmand, *The News*, December 12, 2012; Power outages snap public patience, *The News*, July 29, 2012; Faisalabad: Traders refuse to pay electricity bills, *Dunya News*, March 22, 2012; Power riots in Punjab, *The Express Tribune*, June 18, 2012; WAPDA installations attacked as loadshedding crosses 24 hours, *The Express Tribune*, July 29, 2012; Karachi braces for 13-hour loadshedding, *Samaa TV*, August 17, 2013; Anti-loadshedding protests continue in Sindh, Punjab, *Samaa TV*, June 22, 2015; Protests against load-shedding continue, *The Express Tribune*, April 21, 2018; Residents protest as several areas witness frequent power outages, *The Nation*, August 07, 2019; Power outages, low voltage make life miserable for KP consumers, *The News*, August 17, 2019; Protests against prolonged power outages, The Nation, August 19, 2019

crisis that enveloped Pakistan's entire political economy.[61] One of the direct effects was faced by farmers who relied on electricity-operated tube-wells. Acute energy shortage rendered useless over 200,000 electric tube-wells, forcing farmers to switch to diesel-operated Petter engines to access irrigation water. Power outages exacerbated the cost differential between upper and lower riparian farmers as the latter incurred higher costs to pump water from the aquifer. In addition to increasing the cost of water extraction, extended power outages had deleterious effects on related farm activities such as powering farm machinery, as well as harvest and post-harvest activities such as food processing and storage, etc. Studying the effect of power outages on Pakistan's farm households, Ali et al. (2019) noted that "farmers affected by the energy crisis had lower cereal crop yields and household income with higher food insecurity, and higher poverty compared to farmers who were unaffected" (p. 7).

Although the energy crisis disrupted Pakistan's entire industrial base, the effects were some of the direst for textile industry.[62] Tens of thousands of textile units were shut down[63] or relocated to other countries such as Bangladesh.[64] Shutting down of textile mills was a double blow for farmers who were already incurring losses from dealing with effects of climatic changes. Closing or relocation of textile units translated in much less

---

[61] Loadshedding hits agriculture sector, *The Nation*, October 15, 2008; Energy crunch hits Pakistan's farm productivity, *SciDev.Net*, December 08, 2019
[62] Textile industry badly hurt by loadshedding, *Business Recorder*, July 02, 2009; Textile industry continues tirade against load-shedding, *The Express Tribune*, June 04, 2013; Power outages hobble Pakistan's biggest exporters, *The Wall Street Journal*, November 29, 2013; Textile Industry: Load-shedding a major concern for industrialists, The Express Tribune, August 07, 2014; Poor policy response makes textile industry uncompetitive, *The News*, January 03, 2018; Pakistan loses textile export from 2.2pc to 1.7pc, *The News*, June 07, 2018
[63] Half a million jobs lost as textile crisis hits Pakistan's economy, *Bloomberg*, September 20, 2016; Power looms industry in crisis as owners forced to sell, *The Express Tribune*, February 05, 2019;
[64] Textiles on the move: from Pakistan to Bangladesh, *Reuters*, August 30, 2011; Energy woes: Over 40pc of textile industry has shifted to Bangladesh, *Business Recorder*, September 13, 2012

demand for cotton grown in the country. Oversupply led to price crash and bankrupted cotton farmers. Even those textile units which could stay afloat offered much less price to cotton growers for their produce. [65]

Effects:

Climatic changes and their interactions with Pakistan's political economy had three notable effects on agriculture. These effects would later become the rallying cry for the popular protests and movement spearheaded by farmers.

1. Reduction in farm incomes

The biggest and most direct effect of climatic changes on farmers' lives has been a consistent decline in farm incomes. As the cost of agricultural production has increased due to water shortage, unpredictable weather trends especially intra-annual changes and shifting of seasons, pest attacks, energy shortage, etc., Pakistan's farmers have become uncompetitive.[66] The situation has worsened as a result of input intensification, as it has, by way of putting pressure on prices of agricultural inputs, pushed farmers into a vicious cycle. Additionally, as the energy crisis, which itself was in part attributable to shrinkage in the Indus stream-flows, exacerbated, government pursued corrective policies such as

---

[65] Phutti prices drop to Rs550 per 40kg, *Dawn*, February 12, 2002

[66] High costs of farm input affect yield, *Dawn*, May 07, 2004; Costly inputs affecting farm produce, *Dawn*, May 04, 2005; Call for cut in prices of agricultural inputs, *Dawn*, July 14, 2005; High input prices make farmers cry, *Dawn*, May 24, 2008; How to enhance small farmers' incomes, *Dawn*, September 01, 2008; Farmers hit by input, output trade imbalance, *Dawn*, November 21, 2012; Cost of farm inputs and wheat support price, *Dawn*, November 10, 2014; Support price or input subsidies, *Dawn*, May 04, 2015; Costly inputs are squeezing farmers hard, *Dawn*, October 29, 2018

increasing the electricity tariff and doing away with subsidies for agricultural (electric) tube-wells,[67] thereby increasing the cost of production even more.

As discussed in the introduction section of this chapter, Pakistan's agriculture sector is highly regulated with government setting up targets for agricultural production and floor prices of major crops. This means that farmers, despite being thrashed by the effects of climate change, cannot pass on to consumers the increase in cost of production. This rigidity in the system has resulted in farmers demanding the state that either floor prices of crops be revised, and (or) subsidies provided to match additional costs incurred by changes in weather patterns.[68] Although the government has tried to provide some relief to farmers in terms of both, increase in floor prices of some crops as well as partial subsidies on agricultural inputs,[69] yet it has failed to close the ever-increasing gap between the cost and market prices.[70]

2. *Disruption of local commodity markets*

Where climatic changes have resulted in crop failures, drop in crop yields, and increase in cost of production; the haphazard switching to alternative crops, more suitable for changed weather patterns, has led to disruption of local commodity markets. With no

[67] Subsidy on agricultural tube-wells being withdrawn, *Dawn*, November 24, 2010
[68] Growers get less price for cotton in Ghotki, Sukkur, *Dawn*, October 28, 2001; Growers protest low rates of potatoes, *Dawn*, January 14, 2004; Concern over fall in cotton price, *Dawn*, October 15, 2004; Farm lobby in revolt over crop prices, *Dawn*, December 06, 2014; Depressed commodity prices to impact agricultural growth, *Dawn*, December 29, 2014; Higher production cost, lower crop prices, *Dawn*, July 21, 2015; Farmers demand 'agriculture emergency', *Dawn*, February 21, 2016; Farmers forced to sell wheat at throwaway prices as govt indecisive on procurement, *The News*, April 07, 2019
[69] Pakistan: Government increases wheat support price, *Food Price Monitoring and Analysis*, FAO, January 11, 2014; Pakistan announces cotton support price, *Foreign Agricultural Service*, USDA, October 8, 2014; Package for farmers, *The Express Tribune*, September 17, 2015
[70] Returns on produce: farmers protests for support price raise, *The Express Tribune*, September 13, 2015; Rice production: Losses six times more than cash support, say farmers, *The Express Tribune*, September 20, 2015; Harvesting losses: Behind the trouble on Punjab's rice farms, *Herald*, December 09, 2016; Punjab should withdraw from the wheat market, *Dawn*, June 05, 2017

access to records of long-term climate trends and(or) forecasts of future weather patterns, farmers have little to lean on to, other than relying on their intuition for determining the most optimal substitute crops. In recent years, changes in crop patterns have resulted in overproduction, crop gluts, and resultant price crash in domestic commodity markets.[71] Instability has grown so much in commodity markets that the occasional "bumper crop" (above-average yield) also results in market crash, bankrupting small farmers.[72]

The effect of both, that is an increase in the cost of production on one hand and price crash on the other, has been the financial ruin of farmers, especially those who do not have the means necessary to absorb this thrashing. Even comparatively affluent agriculturists are not able to sustain such shocks that have become increasingly frequent.

The disruption of commodity markets has destabilized the agro-based industry of the country as well. Sugar mill owners, for example, have seen shrinking profits in times of overproduction of sugarcane in the country. Faced with falling crop prices due to overproduction, traders and mill owners struggle to remain profitable by curtailing production. Alternatively, they would negotiate subsidies from the state, and (or) "purchase" raw material from farmers on credit only to pay them in full *after* selling the

[71] Phutti prices drop to Rs550 per 40kg, *Dawn*, February 12, 2002; Growers forced to sell wheat at below Rs. 300, *Dawn*, May 03, 2002; Millers warn against looming sugar crisis, *Dawn*, August 21, 2007; Potato prices crash, *Dawn*, March 09, 2015; Pakistan confronts the curse of potato success, Reuters, March 13, 2015; Pakistan faces glut of agricultural produce, *The News*, October 24, 2015; Another year, another sugar glut, *Business Recorder*, November 09, 2018; Potato glut shows how small-crop farmers are suffering, *Dawn*, March 04, 2019

[72] Farmers fear price crash on bumper wheat crop, *Dawn*, March 23, 2009; Pricing of a bumper crop, *Dawn*, January 25, 2010; Cotton prices going down, *The News*, July 5, 2011; Huge Kinnow trade surplus, *Dawn*, December 09, 2013; Bumper crops hardly a blessing, *Dawn*, April 03, 2015; Worthless surpluses, *Dawn*, February 22, 2016; No signs of wheat glut subsiding soon, *Dawn*, March 07, 2016; Expecting more bumper crops, more problems, *Dawn*, April 11, 2016

end product in domestic or global markets.[73] Sugarcane farmers have to regularly protest for months to get mill owners to pay them for their produce.[74] At times the state and courts have to intervene to provide relief to farmers.[75] Growers of wheat, rice, maize, potatoes, etc., face similar conditions where they are forced to sell their crops at prices below the break-even price.

As globalization blurs boundaries between local and global commodity markets, overproduction or shortage of crops anywhere in the world directly affects crop prices in the domestic market. Global rice glut, for example, has resulted in bankrupting Pakistan's rice farmers. Similarly, depressed wheat and cotton prices in the global market have led to traders importing cheap agricultural products from elsewhere in the world instead of purchasing expensive ones from local growers.

Cognitive liberation and beginning of transgressive contention[76]

Financial squeeze due to crop failures and losses incurred in successive cultivation cycles has engendered widespread unrest in Pakistan's farmers. The temporal

---

[73] Sugar mills owe Rs13bn to govt and growers, *Dawn*, October 09, 2009; Pakistani sugarcane farmers: Between crop and a hard place, *UCA News*, February 20, 2018; Bitter reality of sugar industry, *The News*, December 16, 2018

[74] Cane growers protest against sugar-millers: Non-payment of dues, *Dawn*, December 02, 2003; Growers threaten to move courts: Row over sugarcane price, *Dawn*, January 15, 2008; Sugar mill not paying Rs460m to farmers, *The Nation (AsiaNet)*, April 16, 2010; Cane growers protest as mills 'ignore' PM's price direction, *Dawn*, December 07, 2015; Dues payment to sugarcane growers demanded, *Dawn*, May 08, 2018

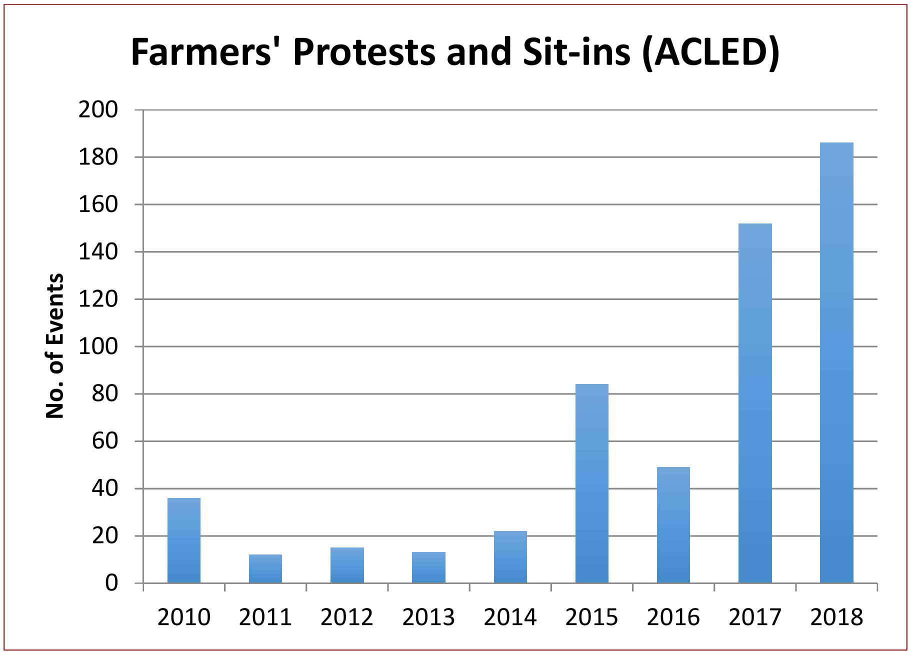
[75] Recovery of dues from sugar mills ordered, *Dawn*, September 27, 2004; Ordinance for recovery of cane growers' dues as revenue arrears, *Dawn*, November 12, 2015; Sugar mills told to clear dues by 20th, *Dawn*, July 16, 2016; Sugar mills asked to pay arrears to growers at SC-fixed rate, *Dawn*, May 22, 2018

[76] McAdam et al. (2001, pp. 7-8) identify two types of political contention, contained and transgressive. Whereas contained contention is regular political struggle between previously established political actors with political means available in an institutionalized political setup, transgressive contention is about new political actors using innovative collective actions that are either unprecedented or forbidden within a political setup.

trend of protests carried out by farmers in the last few years shows a rapidly increasing progression of this unrest (Fig. 5.13).

ACLED records of social and political unrest in Pakistan go back till only 2010. There may be several reasons for this, but the most obvious one appears to be the non-availability of digital records of news stories related to Pakistan prior to 2000s. Moreover, news accounts from LexisNexis about farmers and the state of agriculture in the country reveal that although there were sporadic and spontaneous protests in years leading up to 2010, mobilization of farmers' representative organizations did not begin until later. In fact, during most part of the aughts, farmers were busy coming to grips with effects of climate change, and waking up to the realization that they could not handle the situation by themselves anymore and needed the state's support.

It is important to consider the political climate in the country during the late 2000s that may have provided farmers with a political opportunity to mount a movement for policy change. Social and political unrest in Pakistan was reaching its limits during the late 2000s to early 2010s. Political agitation against then president and military dictator General Pervez Musharraf had brought hundreds of thousands of protesters on the



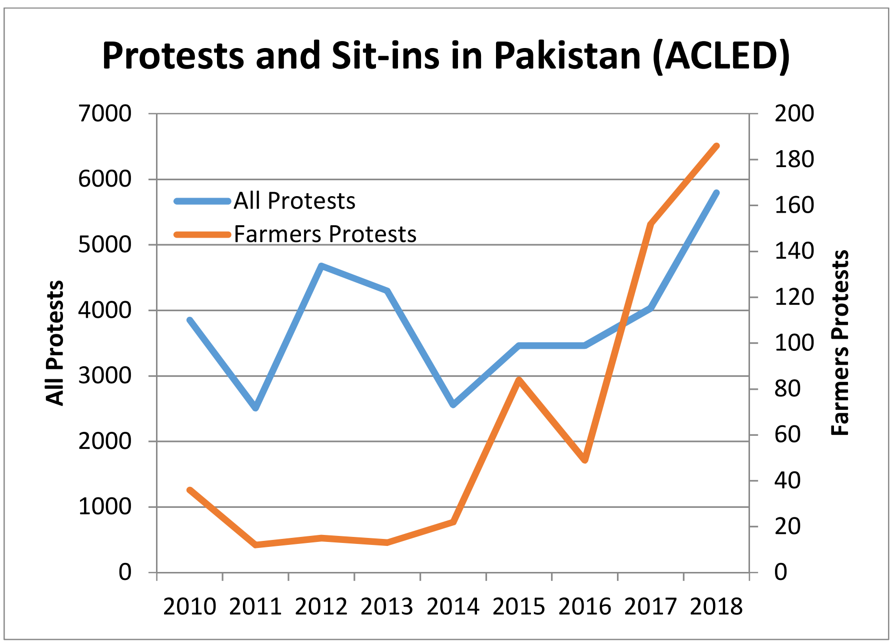


Fig. 5. 13: Protests and sit-ins carried out by farmers in Pakistan
Data source: Armed Conflict Location and Event Database (ACLED)

streets;[77] food shortages due to the global food crisis had led to riots in major cities;[78] power outages had resulted in large-scale protests throughout the country,[79] to name a

[77] Bhutto threatens more protests against Musharraf, *NPR*, November 07, 2007; Journalists protest against Musharraf curbs, *Financial Times*, November 22, 2007; Pakistan: Lawyers in 'long march' against Musharraf, *The Guardian*, June 09, 2008

few reasons for political turmoil in the country during that period. However, during such times when all kinds of social and political frustrations were melding together into an incoherent political chaos, farmers managed to carve out and maintain a distinct identity for their political struggle. As will be discussed later, farmers' protests were singularly focused on problems specific to agriculture sector. Also, unlike other protests that sometimes turned violent and were aimed at regime change, farmers maintained peaceful nature of their agitation and demanded policy reforms.

An important development among Pakistan's farmers in the last several years is what McAdam (1982) calls cognitive liberation.[80] There is a widespread realization among them that they are not being treated fairly, and that the state and ruling elite are not serious in solving the problems that the agriculture sector faces from effects of changing weather patterns and commodity market disruption.[81] Farmers regularly hold rallies and corner meetings in small villages and towns, in addition to protests and sit-ins in big cities, to raise awareness among local peasants about injustice meted out to them by the state and the rich and urban ruling elite.

---

[78] Flour shortages deepen Pakistan's turmoil, *NBC News*, January 17, 2008; Pakistan roiled by flour and electricity shortages, food price rises, *World Socialist Web Site*, January 21, 2008; Pakistan seethes over power, sugar, and flour crises, *Reuters*, September 17, 2009

[79] People clash with police to protest 20-hour power outage, *Gulf News*, May 30, 2012; Pakistan power cut riots spread as politician's house stormed, *The Guardian*, June 19, 2012; Pakistan blackouts power frustration at government, *NPR*, August 07, 2012

[80] McAdam (1982) defines cognitive liberation as a necessary adjunct to mobilization of social movement, and argues that 'Before collective protest can get under way, people must collectively define their situations as unjust and subject to change through group action' (p. 51).

[81] Govt. urged to end growers' exploitation, *The Nation*, January 03, 2012; Struggling Pakistani farmers reject state power subsidy, *Thomas Reuters Foundation*, January 08, 2015; Farmers demand 'agriculture emergency', *Dawn*, February 21, 2016; Calls to make agriculture sustainable, *The News*, March 5, 2016; Farmer bodies express disappointment, *Dawn*, June 05, 2017; Rashid, Hashim bin, A new wave of agrarian protest in Punjab, *Agrarian South*, January 14, 2019; Disappointed farmers, *Dawn*, January 28, 2019;

Some slogans popular among farmers and invoked in their speeches and protests are representative of the feeling of being wronged:

> *Din raat mehnat tu karayn, teray ee baal ghareeb*
>
> Translation: O farmer, you work hard day and night, yet your kids remain paupers
>
> *Jaag kissan jaag, teri faslan no lay gaye naag*
>
> Translation: Farmers, wake up, snakes have stolen your crops
>
> *Paani naahe chho bhala, Karbala Karbala* [82]
>
> Translation: There is Karbala like situation in the area without water

In the midst of this desperation has emerged a sense of unity, and led to mobilization and organization at grassroots levels. Scores of small scale farmers' representative outfits have sprung up at district and union council levels across the country, particularly in the two most populous and agricultural provinces of Punjab and Sindh. Some of the organizations reported in LexisNexis are *Pakistan Kissan Ittehad*, *Kissan Board Pakistan*, *Anjuman Kashtkaran Pakistan*, *Sindh Taraqqi Pasand Party*, *Sindh Abadgar Movement, Sindh Abadgar Association*. The number of such organizations has significantly increased in recent years.

Additionally, sensing that interests of traders and manufacturers in the country do not align anymore with those of farmers, the latter have demanded that a separate "Pakistan Chamber of Agriculture" be established, and agriculture not treated as a

---

[82] 'Dying' of thirst: Farmers march 150km in quest for water, *The Express Tribune*, July 04, 2019

subsector in the existing Federation of Pakistan Chambers of Commerce and Industry (FPCCI).

> The existing chambers of commerce and industries are not the real representatives of the farmers and they have their own interests. All the existing chambers are dominated either by the traders class or the industrialists community and how they would work for the cause of cultivators…. [A]t this moment farmers' real problem is irrigation due to scarcity of water…. [L]ands are fast turning into barrens due to non-availability of water. Canals have dried up and just 25 per cent of their total cultivable land could be irrigated with this scanty water and after the setting up of Pakistan Chamber of Agriculture there would be a proper platform and relevant representatives to voice this matter before the government.[83]

This cognitive liberation has an ethnic element to it as well. There is rising tension between Punjabi speaking upper riparian farmers and Saraiki and Sindhi speaking lower riparian populations over distribution of the shrinking Indus waters. As discussed in the previous section, the effects of climatic changes are some of the worst in southern Punjab and Sindh. Failure of cotton crop, in particular, has devastated farmers in these areas. Moreover, changes in rainfall and temperature patterns are more pronounced there than in upper riparian central Punjab. The disproportionate economic downturn has exacerbated the preexisting ethnic fault lines between these populations. Whereas Saraiki farmers believe that their fair share of Indus waters is being siphoned off by the upper riparian "Takht-e-Lahore", Sindhis consider it a conspiracy by Punjab to destroy Sindh's ancient civilization by depriving it of what historically belongs to it (Mustafa, 2010;

[83] Growers demand own "Chamber of Agriculture", *The Nation (AsiaNet)*, November 17, 2008

Mustafa, Akhter, & Nasrallah, 2013). This sense of deprivation among vulnerable populations has led them to organize at local levels. A big chunk of farmers' protests is carried out by these two groups. Although their ire is apparently aimed at the state for allowing their exploitation, it has deep ethnic fissures that have the potential of becoming active in no time.

Characteristics of farmers' movement in Pakistan

The farmers' movement in Pakistan is still in its infancy, although there is clearly an increase in frequency and intensity of protest events. There is no central organization representing all the farmers, yet some form of consolidation appears to be underway where local groups are forming alliances or merging in relatively larger organizations. Protest data from ACLED and news reports retrieved from LexisNexis uncover a few general characteristics about farmers' protests, and are listed below:

Episodic in nature:

McAdam et al. (2001) argue that regarding entire streams of confrontations such as demonstrations, social movements, rebellions, food riots, tax-rebellions, etc. as self-contained entities is problematic, as it abstracts away the generalizable intermediate processes and mechanisms that may be common to all of them. Instead, dividing a contentious politics phenomenon in individual episodes and looking for recurring uniformities may help identify similarities and differences not just in different phenomena but also uncover the progression of contentious politics from one episode to the next. Episodes, they argue, are not natural phenomena but "iterative sites of interaction in which different streams of mobilization and demobilization intersect, identities form and evolve, and new forms of actions are invented, honed, and rejected as actors interact with one another and with opponents and third parties" (McAdam et al., 2001, p. 30).

Careful perusal of LexisNexis news reports and ACLED records uncover the episodic nature of famers protests in Pakistan. The records show that these episodes take place almost every cultivation cycle either before or after the harvest season as it is then that farmers are in need of money to prepare for next season's cultivation cycle. With farm incomes tumbling one cultivation cycle after the other, farmers' anger and desperation is on the rise and manifests in popular protests.

Each episode begins with a series of mobilization campaigns carried out in smaller cities and villages, which are followed by claim-making[84] in the form of media appearances, press conferences, interviews, etc. Finally, the episode would culminate in a series of contentious gatherings usually planned in big cities. These protests wane either when farmers' demands are fulfilled or when they must return to villages for harvest and/or preparation of next season's crops, and so on.

As will be discussed later in this section, most protests have taken place to demand increase in floor prices of major and minor crops. As inputs costs continue to soar, and water becomes scarcer and weather patterns evermore unpredictable, farmers

[84] Lindekilde (2013) defines claims-making as "the process of performing or articulating claims that bear on someone else's interests. In its simplest form an instance of claims-making includes two actors – a subject (claimant) and an object (addressee) – and a verbal or physical action (demanding, protesting, criticizing, blaming etc.). In the context of social movement studies and contentious politics, claims-making has most often referred to the conscious articulation of political demands in the public sphere, thus leaving aside more private or hidden forms of political claims-making such as voting and lobbyism".

take to streets to seek government's help. In the past five years, farmers have effectively used social media to mobilize their members and to disseminate information about plans for contentious gatherings, as well as pictures and live video feeds of these events.[85] Successful events are celebrated in villages and protesters welcomed like celebrities[86] when they return with some sort of relief or promise of policy change by state officials. These celebrations help attract new members and embolden farmers even further as they prepare for next wave of protests.[87]

In addition to the inherent nature of contentious politics which dictates waxing and waning of episodes of contention, the episodic nature of farmers' protests in Pakistan appears to be rooted in the fact that most protests have been carried out by poor tenant farmers who lack resources necessary for mounting a sustained movement. In order to sustain their livelihoods, farmers descend on big cities for short-term demands such as revision of floor prices for major crops, increase in subsidy on inputs, etc., only to return a few months later as continued climatic stresses and their effects chip away farm-incomes further. The iterative nature in which climatic stresses and their effects pervade through the society and impose burdens on farmers is reflected in increase in frequency and intensity of protests over the years.

The data shows that each successive episode has resulted in farmers becoming more organized and mobilized over the years. Unlike before, every cycle there are more

---

[85] A few of the Facebook pages maintained by farmers' representative organizations include, Kisan Board Pakistan, Anjuman Kashtkaran Punjab, Pakistan Kissan Ittehad, Pakistan Kissan Ittehad – Ch Anwar Group, Pakistan Kissan Ittehad - Qasur, Pakistan Kissan Ittehad Khanewal, Sindh Abadgar Tanzim, Sindh Abadgar Ittehad, Sindh Abadgar Board.

[86] Farmers' future in the balance, *BBC Urdu* (Video report), April 12, 2015 (accessed October 7, 2019)

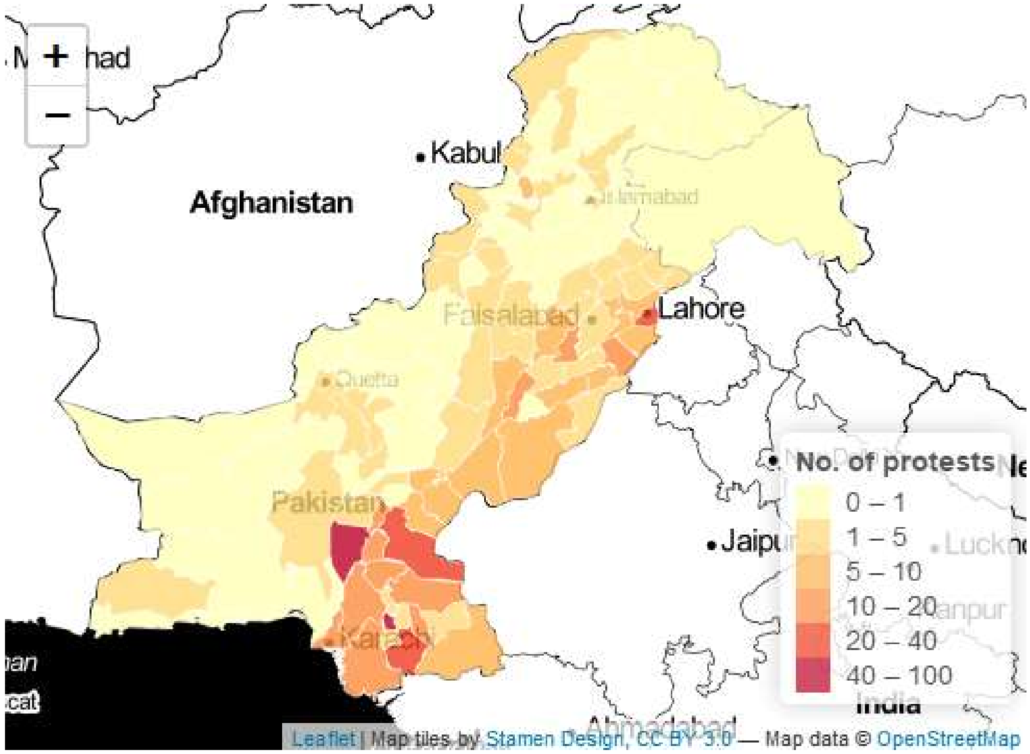
[87] A few examples of farmers' mobilization campaigns can be seen by watching YouTube videos of such public meetings: Jalsa in Bahawalnagar 2015, Jalsa in Bahawalpur 2016, Jalsa in Gojra. Jalsa in Mian Channu 2017, Jalsa in Khanewal

protests that are organized by farmers' organizations and planned well in advance with clear agenda and guidelines for participants. Moreover, successive cycles of mobilization and demonstrations have earned farmers respect and support from their constituents at the local level, and recognition from political actors at the national level.

Spatially diverse

The fact that varied manifestations of climate change have affected different agro-ecological zones differently is also reflected in patterns of unrest. The geo-spatial mapping of ACLED records of farmers' protests shows that unrest among farmers is higher in the southern parts of the country where effects of climate change are the most severe. Based on data from ACLED, Fig. 5.14 shows choropleth maps of farmers' protests in different cities in Pakistan since 2010. The number of protests is significantly higher in Sindh province, followed by that in southern parts of Punjab. Although protests have also taken place in the KPK province in the country's north, as well as in Balochistan, their magnitude is comparatively much less.

Data also reveals that the reasons of farmers' protests in different parts of the country are different and are closely linked with effects of climate change on respective local political economies. Farmers in Sindh, for example, are most concerned about the depleting Indus stream flows, while most protests in Punjab had to do with increasing input costs and commodity market disruptions. As the cotton crop continues to fail, and



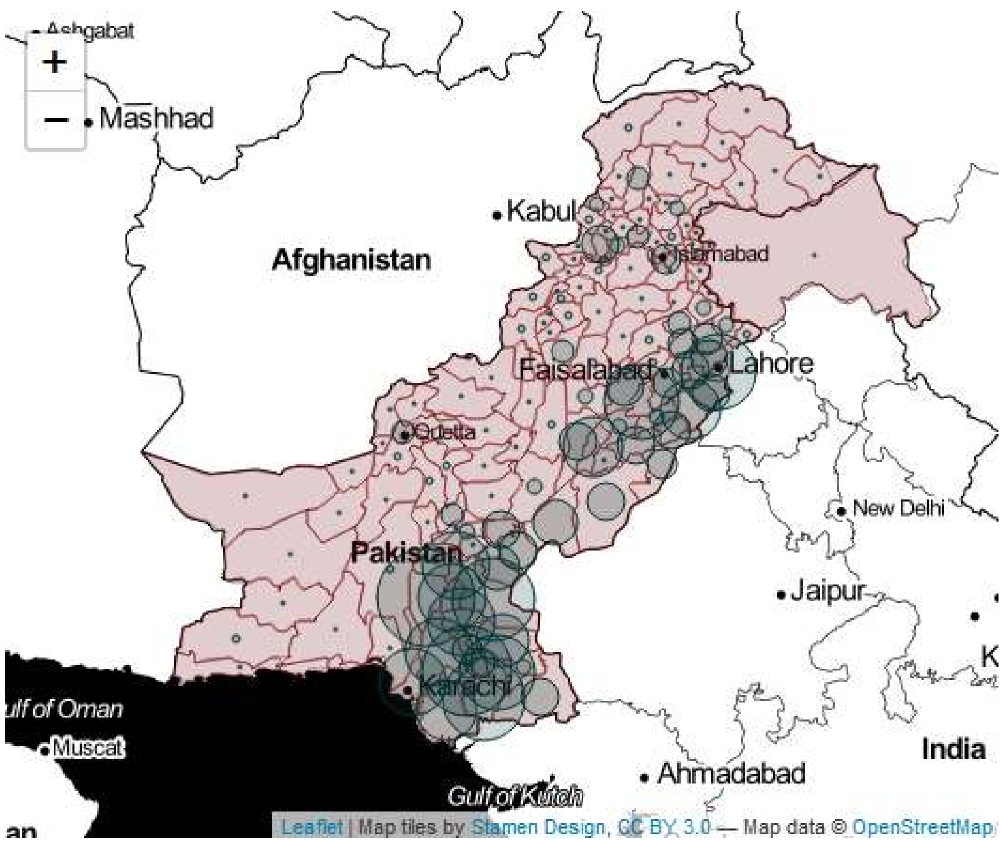


Fig. 5. 14: Choropleth maps illustrating geo-spatial maps of farmers protests over the years

farmers rush to replace it with sugarcane, among other crops, overproduction has destabilized commodity markets, with effects traveling through the entire political economy of the country. In southern Punjab, hundreds of protests against sugar mill owners have brought tens of thousands of farmers on streets, and often led to violent clashes.[88]

It must be noted that the number of protests in a district, city, or province alone may not serve as an accurate indicator of the effectiveness of a social movement or a political campaign. For example, detailed news accounts about contentious gatherings reported in ACLED reveal that although the number of protests in Sindh are higher, it is the demonstrations in Punjab that have proved to be more consequential and yielded favorable results for farmers. However, since agriculture (policy) is a provincial matter since the passing of the 18th amendment in Pakistan's constitution, policy reforms in Punjab do not have bearing on Sindh.[89]

Contentious performances

Analyzing the ten years data that is available through ACLED, an increasing progression towards violence is observable in farmers' demonstrations, although it is still far from full-blown conflict. In the first half of the aughts, farmers' protests consisted of impromptu outbursts in which small groups would block local streets and stop traffic for a few hours. In recent years, however, farmers have become more organized and their

---

[88] Protest against deductions: Farmer killed, others injured as sugar mill guard opens fire, *Dawn*, December 17, 2011; Thee farmers injured by sugar mill guard, *Dawn*, April 18, 2014; Farmers desperate as sugar mill falls short of cash, *Dawn*, December 17, 2014; Sugarcane growers await payments, *Dawn*, March 22, 2015; 22 booked for 'attack' on sugar mills guard, *Dawn*, March 06, 2018
[89] Blaming 18th amendment for agriculture's poor show, *Dawn*, February 15, 2016

contentious performances have improved along the way. A few of the notable practices that have proved to be effective are mentioned below:

Blocking highways, choking urban centers

Blocking major intercity highways as well as traveling to big urban centers for protests have proved to be some of the most effective techniques employed by Pakistan's farmers.[90] Having tried, unsuccessfully, to voice their demands in local press clubs or by protesting in smaller cities, farmers appear to have learned that any chance of policy change lies in disturbing the everyday life in important cities of the country. Judging from the media coverage of protest events organized in big cities, the approach seems to have worked quite well. Both, media as well as government officials are quick to reach out to farmers when they block important inter-city highways or lay siege to major city squares and government buildings. As the choropleth maps show, more protest events are clustered in cities than in remote villages and small towns. The technique is most practiced in Punjab where farmers travel from southern parts of the province to the capital city of Lahore to make themselves heard. It is one of the reasons why protests taken out in Punjab have yielded better results for farmers, as compared to those in Sindh.

---

[90] Protesters on camel carts reach city, *The Nation (AsiaNet)*, April 03, 2010; Samundri villagers out against govt callousness, *The Nation (AsiaNet)*, March 20, 2012; Electricity problems: Farmers protest at WAPDA office, *The Express Tribune*, November 02, 2012; Farmers end 19-hour protest on GT Road, *Dawn*, March 03, 2013; Farmers' protest triggers gridlock, *Dawn*, May 03, 2013; Thousands vent spleen against low cane rates, *The Nation (AsiaNet)*, December 08, 2014; Police puts 100 farmers behind bars for 'obstructing traffic', *The Express Tribune*, March 25, 2015; Farmers rally in Lahore on 31st, *Dawn*, May 25, 2015; Last resort: farmers protest low wheat price, high power bills, *The Express Tribune*, June 05, 2015; 260 farmers booked for blocking road, *Dawn*, March 18, 2016; PKI farmers threaten to shut roads if demands not met, *The Nation (AsiaNet)* June 07, 2017; Badin shuts down over water crisis, *The News International*, February 25, 2019; Protesters hold march, vow to besiege CM House over water shortage, *Dawn*, March 5, 2019

Sit-ins

Sit-in as a contentious performance gained prominence in Pakistan in 2014 when a mainstream political party, *Pakistan Tehrik e Insaaf* (Pakistan Justice Party), organized a sit-in in Islamabad that lasted for 126 days.[91] The protest was a huge success and brought the government to its heels. Given its effectiveness, other political actors, including farmers, have copied the technique successfully since then.

Since organizing and successfully conducting a sit-in requires a strong central leadership and utmost discipline in participants, its use as a pressure tactic was least expected of farmers, hitherto unheard of as an established political entity. This was the reason that the government was blindsided when thousands of farmers laid siege to Punjab Assembly in Lahore by carrying out a sit-in for three days.[92] The event was a big political success for farmers as it established them as a political force to be reckoned with. Political parties from across the country sensed a political opportunity and participated in the sit-in to show solidarity with farmers.[93] The event ended after the government leadership met with farmers and promised to address their demands.[94]

The success of this *dharna*, as it is called in local vernacular, inspired farmers across the country to employ the tactic. Since then, as farmers have become more

---

[91] For a national cause: PTI calls off dharna after 126 days, *The Express Tribune*, December 18, 2014
[92] Farmers take to the streets, *The Express Tribune*, September 29, 2016
[93] Famers' protest gets political parties support, *Dawn*, September 29, 2016; Boycott over farmers' issue disrupts Senate session, *Dawn*, September 29, 2016;
[94] Farmers to wait and see amid govt. assurances, *Dawn*, September 30, 2016

politically active in recent years, sit-ins have become a key contentious performance employed throughout the country.[95]

Planning for sit-ins begins weeks and months in advance. Farmers announce such events through their social media accounts, messaging groups, as well as corner meetings conducted in remote villages, towns, and small cities. They travel to big cities in large processions of tractors, trolleys, motorcycles, etc., to show their strength. Upon being intercepted by the police, they carry out the sit-in on highways wherever they are stopped.

Burning crops, self-immolation

As farmers struggle to stay afloat amid crop failures and price crash of one crop after the other, there have been instances of some of them setting their crops on fire than selling at a loss. To express their frustration, and to draw public attention to their financial stress, farmers bring truckloads to major city squares and set the crops ablaze. In addition to disrupting traffic, the action has a strong psychological effect on viewers. This contentious performance has been employed by farmers more frequently in recent

---

[95] Farmers' sit-in for water disrupts rail traffic, *Dawn*, April 28, 2013; Farmers end Thokar sit-in as govt 'accepts' their demands, *Dawn*, March 27, 2015; Farmers get concessions through street strength, *Dawn*, June 05, 2015; CS intervenes as farmers refuse to end agitation over 'water theft', *Dawn*, July 14, 2015; Farmers launch Kissan Raj Tehrik, stage sit-in, *Dawn*, September 04, 2015; Farmers back to the Mall, *The Nation (AsiaNet)*, May 24, 2016; Farmers stage sit-in, *The News International*, August 11, 2016; Farmers stage sit-in against 'unscheduled outages', *Dawn*, June 01, 2017; Payment of dues: Farmers protest outside sugar mills, *Dawn*, August 08, 2017; Farmers stage sit-in at Thokar, *Dawn*, December 06, 2018; Potato growers end sit-in after assurance, *The News International*, January 17, 2019; Farmers stage sit-in on highway to protest water shortage, *Dawn*, July 13, 2019

years.[96] In addition to burning, sometimes farmers dump their produce on roads to cause traffic jams.

There have been a few incidents when farmers set themselves on fire during protests,[97] although farmers' suicides are not a widespread phenomenon in Pakistan.

Civil disobedience

Financial distress has led farmers to carry out civil disobedience a few times, [98] although it has not become a common practice. The most notable case occurred in 2012, when farmers in the city of Marot in southern Punjab announced that they will not pay utility bills to protest against the state. Farmers' representative organization Pakistan Kissan Ittehad, led the protest, and with the help of local farmers-turned-vigilantes turned the area into a no-go-zone for utility company officials. Farmers did not pay their "electricity bills for three years, and even 375 turbines installed in these villages were defaulting on over Rs. 330 million….When WAPDA teams visit the areas to recover the outstanding bills, Wattoo instigated the locals against them and tortured Wapda as well as police teams".[99]

---

[96] Farmers burn sugarcane in protest, *Dawn*, December 27, 2002; Farmers decry 'low' cotton rates, *Dawn*, November 05, 2011; Farmers threaten to set wheat ablaze, *Dawn*, May 07, 2012; Farmers protest low price of cotton, *Dawn*, September 27, 2014; Sugar cane production in Sindh likely to drop by 15pc this year, *Dawn*, September 27, 2018; Farmers for potato support price, *Dawn*, December 20, 2018; Potato glut shows how small-crop farmers are suffering, *Dawn*, March 04, 2019

[97] نوشہرو میں خود سوزی کی کوشش (Two farmers set themselves on fire in a protest in Naushehro, Sindh), *BBC Urdu Video*, September 07, 2010; Peasant attempts self-immolation during Sindh sugar cane growers' protest, *Dawn*, December 28, 2017

[98] PMKM warns government of launching civil disobedience movement, *Business Recorder*, July 29, 2011; Farmers protest raise in electricity tariff, *The Nation (AsiaNet)*, December 11, 2012

[99] Marot villages made no-go areas by extortionist, *Daily The Post*, December 04, 2014

The episode ended in a police crackdown in which police baton charged and arrested hundreds of farmers, and set local farmers' houses on fire.[100]

Stated causes of protests:

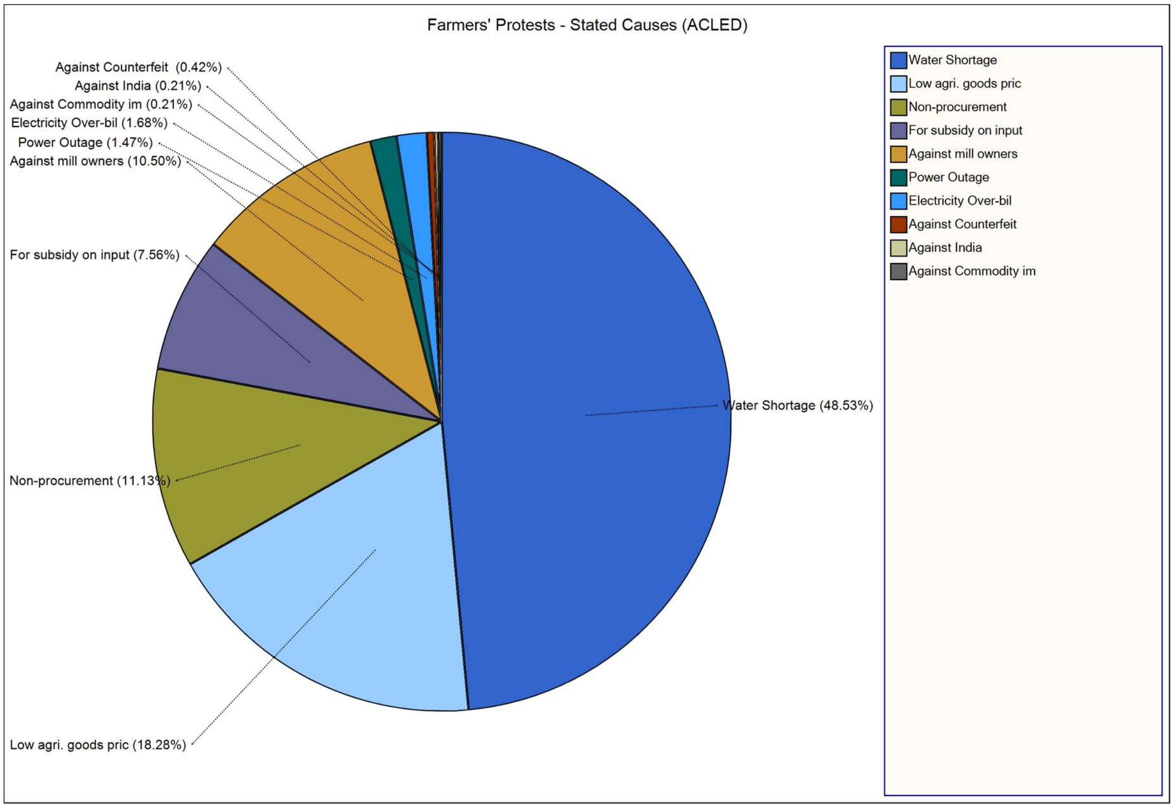
Fig. 5.15 shows notable causes for protests as stated in data records in ACLED. Although objectively ranking them in terms of their importance is problematic, because of potential shortcomings of data entry mentioned earlier in this section, these stated causes are coded in NVivo to develop a tentative ordering for the sake of analysis.

The data shows water scarcity as by far the biggest reason for protests over the years. Most of the protests taken out solely for water scarcity have taken place in Sindh, although the problem is not exclusive to that region. However, being a lower riparian, Sindh's population is more vulnerable to shrinkage in the Indus stream-flows and/or fluctuations in rainfall trends than any other part in the country. Also, since water tables are much lower in Sindh, surface water is the only sustainable source of irrigation available to most farmers. Unable to water their crops or even prepare their fields for cultivation, protests taken out by Sindhi farmers at times become violent as they storm offices of irrigation officials, attack canals regulators, or block highways and conduct sit-ins. Water shortage has also caused unrest in southern parts of Punjab, yet the number of protests solely attributable to water shortage is comparatively smaller. The number of protests attributable to water scarcity is much smaller in the upper riparian central Punjab.

[100] 5000 cops launch op to quell 'farmers' mutiny', *The Nation*, November 18, 2014; 300 farmers booked on charges of revolt, *The Nation*, November 20, 2014; 'کسانوں کو کچھ بچے گا تبھی وہ بل ادا کریں گے' (How can farmers pay utility bills if they have no money) *BBC Urdu*, April 13, 2015

Low agricultural goods prices and non-procurement of agricultural products constitute the second and third biggest reasons for protests in the last few years. The two are interrelated, as discussed previously, but their distinct classifications are representative of the timings of protests. Most protests regarding low prices of agricultural goods have taken place before harvest, when farmers protested to lobby the state to improve floor-price of major and minor crops. The unrest related to non-procurement of their produce, on the other hand, manifests in protests after the harvest. In the past several years, as crop prices have tumbled due to either overproduction at home or price crash in international market, local traders have denied farmers the government-set floor prices. In recent years, farmers have struggled to sell even major crops such as wheat, whose purchase has historically been ensured by the state. As farmers try to switch to alternative crops, the market for almost every crop has crashed due to overproduction, resulting in farmers losing their livelihoods, and resorting to protests.

Protests against sugar mill owners have been some of the most violent. Farmers complain that sugar mill owners withhold their payments; sugar mill owners, on the other hand argue that due to plummeting sugarcane prices, they can’t afford to stay in business and pay farmers the floor-price mandated by the state. The situation has worsened in situations when global sugarcane glut has caused even more price crash, resulting in mill owners withholding money to reflect cane prices prevailing in global markets.



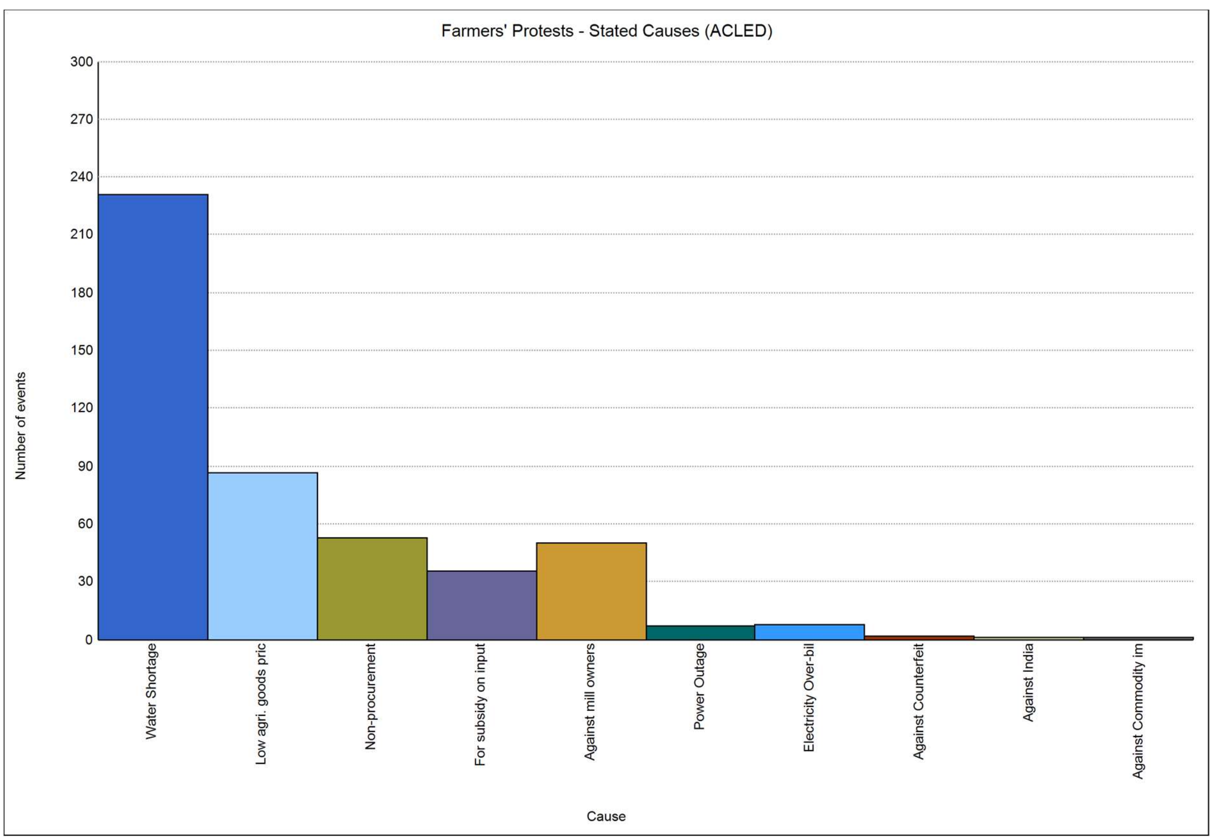


Fig. 5. 15: Stated causes of farmers' protests

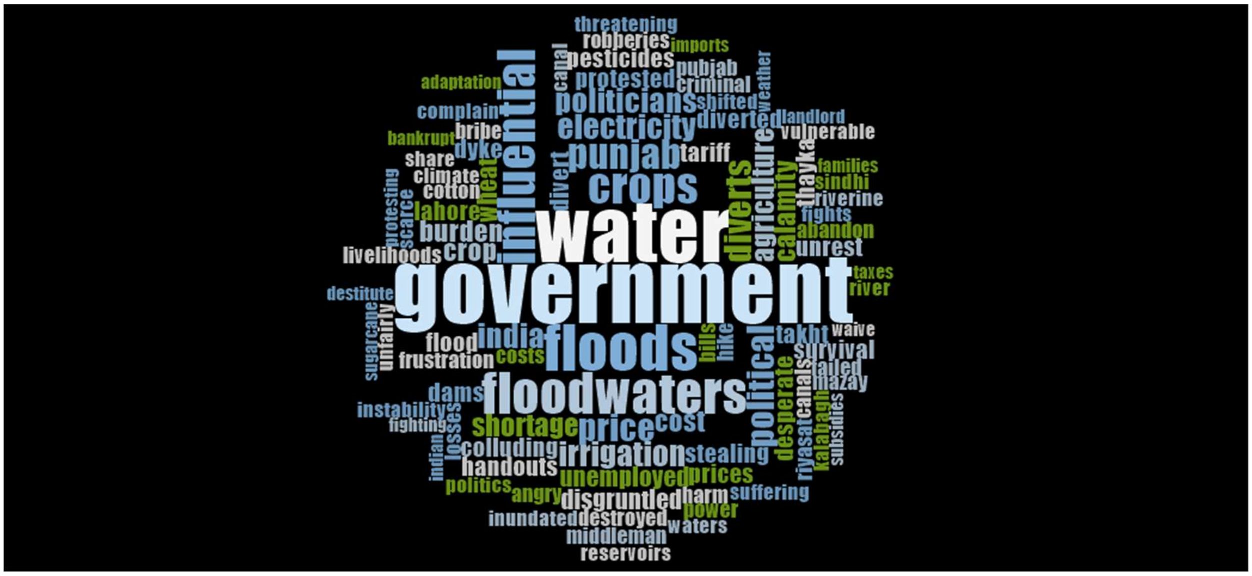


Fig. 5. 16: Word cloud based on ACLED records of farmers' protests

Protesting to get subsidies on agricultural inputs have led to large number of protests in Punjab. Prices of agricultural inputs have increased due to farmers resorting to input intensification to counter adverse effects of climate change. Since farmers are already suffering losses in their agricultural production and farm incomes, they demand the state to help them by subsidizing inputs such as fertilizers, pesticides, electricity, etc. Some of the largest protests conducted by farmers have taken place over this issue, at times resulting in government conceding to their demands. However, as farmers' incomes have continued to plummet and input costs continued to increase, protests demanding subsidies on inputs have spiraled.

Other causes of protest as stated in ACLED records include protests against electricity outage and/or overbilling, against counterfeit pesticides, against imports of agricultural commodities from elsewhere in the world, etc. Fig. 5.16 shows a word cloud generated from news accounts of farmers' protests listed in ACLED.

Conclusion:

The climate-security literature, as discussed in the literature review chapter, suffers from two key shortcomings. First, the methodological designs proposed in studies conducted on the topic lack the ability to isolate the "pure climate effect" in inducing unrest from other confounding factors that may be producing the similar effect. Secondly, there is no guidance whatsoever, in disentangling social and political unrest strictly attributable to climate change, from all other forms of political contention that a society may be mired in. This chapter has tried to address these two lacunae by opening the black-box and looking for generalizable bits of theory as proposed in the theoretical framework chapter. The data presented in this chapter gives credence to the argument put forth in this dissertation on three counts:

First, unpacking the hydro-meteorological data in Pakistan shows that mechanisms of climate change may not always be visible at the macro-level. In fact, far-reaching and potentially destructive changes in a society's natural system may be taking place at a subliminal level, thereby requiring investigating climate-trends at sub-annual as well as sub-national level.

Second, no analysis of climate-induced instability can be complete without zooming into the climate-society interaction at micro-level of society. Data presented in this chapter illustrates that human populations are not passive entities. They act and react to changes in their environment, constituting the basis for the never-ending dance between social and ecological systems. Understanding this interaction is the key to untangling the climate effect from confounding factors.

Third, just as is the case with every other stressor, societal instability attributable to climate change does not translate into political violence and conflict overnight. In fact, this unrest and instability goes through the process of contentious politics, ebbs and flows by interacting with the society's political system, and passes through the entire spectrum of contention before taking the form of full-blown conflict. Social and political unrest attributable to climate change in Pakistan is although far from reaching the final stage of civil conflict, it has become a potent force capable of imposing significant burdens on the country's political system. Given the stresses that climatic changes in the country have already locked in into the system, not to mention additional changes that are inevitable given the trajectory of global climate trends, the situation is bound to get worse, and may require wide ranging and transformational policy reforms.

Chapter 6: Conclusion

Over the last few years, the field of climate-security research has undergone remarkable change. Instead of a narrow focus on a direct link between climate change and onset of violent conflict, the field has opened up to include indirect pathways through which climatic changes may induce social and political instability. To account for indirectness through which climatic changes may interact with society, scholars have acknowledged the need to include mechanisms in explanations. Moreover, despite researchers' inability to converge on a link between environmental stresses and civil conflict, the potential of the former to threaten human security is broadly accepted. This is a sea change, given the bitter debates that research on the topic had triggered among scholars to the extent that calls for peace had to be issued. In this dissertation I have argued that although this evolution in thinking is laudable, it is still lacking on at least two counts: the first is that the prevailing conceptualization of climate change and its interaction with society is highly structural and fails to capture the emergence and complexity that the phenomenon imposes. The second is about the ontological assumptions that lack the capacity to incorporate the said complexity in research design.

To improve our understanding of the climate-induced unrest and social and political stresses, this dissertation has put forth an alternative theory using the rich concepts of social-ecological systems as well as decision-making under uncertainty. I have argued that climatic changes impose uncertainty on vulnerable populations who, in the absence of complete understanding of the nature of the stressor, are prone to undertake coping responses that may not only be ineffective but also may result in exacerbating their respective situations. Interaction of climate stresses with the society's preexisting processes may lead to widespread instability and even contention.

I have also argued that the prevailing ontology of positivism lacks the capacity to incorporate in research design emergence and complexity that climatic stresses impose on societies. Statistical correlations of structural variables may miss out interactive nature of the stressor as well as feedback and system effects that climate-society interaction may engender. I have argued that critical realism may be helpful in identifying generalizable mechanisms and provide a middle ground between highly structural positivist ontology and the descriptive anthropological accounts.

This final chapter has two goals. The first goal is to summarize the state of the literature, and provide a bird's-eye view of the theoretical framework proposed in this dissertation. The second goal is to demonstrate that the processes of climate-society interaction and imposition of social and political stresses are not exclusive to Pakistan, and that the framework is extensible to other societies undergoing climatic changes.

State of the literature:

Perusing through the sprawling literature on climate-security generated in the last several decades, one can divide the scholarship in three distinct waves or generations, each marking evolution in thinking and analytical approaches employed by scholars.

The first generation of the literature can be traced back to Garrett Hardin's influential essay 'The tragedy of the commons' in which he used the scarcity argument to link environmental changes with widespread instability in human societies (Hardin, 1968). Hardin's argument gained traction with scholars investigating the potential of climate change to stoke civil conflict. Notable among these scholars was Homer-Dixon who spelled out the argument in great detail and proposed a taxonomy of resource scarcity, arguing that population pressure and environmental degradation may result in violent conflict (Homer-Dixon, 1991, 1994).

Opponents of the scarcity argument questioned the deterministic approach taken by the Generation 1 scholars, and questioned the notion of scarcity being the sole reason for conflict – for instance, resource-poor countries such as Japan are wealthy while resource-rich countries are poor (Deudney, 1990). More importantly, the critics called into question the methodological approach, and argued that the logic of the scarcity argument is anecdotal and near-sighted, violates the rules of quasi-experimental methodology, and therefore does not qualify as systematic research (Gleditsch, 1998; Levy, 1995). This critique marked the beginning of the second wave of research on the topic, and opened the flood gates of quantitative studies searching for statistical association between variables of climate change and predictors of onset of civil conflict. However, despite numerous studies, books, monographs, and refereed journal articles published on the topic, scholars failed to develop a consensus that civil conflict can be directly traced back to variables of climate change.

The failure to converge on a link between environmental changes and predictors of onset of civil conflict led to the realization among the Generation 2 scholars that a narrow focus on violent conflict may not be advisable. Also, instead of seeking a direct connection between the two, a more nuanced approach may be useful. This third wave of scholarship, which is still underway, has since focused on investigating the role of climate change in endangering human security. Based on a political ecology approach, the argument has gained more acceptability than the previous efforts, although scholars are still puzzled about the causal pathways that may link climate change with social and political instability and conflict.

Each of the three waves of scholarship, although improved on the methodological approach as well as the logic of the previous one, all three share the following two shortcomings:

Absence of the climate change *process* from the climate-conflict research:

Perhaps one of the most compelling effects of the variable-based approach is the collective silence of climate-conflict scholars regarding the process of climate change itself. Despite all the emphasis and urgency in figuring out its deleterious effects on local and global security, its elucidation is effectively absent from most formulations of the problem. It appears as if there is an underlying assumption that climate change is a self-evident phenomenon that needs no articulation; and that everything about it can be summarized in a few variables. Theisen et al. (2017) list four climate variables most often used in the literature. These include: 1) change in annual precipitation, 2) average annual temperature, 3) rising sea levels, and 4) natural (hydro-meteorological and climatic) disasters. These generalizations are limiting, to say the least, and do little to improve understanding of the climate change process and its effects on human behavior, for example, the propensity to participate in conflict under varied forms of changes in the natural system.

Firstly, the usefulness of abstract variables extensively used in research on the topic is suspect as no one experiences average annual temperature or average annual rainfall. A society's climate is composed of sub-annual and sub-seasonal trends of a large array of ecological processes that constitute its meteorological calendar as well as its ecological system. Over the course of millennia, agricultural practices as well as local political economies built around them have been calibrated to such an extent that even the slightest of change in climate and weather patterns can cause significant instability in a society. In today's highly integrated and interdependent world, this vulnerability has seen new heights, as instabilities brought about by climate change do not stay local, and in fact travel to far away societies through formal and informal trade channels (Sternberg, 2013a).

Secondly, aggregate datasets leave out many other possible local or regional manifestations of the changing climate that are far more important to local populations regarding the impact on their respective economies and livelihoods. For example, changes in diurnal temperature may provide a conducive environment for pest population to thrive (Thomson, Macfadyen, & Hoffmann, 2010) and impose financial burdens on local farmers by inducing crop failure and (or) increased cost of production. Similarly, proliferation of vector borne diseases such as Dengue is shown to be traceable to climate change (Xu et al., 2017) and can plausibly result in widespread unrest (Cervellati, Sunde, & Valmori, 2011). In some societies, variability and change in stream-flows may have a much larger impact on livelihoods than change in rainfall patterns.

The United Nations' Food and Agricultural Organization (FAO) divides agricultural lands within and across societies in terms of Agro-Ecological Zones (AEZ), or areas of land with 'similar characteristics related to land suitability, potential production and environmental impact' (FAO, 1996). Changes in weather and climate trends may vary within and across societies based on the ecological zones they are comprised of. These differences are also reflected in their respective agricultural practices and related political economies. An agro-ecological zone with its political economy built around hot and dry conditions, for example, may be affected more adversely by a downward trend in its summer temperatures as compared to regions where moderate summer temperatures are a norm. Similarly, shifting of rainfall by a few weeks or months may have varied impacts on different agro-ecological zones and their populations. The fact that more than one ecological zone, each with different climate patterns, may exist within a single country turns the country-year approach, around which most aggregate climate-conflict datasets are developed, on its head.

Finally, the variable based approach misses out the interactive nature of ecological systems across scales. The earth's climate is not a monolithic system. It is a constellation of local climates and ecological systems. In fact, it is the continual interaction and feedbacks among them that render the global climate system its complexity (Lorenz, 1963; Rind, 1999). The effects of climatic changes in one part of the world travel to other geographically distant locations in a seamless manner. For example, an increase in ocean temperatures speeds up the evaporation of water into water vapors, thereby supercharging the hurricanes and resulting in widespread destruction (Trenberth et al., 2018). Atmospheric circulation under climate change affects local weather patterns such as temperature, rainfall, winds, cloud cover, etc. (Santer et al., 2018). Similarly, erratic monsoon rains in the upstream countries wreak havoc on the downstream as floodwaters flow through lower riparian societies and destroy everything in their path, etc.

Extraction of the "social" from social-ecological phenomena

Another important implication of the current approach is extraction of the 'social' from social-ecological phenomena. The climate of a society is more than a graph showing annual mean temperature or rainfall trend. It is a phenomenon around which a society's social norms and culture evolve over a long period of time, traditions develop, habits of its inhabitants are formed, and probably most importantly, its political economy takes shape. When viewed through this lens, change in a society's climate is not merely an increase in average annual temperature but a forced change in the very fabric of that society. Reducing the climate process to data points in a time series sanitizes it of its social context or 'lived environment'. Hulme (2008) convincingly argues:

> A rainstorm which offers an African farmer the visceral experience of wind, dust, thunder, lightening, rain – and all the ensuing social, cultural and economic signifiers of these phenomena – is reduced to a number, say 17.8 mm. . . . [T]he essential loading of climate with culture – what climate means for people and places and the relationships between people and places over time – is completely lost through such purifying practices. (pp. 5-6)

Separating the 'social' from the 'natural' is of course essential for the purposes of modeling and keeping track of the 'vital signs' of the natural system. An accurate depiction of the trends of climate variables, as well as projections of these trends under different scenarios is integral to climate science and a central piece of the global climate policies. However, separating 'lived environments and their socio-ecological dynamics at various scales' (Taylor, 2014, p. 31) from the "climate change proper" has serious ramifications for not just analysis, but also for policy interventions.

The other scenario that is borne out of the Cartesian climate-society dichotomy constitutes the basis of the scarcity argument. That is, climate induced scarcity may catapult vulnerable populations into turmoil and ultimately lead to the onset of civil conflict. The underlying assumption being that climate change (an external stressor) imposes a burden (scarcity) and disturbs the equilibrium of a society where everything was in some form of order before the introduction of the alien stress. This external stress, the logic goes, would galvanize turbulence in the social fabric by dividing populations along preexisting fault lines such as political, ethnic, social, religious, etc. Disregarding an oversimplification of the complex social-ecological phenomena and ignoring the 'microdynamics' of violent collective action (Kalyvas, 2006; McAdam et al., 2001), this dichotomy of climate and society makes a highly complex, interactive, and iterative process appear linear and static.

The missing piece in the extant conceptualization is regarding what happens in society between the occurrence of climate change, however one may define it, and the onset of violence. Except for extreme climate events that do not provide much of a warning for societies to prepare and to adjust, most climatic changes are gradual and interact with social, economic, and political processes. How vulnerable populations in a society (individuals, groups, or even states) perceive the threat of climate change is as much dependent on its political processes as it is on the accurate knowledge of change in the natural system. Similarly, what coping strategies are employed, for example, in response to reduced water availability, are a function of perception as well as a society's culture and the structure of its political economy. A ruling elite comprising of agriculturists may devise adaptation policies that may be different from those adopted in a more urban society. In both cases, the same or similar original stressor may result in different stresses, affect different groups in a population, and create different sets of winners and losers.

Agricultural societies, especially those in the developing world, tend to be protective of their respective agricultural sectors as, besides its importance for food security, agriculture remains one of the major sources of employment (Alston & Pardey, 2014). This also means that agriculture enjoys significant protection from external pressure, be it from foreign competitors or adverse changes in the natural system. In the case of the latter, distributional conflicts may arise, for example, between using water for irrigation or hydroelectric power generation, or for prioritizing for urban use or diverting to rural areas. Based on corresponding responses, climate vulnerability may shift elsewhere in society. In the case of preferential treatment of the agricultural sector, social unrest attributable to reduced water availability may manifest not in agricultural fields but in urban centers due to power blackouts, drinking water shortages, etc. Similar examples can be found for other climatic stresses and their interaction with local processes and cultural practices. For example, shifting of the agricultural calendar, haphazard crop switching, or abandoning of agriculture altogether, in response to changing temperature and rainfall patterns may have ramifications throughout commodity markets and local industrial units that depend on them, as well as the supply chains associated with them.

Theoretical framework proposed in this research:

The theoretical framework proposed in this research has made two distinct contributions. The first is regarding the intellectual resources that may allow incorporating complexity and emergence in the research design. Using critical realism as the ontological basis, this dissertation argues in favor of modeling the climate-society interaction as stratified reality composed of ‘real’, ‘empirical’ and ‘actual’ (Bhaskar, 1975). Instead of relying solely on the ‘empirical’ or the quantifiable, analysts should be able to incorporate in their research designs the emergent and the complex as well. Whereas quantitative models may explain the observable and the measurable, mechanisms may enrich the analysis by opening the black-box of climate-society interaction and explain the emergent and the un-quantifiable, e.g. impromptu coping responses taken by individuals, system effects, resentment formation, and escalation of grievances before onset of conflict, etc.

It must be noted that the mechanisms proposed in this research are not intervening variables. Instead, they have logical structure and distinct ontological status. In other words, mechanisms may operate in diverse societies, yet they produce the same result.

The intellectual freedom that the proposed framework allows is liberating as it does away with the rigid structural approach that the extant methodology imposes. Proposing a new conceptualization of the phenomenon, the second contribution of this research, is possible only because of additional intellectual resources that critical realism allows.

The first component of the new formulation of the problem is climate change process, contrasted from structural variables of climate change aggregated at country-year level. The fact that climatic changes may unfold at intra-annual level, and manifest in a varied fashion within and across societies flies in the face of hardwired statistical models searching for correlations between variants of average annual values of climate variables and onset of conflict. As demonstrated in the case study of Pakistan, different agro-ecological zones may experience different forms of environmental stress at different times during a year, affecting different populations in a varied manner. Moreover, since each agro-ecological zone may have its own local political economy built around the local agricultural activity as well as related businesses and commodity markets, it may be a mistake to abstract the effects of climate change in one part of a society at the country-year level.

This situation is not exclusive to Pakistan. In neighboring India, rainfall patterns have become variable at an intra-annual level, with ‘significant rising trends in the frequency and the magnitude of extreme rain events and.… a significant decreasing trend in the frequency of moderate events (Goswami et al., 2006). It is notable that the seasonal mean of rainfall in the country shows no significant trend because ‘contribution from increasing heavy events is offset by decreasing moderate events’ (ibid). Same is true of spatial variability vis- à-vis rainfall extremes across India (Ghosh, Das, Kao, & Ganguly, 2011). One can assume that the phenomenon (of intra-annual spatial and temporal variability) may be more prevalent in countries around the world than it is made out to be in extant analytical approach.

The second component of the climate-contention conceptualization proposed in this research is about the interaction between social and ecological systems. I have argued in chapter 3 that, with the exception of extreme climate events, most climatic changes unfold in an interactive manner, and elicit responses from vulnerable populations in real time. Since in most countries in the Global South, Pakistan being one of the many examples, access to long-term climate records may not be as straightforward for vulnerable populations as it is assumed in extant research models. This means that most coping responses may be taken without complete information about the nature of the stressor, and with almost no computational resources that may be needed to find the optimal coping responses. Given the complexity and emergence inherent in the natural system, assuming 'efficient' and 'optimal' adaptation response from vulnerable populations in such situations may be inconsistent with reality.

The important theme of climate-society interaction that I have tried to address in this dissertation is the all-important macro-micro link, between the macro stressor, climate change in our case, and the micro and meso level mechanisms and processes that it may invoke or interact with. These micro and meso level mechanisms and processes, in turn, are instrumental in generating the macro-level outcome, for example social and political unrest. The underlying idea behind this formulation is the realization that macro level phenomena such as social movements, rebellions, civil conflicts, etc., are not born at macro level; but in fact have their roots in mechanisms invoked at micro level where individuals interact with each other, shape each other's opinions and decision-making calculus, and have their own decision-making calculus shaped in return (McAdam, 2001; McAdam et al., 2001). For example, in the case of Pakistan, individual farmers are choosing coping responses at micro level in response to the perceived climatic variability and change. These coping responses, in turn are interacting with the antecedent processes to result in commodity market disruption. Similarly, grievances of individual farmers at micro-level morphing into a large-scale political mobilization and organization is an example of the micro-macro social phenomena.

Finally, I have followed in the footsteps of scholars of contentious politics in arguing that climate-induced instability may not result in civil conflict overnight. Instead, the unrest that it may impose at the individual level, either directly or indirectly through maladaptation or inefficient coping responses, may fester and interact with antecedent processes and fault lines in that society before resulting in widespread contention and ultimately conflict.

The framework proposed in this dissertation is extensible enough to explain climate-society interaction in other societies operating under different contexts and experiencing varied forms of climate stress.

Future Directions:

Steinbruner et al. (2013) warned:

> [We] know that the rate at which carbon dioxide is currently being added to the atmosphere substantially exceeds the natural rate that prevailed before the rise of human societies. That means that a large and unprecedentedly rapid thermal impulse is being imparted to the earth's ecology that will have to be balanced in some fashion. We know beyond reasonable doubt that the consequences will be extensive. We do not, however, know the timing, magnitude, or character of those consequences with sufficient precision to make predictions that meet scientific standards of confidence. As the frequency and intensity of climate events increases, they also interact with preexisting vulnerabilities and fault lines in societies around the world. (p. ix)

In recent years, as climate induced stresses continue to batter societies rich and poor alike, the warning seems to be bearing out. Also, from debates over climate change's possible role in triggering Syria's civil conflict, we have learned how little we know about the phenomenon, and how gross the consequences of our lack of knowledge can be. A map of 'equivalent impacts' revealed at the annual meeting of the European Geosciences Union in 2018 showed that global temperatures would have to rise above 3 degrees Celsius 'before most people in wealthy nations would feel departures from familiar climate conditions equal to those that residents of poorer nations will suffer under moderate warming' (Schiermeier, 2018). The fact that this inequitable distribution of climate stress coincides with weaker governments and fragmented societies does not bode well for a majority of human population that happens to be living in the Global South.

This dissertation has presented a new mechanism-based framework in the hopes of improving our understanding of the causal dynamics of the phenomena involved. The power of this framework comes from the fact that it does not propose yet another hardwired theory. Instead, it allows searching for new mechanisms in diverse settings to be concatenated in varying sequences and combinations to produce varied outcomes ranging from cooperation among vulnerable populations to ward off pressures imposed by climate change to more grim outcomes of violence and possibly conflict.

Moreover, during times of vociferous disagreements over methodological approaches, the framework calls for an interdisciplinary approach to develop a deeper understanding of the phenomenon.

The mechanisms identified in the case study of Pakistan showcase only a sliver of what may unfold in other societies. Conducting more case studies is essential to understand the true potential of climate change and the burdens it is imposing on societies around the world. The more mechanisms are identified, the richer the suite of mechanisms will be, and better and effective policies may be formulated to mitigate or preempt the deleterious effects of climate change.

Bibliography

Abbas, F. (2013). Analysis of a historical (1981–2010) temperature record of the Punjab province of Pakistan. *Earth Interactions, 17*(15), 1-23.

Abbas, F., Ahmad, A., Safeeq, M., Ali, S., Saleem, F., Hammad, H. M., & Farhad, W. (2014). Changes in precipitation extremes over arid to semiarid and subhumid Punjab, Pakistan. *Theoretical and applied climatology, 116*(3-4), 671-680.

Adams, R., Glyer, J. D., & McCarl, B. (1989). The economic effects of climate change on US agriculture: a preliminary assessment. *The Potential Effects of Global Climate Change on the United States, 1*, 4.1-4.56.

Adano, W. R., Dietz, T., Witsenburg, K., & Zaal, F. (2012). Climate change, violent conflict and local institutions in Kenya's drylands. *Journal of Peace Research, 49*(1), 65-80.

Adger, W. N. (2000). Social and ecological resilience: are they related? *Progress in human geography, 24*(3), 347-364.

Adger, W. N. (2006a). *Fairness in adaptation to climate change*: MIT press.

Adger, W. N. (2006b). Vulnerability. *Global environmental change, 16*(3), 268-281.

Adger, W. N. (2010). Climate change, human well-being and insecurity. *New Political Economy, 15*(2), 275-292.

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global environmental change, 15*(2), 77-86.

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., . . . Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic change, 93*(3-4), 335-354.

Adger, W. N., Eakin, H., & Winkels, A. (2009). Nested and teleconnected vulnerabilities to environmental change. *Frontiers in Ecology and the Environment, 7*(3), 150-157.

Adger, W. N., & Kelly, P. M. (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and adaptation strategies for global change, 4*(3-4), 253-266.

Adger, W. N., Lorenzoni, I., & O'Brien, K. L. (2009). Adaptation now. In N. Adger, I. Lorenzoni, & K. O'Brien (Eds.), *Adapting to climate change: thresholds, values, governance* (pp. 1-22): Cambridge University Press.

Adger, W. N., Paavola , J., Huq, S., & Mace, M. J. (Eds.). (2006). *Fairness in adaptation to climate change*: MIT press.

Adger, W. N., Pulhin, J. M., Barnett, J., Dabelko, G. D., Hovelsrud, G. K., Levy, M., . . . Vogel, C. H. (2014a). Human security. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 755-791). Cambridge, United Kingdom; New York, USA: Cambridge University Press.

Adger, W. N., Pulhin, J. M., Barnett, J., Dabelko, G. D., Hovelsrud, G. K., Levy, M., . . . Vogel, C. H. (2014b). Human security. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O.

Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and*
Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental
Panel on Climate Change (pp. 755-791). Cambridge, United Kingdom
New York, USA: Cambridge University Press.

Ahmad, A., Ashfaq, M., Rasul, G., Wajid, S. A., Khaliq, T., Rasul, F., . . . Ahmad Baig, I. (2015). Impact of climate change on the rice–wheat cropping system of Pakistan. In *Handbook of Climate Change and Agroecosystems: The Agricultural Model Inter-comparison and Improvement Project Integrated Crop and Economic Assessments, Part 2* (pp. 219-258).

Ahmed, M., & Schmitz, M. (2011). Economic assessment of the impact of climate change on the agriculture of Pakistan. *Business and Economic Horizons (BEH), 4*(1232-2016-101145), 1-12.

Alavi, H. (1972). The state in post-colonial societies: Pakistan and Bangladesh. *New Left Review, 74*(1), 59-81.

Alexander, J. C., Giesen, B., Munch, R., & Smelser, N. J. (Eds.). (1987). *The micro-macro link*: University of California Press.

Alexander, L., Zhang, X., Peterson, T., Caesar, J., Gleason, B., Tank, A. K., . . . Rahimzadeh, F. (2006). Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research: Atmospheres, 111*(D5).

Ali, A. (2013). *Indus Basin Floods: Mechanisms, Impacts, and Management*. Retrieved from Mandaluyong City, Philippines:

Ali, A., Rahut, D. B., & Imtiaz, M. (2019). Effects of Pakistan's energy crisis on farm households. *59*, 100930.

Ali, F., & Beg, F. (2007). *The History of Private Power in Pakistan*. Working Paper Series. Sustainable Development Policy Institute. Islamabad, Pakistan.

Allison, G. T. (1971). Essence of decision. *Boston: Little, Brown, 536*.

Allison, H. E., & Hobbs, R. J. (2004). Resilience, adaptive capacity, and the lock-in trap of the Western Australian agricultural region. *Ecology and society, 9*(1).

Alston, J. M., & Pardey, P. G. (2014). Agriculture in the global economy. *The Journal of Economic Perspectives, 28*(1), 121-146.

Aminzade, R., & McAdam, D. (2001). Emotions and contentious politics. In R. Aminzade, J. Goldstone, D. McAdam, E. Perry, W. Sewell Jr., S. Tarrow, & C. Tilly (Eds.), *Silence and voice in the study of contentious politics* (pp. 14-50): Cambridge University Press.

Archer, D. (2003). Contrasting hydrological regimes in the upper Indus Basin. *Journal of Hydrology, 274*(1), 198-210.

Archer, D., Forsythe, N., Fowler, H. J., & Shah, S. M. (2010). Sustainability of water resources management in the Indus Basin under changing climatic and socio economic conditions. *Hydrology and Earth System Sciences, 14*(8), 1669.

Archer, D., & Fowler, H. (2004). Spatial and temporal variations in precipitation in the Upper Indus Basin, global teleconnections and hydrological implications. *Hydrology and Earth System Sciences Discussions, 8*(1), 47-61.

Archer, D., & Fowler, H. J. (2004). Spatial and temporal variations in precipitation in the Upper Indus Basin, global teleconnections and hydrological implications. *Hydrology and Earth System Sciences Discussions, 8*(1), 47-61.

Archer, D., & Fowler, H. J. (2008). Using meteorological data to forecast seasonal runoff on the River Jhelum, Pakistan. *Journal of Hydrology, 361*(1), 10-23.

Asmal, K., Jain, L. C., Henderson, J., Lindahl, G., Scudder, T., Cariño, J., . . . Steiner, A. (2000). *Dams and development: A new framework - The report of the World Commission on Dams*. Retrieved from Sterling, VA:

Bank, W. (2007). *Pakistan - Promoting rural growth and poverty reduction*. Retrieved from Washington, DC: World Bank:

Barnes, J., Dove, M., Lahsen, M., Mathews, A., McElwee, P., McIntosh, R., . . . Puri, R. (2013). Contribution of anthropology to the study of climate change. *Nature Climate Change, 3*(6), 541-544.

Barnett, J. (2009). The prize of peace (is eternal vigilance): a cautionary editorial essay on climate geopolitics. *Climatic Change, 96*(1), 1-6.

Barnett, J., & Adger, W. N. (2007). Climate change, human security and violent conflict. *Political geography, 26*(6), 639-655.

Barnett, J., & O'Neill, S. (2010). Maladaptation. *Global Environmental Change, 20*(2), 211-213.

Barrett, C. B. (2008). Poverty traps and resource dynamics in smallholder agrarian systems. *Economics of poverty, environment and natural-resource use*, 17-40.

Beisner, B. E., Haydon, D. T., & Cuddington, K. (2003). Alternative stable states in ecology. *Frontiers in Ecology and the Environment, 1*(7), 376-382.

Bellemare, M. F. (2015). Rising food prices, food price volatility, and social unrest. *American Journal of Agricultural Economics, 97*(1), 1-21.

Bennett, A. (2010). Process tracing and causal inference. In H. Brady & D. Collier (Eds.), *Rethinking Social Inquiry*: Rowman and Littlefield.

Berazneva, J., & Lee, D. R. (2013). Explaining the African food riots of 2007–2008: An empirical analysis. *Food Policy, 39*, 28-39.

Bergholt, D., & Lujala, P. (2012). Climate-related natural disasters, economic growth, and armed civil conflict. *Journal of Peace Research, 49*(1), 147-162.

Berkes, F., Folke, C., & Colding, J. (2000). *Linking social and ecological systems: management practices and social mechanisms for building resilience*: Cambridge University Press.

Berkes, F. C., Johan Folke, Carl (Ed.) (2008). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*: Cambridge University Press.

Bevir, M., & Kedar, A. (2008). Concept formation in political science: An anti-naturalist critique of qualitative methodology. *Perspectives on Politics, 6*(3), 503-517.

Bhaskar, R. (1975). *A realist theory of science*. Leeds: Leeds Books.

Bolch, T., Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, J., . . . Scheel, M. (2012). The state and fate of Himalayan glaciers. *Science, 336*(6079), 310-314.

Boonstra, W. J., & Hanh, T. T. H. (2015). Adaptation to climate change as social–ecological trap: a case study of fishing and aquaculture in the Tam Giang Lagoon, Vietnam. *Environment, Development and Sustainability, 17*(6), 1527-1544.

Boudon, R. (1998). Social mechanisms without black boxes. In P. Hedström & R. Swedberg (Eds.), *Social Mechanisms: An Analytical Approach to Social Theory* (pp. 172-203). Cambridge: Cambridge University Press.

Brady, H. E., & Collier, D. (2010). *Rethinking social inquiry: Diverse tools, shared standards*: Rowman & Littlefield Publishers.

Briscoe, J., & Qamar, U. (2005). *Pakistan's water economy : running dry*. Retrieved from Washington, DC:

Brosig, M., Frawley, P., Hill, A., Jahn, M., Marsicek, M., Paris, A., . . . Thomas, N. (2019). *Implications of Climate Change for the U.S. Army*. Retrieved from Washington DC:

Brzoska, M. (2009). The securitization of climate change and the power of conceptions of security. *S&F Sicherheit und Frieden, 27*(3), 137-145.

Buhaug, H. (2010). Climate not to blame for African civil wars. *Proceedings of the National Academy of Sciences, 107*(38), 16477-16482.

Buhaug, H. (2015). Climate–conflict research: some reflections on the way forward. *Wiley Interdisciplinary Reviews: Climate Change, 6*(3), 269-275. doi:10.1002/wcc.336

Burke, M., & Lobell, D. (2010). Food security and adaptation to climate change: What do we know? In *Climate change and food security* (pp. 133-153): Springer.

Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., & Lobell, D. B. (2009). Warming increases the risk of civil war in Africa. *Proceedings of the national Academy of sciences, 106*(49), 20670-20674.

Busby, J. (2018). The State of the Field in Climate and Security.

Busby, J. W., Smith, T. G., White, K. L., & Strange, S. M. (2013). Climate change and insecurity: mapping vulnerability in Africa. *International Security, 37*(4), 132-172.

Bush, R. (2010). Food riots: Poverty, power and protest1. *Journal of Agrarian Change, 10*(1), 119-129.

Byg, A., & Salick, J. (2009). Local perspectives on a global phenomenon—climate change in Eastern Tibetan villages. *Global Environmental Change, 19*(2), 156-166.

Carleton, T. A. (2017). Crop-damaging temperatures increase suicide rates in India. *Proceedings of the National Academy of Sciences*, 201701354.

Carpenter, S. R., & Brock, W. A. (2008). Adaptive capacity and traps. *Ecology and society, 13*(2), 40.

Catarious Jr., D., Filadelfo, R., Gaffney, H., Maybee, S., & Morehouse, T. (2007). *National security and the threat of climate change*. Retrieved from

Cervellati, M., Sunde, U., & Valmori, S. (2011). Disease environment and civil conflicts. *IZA Discussion Papers*.

Chaudhry, Q. U. Z. (2017). *Climate Change Profile of Pakistan*: Asian Development Bank.

Chen, C., Noble, I., Hellmann, J., Coffee, J., Muri llo, M., & Chawla, N. (2015). *University of Notre Dame Global Adaptation Index*. Retrieved from: https://gain.nd.edu/our-work/country-index/

Chenoweth, E., & Lawrence, A. (2010). *Rethinking violence: states and non-state actors in conflict*: MIT press.

Christensen, N. S., Wood, A. W., Voisin, N., Lettenmaier, D. P., & Palmer, R. N. (2004). The Effects of Climate Change on the Hydrology and Water Resources of the Colorado River Basin. *62*(1), 337-363.
Ciccone, A. (2011). Economic shocks and civil conflict: A comment. *American Economic Journal: Applied Economics, 3*(4), 215-227.
Cinner, J. E. (2011). Social-ecological traps in reef fisheries. *Symposium on Social Theory and the Environment in the New World (dis)Order, 21*(3), 835-839.
Coleman, J., Katz, E., & Menzel, H. (1957). The diffusion of an innovation among physicians. *Sociometry, 20*(4), 253-270.
Coleman, J. S. (1986). Social theory, social research, and a theory of action. *American journal of Sociology, 91*(6), 1309-1335.
Coleman, J. S. (1987). Microfoundations and macrosocial behavior. In J. C. Alexander, B. Giesen, R. Munch, & N. J. Smelser (Eds.), *The micro-macro link* (pp. 153-173): University of California Press.
Collier, P. (2008). Politics of Hunger-How Illusion and Greed Fan the Food Crisis, The. *Foreign Aff., 87*, 67.
Collier, P., & Hoeffler, A. (1998). On economic causes of civil war. *Oxford economic papers, 50*(4), 563-573.
Collier, P., & Hoeffler, A. (2004). Greed and grievance in civil war. *Oxford economic papers, 56*(4), 563-595.
Crate, b. S. A., Einarsson, N., Ford, J. D., Lahsen, M., Paolisso, M., Schlee, G., & Crate, S. A. (2008). Gone the bull of winter? Grappling with the cultural implications of and anthropology's role (s) in global climate change. *Current anthropology, 49*(4), 569-595.
Cumming, G. S. J. C. L. (2018). A Review of Social Dilemmas and Social-Ecological Traps in Conservation and Natural Resource Management. *11*(1), e12376.
Dabelko, G. D., Herzer, L., Null, S., Parker, M., & Sticklor, R. (2013). Backdraft: the conflict potential of climate change adaptation and mitigation. *Washington DC: Woodrow Wilson Center Environmental Change and Security Program Report, 14*(2), 1-60.
De Fazio, G. (2013). *Political radicalization in the making: The civil rights movement in northern ireland, 1968-1972.* Emory University,
De Soysa, I. (2002a). Ecoviolence: shrinking pie, or honey pot? *Global Environmental Politics, 2*(4), 1-34.
De Soysa, I. (2002b). Paradise is a bazaar? Greed, creed, and governance in civil war, 1989-99. *Journal of Peace Research, 39*(4), 395-416.
Della Porta, D. (2015). *Social movements in times of austerity: Bringing capitalism back into protest analysis*: John Wiley & Sons.
Descartes, R. (1637/1993). *Discourse on method and Meditations on first philosophy* (D. A. Cress, Trans. 4th ed.): Hackett Publishing Company.
Deschenes, O., & Greenstone, M. (2007). The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather. *The American Economic Review, 97*(1), 354-385.
Dettinger, M. D., & Diaz, H. F. (2000). Global characteristics of stream flow seasonality and variability. *Journal of Hydrometeorology, 1*(4), 289-310.

Deudney, D. (1990). The Case Against Linking Environmental Degradation and National Security. *Millennium-Journal of International Studies, 19*(3), 461-476.
Diehl, P. F. (1998). Environmental conflict: An introduction. In (pp. 275-277): JSTOR.
Donner, R., Barbosa, S., Kurths, J., & Marwan, N. (2009). Understanding the Earth as a Complex System–recent advances in data analysis and modelling in Earth sciences. *The European Physical Journal Special Topics, 174*(1), 1-9.
Dow, K., Berkhout, F., & Preston, B. L. (2013). Limits to adaptation to climate change: a risk approach. *Current Opinion in Environmental Sustainability, 5*(3), 384-391.
Dow, K., Berkhout, F., Preston, B. L., Klein, R. J., Midgley, G., & Shaw, M. R. (2013). Limits to adaptation. *Nature Climate Change, 3*(4), 305-307.
Doyle, J. T., Redsteer, M. H., & Eggers, M. J. (2013). Exploring effects of climate change on Northern Plains American Indian health. *Climatic change, 120*(3), 643-655.
Döll , P., Mueller Schmied, H., Schuh, C., Portmann, F. T., & Eicker, A. (2014). Global-scale assessment of groundwater depletion and related groundwater abstractions: Combining hydrological modeling with information from well observations and GRACE satellites. *Water Resources Research, 50*(7), 5698-5720.
Easterling III, W. E., Crosson, P. R., Rosenberg, N. J., McKenney, M. S., Katz, L. A., & Lemon, K. M. (1993). Agricultural impacts of and responses to climate change in the Missouri-Iowa-Nebraska-Kansas (MINK) region. In *Towards an integrated impact assessment of climate change: The MINK study* (pp. 23-61): Springer.
Eckstein, D., Hutfils, M.-L., & Winges, M. (2019). GLOBAL CLIMATE RISK INDEX 201 9. In. Bonn, Germany: Germanwatch.
Elster, J. (1989). *Nuts and bolts for the social sciences*: Cambridge University Press.
Eriksen, S., & Silva, J. A. (2009). The vulnerability context of a savanna area in Mozambique: household drought coping strategies and responses to economic change. *Environmental science & policy, 12*(1), 33-52.
Evans, L., Barnett, J., Gross, C., Kiem, A. S., Kingsford, R. T., Palutikof, J. P., . . . Smithers, S. G. (2015). From barriers to limits to climate change adaptation: path dependency and the speed of change.
Falleti, T. G., & Lynch, J. F. (2009). Context and causal mechanisms in political analysis. *Comparative political studies*.
Fankhauser, S., Smith, J. B., & Tol, R. S. (1999). Weathering climate change: some simple rules to guide adaptation decisions. *Ecological economics, 30*(1), 67-78.
FAO. (1996). Agro-Ecological Zoning Guidelines. In M. a. C. S. Soil Resources, FAO Land and Water Development Division (Ed.), (Vol. FAO Soils Bulletin 73). Rome: Food and Agriculture Organization of the United Nations.
FAO. (2018). *The State of Agricultural Commodity Markets 2018. Agricultural trade, climate change and food security*. Retrieved from Rome:
FAO. (2019). *FAO Cereal Supply and Demand Brief* Retrieved from http://www.fao.org/worldfoodsituation/csdb/en/
FAO/WFP. (2001). *Special Report: FAO/WFP Crop and Food Supply Assessment Mission to Pakistan*. Retrieved from http://www.fao.org/3/y1260e/y1260e00.htm
Farooq, S. (2015). *The Rural Non-farm Economy, Livelihood Strategies and Household Welfare in Rural Pakistan*.

Fearon, J. D., & Laitin, D. D. (1999). *Weak states, rough terrain, and large-scale ethnic violence since 1945.* Paper presented at the Annual Meetings of the American Political Science Association, Atlanta, GA.

Fischer, J., Gardner, T. A., Bennett, E. M., Balvanera, P., Biggs, R., Carpenter, S., . . . Hughes, T. P. (2015). Advancing sustainability through mainstreaming a social–ecological systems perspective. *Current Opinion in Environmental Sustainability, 14*, 144-149.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change, 16*(3), 253-267.

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour., 30*, 441-473.

Fowler, H., & Archer, D. (2005). Hydro-climatological variability in the Upper Indus Basin and implications for water resources. *Regional Hydrological Impacts of Climatic Change—Impact Assessment and Decision Making, 295*, 131-138.

Fowler, H., & Archer, D. (2006). Conflicting signals of climatic change in the Upper Indus Basin. *Journal of Climate, 19*(17), 4276-4293.

Fowler, H. J., & Archer, D. R. (2006). Conflicting signals of climatic change in the Upper Indus Basin. *Journal of Climate, 19*(17), 4276-4293.

Franzosi, R. (1994). From words to numbers: A set theory framework for the collection, organization, and analysis of narrative data. *Sociological methodology*, 105-136.

Franzosi, R. (2017). A third road to the past? Historical scholarship in the age of big data. *Historical Methods: A Journal of Quantitative and Interdisciplinary History, 50*(4), 227-244.

Gambetta, D. (1998). Concatenations of mechanisms. *Social mechanisms: An analytical approach to social theory*, 102-124.

Gamson, W. A. (1992). *Talking politics*: Cambridge university press.

Gamson, W. A. (1995). Constructing social protest. *Social movements and culture, 4*, 85-106.

Gardelle, J., Berthier, E., & Arnaud, Y. (2012). Slight mass gain of Karakoram glaciers in the early twenty-first century. *Nature geoscience, 5*(5), 322-325.

Geertz, C. (1983). Local Knowledge: Further Essays in Interpretive Anthropology. In: Basic Books.

Gemenne, F., Barnett, J., Adger, W. N., & Dabelko, G. D. (2014). Climate and security: evidence, emerging risks, and a new agenda. *Climatic Change, 123*(1), 1-9.

George, A., & Bennett, A. (2004). *Case Studies and Theory Development in the Social Sciences*: MIT Press.

Ghosh, S., Das, D., Kao, S.-C., & Ganguly, A. R. (2011). Lack of uniform trends but increasing spatial variability in observed Indian rainfall extremes. *2*, 86.

Gleditsch, N. P. (1998). Armed conflict and the environment: A critique of the literature. *Journal of peace research, 35*(3), 381-400.

Gleditsch, N. P. (2003). Environmental conflict: Neomalthusians vs. cornucopians. In *Security and Environment in the Mediterranean* (pp. 477-485): Springer.

Gleditsch, N. P., & Sverdrup, B. r. O. (2002). 2. Democracy and the environment1. *Human security and the environment: International comparisons*, 45.

Gleick, P. H. (2014). Water, drought, climate change, and conflict in Syria. *Weather, Climate, and Society, 6*(3), 331-340.

Goff, L., Atkin, J., Malone, L., & McCutcheon, C. (2014). *National Security and the Accelerating Risks of Climate Change*. Retrieved from

Goklany, I. M. (2009). Is climate change the "defining challenge of our age"? *Energy & environment, 20*(3), 279-302.

Goldstone, J. (1991). *Revolution and rebellion in the early modern world*: Univ of California Press.

Goldstone, J. (1994). Is revolution individually rational? Groups and individuals in revolutionary collective action. *Rationality and Society, 6*(1), 139-166.

Goldstone, J. (1998a). Social movements or revolutions?: On the evolution and outcomes of collective action. In M. G. Giugni, D. McAdam, & C. Tilly (Eds.), *From contention to democracy* (pp. 125-145): Rowman & Little Field.

Goldstone, J. (1998b). Social movements or revolutions?: On the evolution and outcomes of collective action. In M. G. Giugni, D. McAdam, & C. Tilly (Eds.), *From contention to democracy* (pp. 125-145): Rowman & Little Field.

Goldstone, J. (2001). Demography, environment and security: an overview. *Demography and national security*, 38-61.

Goldstone, J. (2011). Cross-class Coalitions and the Making of the Arab Revolts of 2011. *Swiss Political Science Review, 17*(4), 457-462.

Goldstone, J. A., & McAdam, D. (2001). Contention in Demographic and Life-Course Context. In C. Tilley, D. McAdam, E. J. Perry, J. A. Goldstone, R. R. Aminzade, S. Tarrow, & W. H. Sewell (Eds.), *Silence and Voice in the Study of Contentious Politics* (pp. 195-221). Cambridge: Cambridge University Press.

Goswami, B. N., Venugopal, V., Sengupta, D., Madhusoodanan, M., & Xavier, P. K. (2006). Increasing trend of extreme rain events over India in a warming environment. *Science, 314*(5804), 1442-1445.

Granovetter, M. (1978). Threshold models of collective behavior. *American journal of sociology, 83*(6), 1420-1443.

Guha-Sapir, D., Hoyois, P., Wallemacq, P., & Below, R. (2017). *Annual Disaster Statistical Review 2016: The numbers and trends*. Retrieved from Brussels, Belgium:

Gurr, T. R. (1970). *Why men rebel*. Princeton, N.J.: Princeton University Press.

Hanemann, W. M. (2000). Adaptation and its measurement. *Climatic Change, 45*(3), 571-581.

Hanif, M., Khan, A. H., & Adnan, S. (2013). Latitudinal precipitation characteristics and trends in Pakistan. *Journal of Hydrology, 492*, 266-272.

Hanif, U., Syed, S. H., Ahmad, R., Malik, K. A., & Nasir, M. (2010). Economic impact of climate change on the agricultural sector of Punjab. *The Pakistan Development Review*, 771-798.

Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V., . . . Rignot, E. (2015). Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2° C global warming is highly dangerous. *Atmospheric Chemistry & Physics Discussions, 15*(14).

Hansen, J., Sato, M., & Ruedy, R. (2012). Perception of climate change. *Proceedings of the National Academy of Sciences, 109*(37), E2415-E2423.

Hardin, G. (1968). The Tragedy of the Commons. *Science, 162*(3859), 1243-1248.

Harris, R., Beaumont, L., Vance, T., Tozer, C., Remenyi, T., Perkins-Kirkpatrick, S., . . . Andrew, N. (2018). Biological responses to the press and pulse of climate trends and extreme events. *Nature Climate Change, 8*(7), 579.
Hartmann, B. (2009). *Lines in the shifting sand: The strategic politics of climate change, Human security and national defence.* Paper presented at the rethinking security in a changing climate conference, Oslo, June.
Hauge, W., & Ellingsen, T. (1998). Beyond environmental scarcity: Causal pathways to conflict. *journal of Peace Research, 35*(3), 299-317.
Hayward, B., & O'Brien, K. (2010). Social contracts in a changing climate: security of what and for whom? In K. O'Brien, A. L. St. Clair, & B. Kristoffersen (Eds.), *Climate change, ethics, and human security* (pp. 199-214): Cambridge University Press.
Hedstrom, P., & Swedberg, R. (1998). Social mechanisms: An introductory essay. In *Social mechanisms: An analytical approach to social theory* (pp. 1-31).
Hedström, P. (1998a). Rational imitation. In P. Hedström & R. Swedberg (Eds.), *Social mechanisms: An analytical approach to social theory* (pp. 306-328): Cambridge University Press.
Hedström, P. (1998b). *Rational imitation*: Univ., Sociologiska institutionen.
Hedström, P., Sandell, R., & Stern, C. (2000). Mesolevel Networks and the Diffusion of Social Movements: The Case of the Swedish Social Democratic Party. *American Journal of Sociology, 106*(1), 145-172. doi:10.1086/303109
Hedström, P., & Swedberg, R. (1998). Social mechanisms: An introductory essay. In *Social mechanisms: An analytical approach to social theory* (pp. 1-31).
Hempel, C. G. (1942). The function of general laws in history. *The Journal of Philosophy, 39*(2), 35-48.
Hendrix, C. S. (2017). A comment on "climate change and the Syrian civil war revisited". *Political Geography*.
Hendrix, C. S., & Salehyan, I. (2012). Climate change, rainfall, and social conflict in Africa. *Journal of Peace Research, 49*(1), 35-50.
Hertel, T. W., Burke, M. B., & Lobell, D. B. (2010). The poverty implications of climate-induced crop yield changes by 2030. *Global Environmental Change, 20*(4), 577-585.
Hetherington, R., & Reid, R. G. (2010). *The climate connection: climate change and modern human evolution*: Cambridge University Press.
Hewitt, K. (2005). The Karakoram anomaly? Glacier expansion and the 'elevation effect,'Karakoram Himalaya. *Mountain Research and Development, 25*(4), 332-340.
Hewitt, K. (2011). Glacier change, concentration, and elevation effects in the Karakoram Himalaya, Upper Indus Basin. *Mountain Research and Development, 31*(3), 188-200.
Hewitt, K., Wake, C. P., Young, G., & David, C. (1989). Hydrological investigations at Biafo Glacier, Karakoram Range, Himalaya; an important source of water for the Indus River. *Annals of Glaciology*.
Holdren, J. (2017a, 26 October 2017). *Why the Wafflers are Wrong:*
Addressing Climate Change is Urgent

(and a Bargain). Paper presented at the World Conference of Science Journalists, San Francisco.
Holdren, J. (2017b). Why the Wafflers are Wrong: Addressing Climate Change is Urgent (and a Bargain). In *World Conference of Science Journalists*. San Francisco.
Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems, 4*(5), 390-405.
Holling, C. S. (2004). From complex regions to complex worlds. *Ecology and society, 9*(1).
Homer-Dixon, T. F. (1991). On the threshold: environmental changes as causes of acute conflict. *International security, 16*(2), 76-116.
Homer-Dixon, T. F. (1994). Environmental scarcities and violent conflict: evidence from cases. *International security, 19*(1), 5-40.
Homer-Dixon, T. F. (1999). *Environment, scarcity, and violence*. Princeton, NJ: Princeton University Press.
Hsiang, S. M., & Burke, M. (2014). Climate, conflict, and social stability: what does the evidence say? *Climatic Change, 123*(1), 39-55.
Hsiang, S. M., Meng, K. C., & Cane, M. A. (2011). Civil conflicts are associated with the global climate. *Nature, 476*(7361), 438-441.
Hulme, M. (2008). Geographical work at the boundaries of climate change. *Transactions of the Institute of British Geographers, 33*(1), 5-11.
Hulme, M. (2010). Problems with making and governing global kinds of knowledge. *Global Environmental Change, 20*(4), 558-564.
Hume, D. (1748, 2016). An enquiry concerning human understanding. In *Seven Masterpieces of Philosophy* (pp. 191-284): Routledge.
Hume, D. (1748/2016). An enquiry concerning human understanding. In *Seven Masterpieces of Philosophy* (pp. 191-284): Routledge.
Hussain, S. S., & Mudasser, M. (2007). Prospects for wheat production under changing climate in mountain areas of Pakistan–An econometric analysis. *Agricultural Systems, 94*(2), 494-501.
Ignatieff , M. (2005, 9-25-2005). The Broken Contract. *The New York Times Magazine*. Retrieved from http://www.nytimes.com/2005/09/25/magazine/the-broken-contract.html
Immerzeel, W. W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science, 328*(5984), 1382-1385.
Inderberg, T. H., & Eikeland, P. O. (2009). *Limits to adaptation: analysing institutional constraints*: Cambridge University Press, Cambridge, UK.
IPCC. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Vol. 1): IPCC.
Jackson, P. T. (2010). *The conduct of inquiry in international relations: Philosophy of science and its implications for the study of world politics*: Routledge.
Jacoby, H. G., & Mansuri, G. (2018). *Governing the commons? water and power in Pakistan's Indus basin*: The World Bank.
Johnstone, S., & Mazo, J. (2011). Global warming and the Arab Spring. *Survival, 53*(2), 11-17.

Kahl, C. H. (2006). *States, scarcity, and civil strife in the developing world*: Princeton University Press.

Kaiser, H. M., Riha, S. J., Wilks, D. S., Rossiter, D. G., & Sampath, R. (1993). A farm-level analysis of economic and agronomic impacts of gradual climate warming. *American journal of agricultural economics, 75*(2), 387-398.

Kalyvas, S. N. (2006). *The logic of violence in civil war*: Cambridge University Press.

Kalyvas, S. N. (2008). Promises and pitfalls of an emerging research program: the microdynamics of civil war. In S. N. Kalyvas, I. Shapiro, & T. E. Masoud (Eds.), *Order, conflict, and violence*. Cambridge: Cambridge University Press.

Kapnick, S. B., Delworth, T. L., Ashfaq, M., Malyshev, S., & Milly, P. (2014). Snowfall less sensitive to warming in Karakoram than in Himalayas due to a unique seasonal cycle. *Nature Geoscience, 7*(11), 834-840.

Karl, T. R., Kukla, G., Razuvayev, V. N., Changery, M. J., Quayle, R. G., Heim, R. R., . . . Fu, C. B. (1991). Global warming: Evidence for asymmetric diurnal temperature change. *Geophysical Research Letters, 18*(12), 2253-2256.

Kastner, T., Erb, K.-H., & Haberl, H. (2014). Rapid growth in agricultural trade: effects on global area efficiency and the role of management. *Environmental Research Letters, 9*(3), 034015.

Kazi, A. (2003). Kalabagh Dam: Varying points of view. In K. Bangali (Ed.), *The politics of managing water* (pp. 182-192). Karachi: Oxford University Press.

Kelley, C. P., Mohtadi, S., Cane, M. A., Seager, R., & Kushnir, Y. (2015). Climate change in the Fertile Crescent and implications of the recent Syrian drought. *Proceedings of the National Academy of Sciences, 112*(11), 3241-3246.

Khan, A. A., & Khan, M. (2010). Pakistan textile industry facing new challenges. *Research journal of international studies, 14*(14), 21-29.

Khan, H.-u.-R. (1959). Indo-Pakistan Waters Dispute. *Pakistan Horizon, 12*(4), 323-336.

Khan, S., Rana, T., Gabriel, H. F., & Ullah, M. K. (2008). Hydrogeologic assessment of escalating groundwater exploitation in the Indus Basin, Pakistan. *Hydrogeology Journal, 16*(8), 1635-1654. doi:10.1007/s10040-008-0336-8

Khan, S. R. (1999). *The Case Against Kalabagh Dam*: Commission on Environmental Economic and Social Policy, South Asia.

Khattak, M. S., Babel, M., & Sharif, M. (2011). Hydro-meteorological trends in the upper Indus River basin in Pakistan. *Climate research, 46*(2), 103-119.

King, G., Keohane, R. O., & Verba, S. (1994). *Designing social inquiry: Scientific inference in qualitative research*: Princeton University Press.

Klotz, A., & Lynch, C. M. (2014). *Strategies for research in constructivist international relations*: Routledge.

Koopmans, R. (1993). The dynamics of protest waves: West Germany, 1965 to 1989. *American sociological review*, 637-658.

Koubi, V., Bernauer, T., Kalbhenn, A., & Spilker, G. (2012). Climate variability, economic growth, and civil conflict. *Journal of Peace Research, 49*(1), 113-127.

Krishna Kumar, K., Rupa Kumar, K., Ashrit, R., Deshpande, N., & Hansen, J. (2004). Climate impacts on Indian agriculture. *International Journal of climatology, 24*(11), 1375-1393.

Krishnamurthy, C. K. B., Lall, U., & Kwon, H.-H. (2009). Changing Frequency and Intensity of Rainfall Extremes over India from 1951 to 2003. *Journal of Climate, 22*(18), 4737-4746. doi:10.1175/2009jcli2896.1

Kugelman, M. (2013). Pakistan's Energy Crisis: From Conundrum to Catastrophe?

Kuhn, T. S. (1962). *The structure of scientific revolutions*: University of Chicago press.

Kumar, P., & Wood, M. D. (2010). *Valuation of regulating services of ecosystems: methodology and applications* (Vol. 27): Routledge.

Kurki, M. (2008). *Causation in international relations: reclaiming causal analysis* (Vol. 108): Cambridge University Press.

Kurukulasuriya, P., & Mendelsohn, R. (2008). Crop switching as a strategy for adapting to climate change. *African Journal of Agricultural and Resource Economics, 2*(311-2016-5522).

Laghari, A., Vanham, D., & Rauch, W. (2012). The Indus basin in the framework of current and future water resources management. *Hydrology and Earth System Sciences, 16*(4), 1063.

Leenders, R. (2013). Social movement theory and the onset of the popular uprising in Syria. *Arab studies quarterly, 35*(3), 273-289.

Leichenko, R., & O'Brien, K. (2008). *Environmental change and globalization: Double exposures*: Oxford University Press.

Leichenko, R., & O’Brien, K. (2006). Is it appropriate to identify winners and losers? *Fairness in Adaptation to Climate Change*, 97-114.

Levy, M. A. (1995). Is the environment a national security issue? *International security, 20*(2), 35-62.

Lichbach, M. I. (1994). What makes rational peasants revolutionary? Dilemma, paradox, and irony in peasant collective action. *World Politics, 46*(3), 383-418.

Lindekilde, L. (2013). Claims-Making. *The Wiley-Blackwell Encyclopedia of Social and Political Movements*.

Liu, J., Dietz, T., Carpenter, S. R., Alberti, M., Folke, C., Moran, E., . . . Lubchenco, J. (2007). Complexity of coupled human and natural systems. *science, 317*(5844), 1513-1516.

Liu, J., Dietz, T., Carpenter, S. R., Folke, C., Alberti, M., Redman, C. L., . . . Lubchenco, J. (2007). Coupled human and natural systems. *AMBIO: a journal of the human environment, 36*(8), 639-649.

Lobell, D. B., & Field, C. B. (2007). Global scale climate–crop yield relationships and the impacts of recent warming. *Environmental research letters, 2*(1), 014002.

Lobell, D. B., & Gourdji, S. M. (2012). The influence of climate change on global crop productivity. *Plant Physiology, 160*(4), 1686-1697.

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science, 333*(6042), 616-620.

Lomborg, B. (2001). Resource Constraints or Abundance? In P. Diehl & N. P. Gleditsch (Eds.), *Environmental Conflict*. New York: Routledge.

Lorenz, E. N. (1963). Deterministic nonperiodic flow. *Journal of the atmospheric sciences, 20*(2), 130-141.

Magnan, A., Schipper, E., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., . . . Ziervogel, G. (2016). Addressing the risk of maladaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change, 7*(5), 646-665.

Mahoney, J. (2001). *Review essay: Beyond correlational analysis: Recent innovations in theory and method.* Paper presented at the Sociological Forum.
Mahoney, J. (2010). After KKV: The new methodology of qualitative research. *World Politics, 62*(1), 120-147.
Malik, S. J., Ali, S., Riaz, K., Whitney, E., Malek, M., & Waqas, A. (2016). Agriculture, land, and productivity in Pakistan. In D. J. Spielman, S. J. Malik, P. A. Dorosh, & N. Ahmad (Eds.), *Agriculture and the rural economy in Pakistan: Issues, outlooks, and policy priorities* (pp. 41-80). Philadelphia, PA: University of Pennsylvania Press on behalf of the International Food Policy Research Institute (IFPRI).
Malthus, T. (1798/1998). *An Essay on the Principle of Population*. Amherst, NY: Prometheus Books.
Margat, J., & Van der Gun, J. (2013). *Groundwater around the world: a geographic synopsis*: Crc Press.
Matthew, R. A., Barnett, J., McDonald, B., & O'Brien, K. L. (2010). *Global environmental change and human security*: MIT press Cambridge, MA.
McAdam, D. (1982). *Political process and the development of black insurgency, 1930-1970*: University of Chicago Press.
McAdam, D. (1999). *Political process and the development of black insurgency, 1930-1970*: University of Chicago Press.
McAdam, D. (2001). Harmonizing the Voices: Thematic Continuity Across the Chapters. In C. Tilley, D. McAdam, E. J. Perry, J. A. Goldstone, R. R. Aminzade, S. Tarrow, & W. H. Sewell (Eds.), *Silence and Voice in the Study of Contentious Politics* (pp. 222-240). Cambridge: Cambridge University Press.
McAdam, D., Tarrow, S., & Tilly, C. (1996). To map contentious politics. *Mobilization: An International Quarterly, 1*(1), 17-34.
McAdam, D., Tarrow, S. G., & Tilly, C. (2001). *Dynamics of contention*. New York: Cambridge University Press.
Meier, P., Bond, D., & Bond, J. (2007). Environmental influences on pastoral conflict in the Horn of Africa. *Political Geography, 26*(6), 716-735.
Mendelsohn, R. (2000). Efficient adaptation to climate change. *Climatic Change, 45*(3), 583-600.
Merton, R. (1948). The self-fulfilling prophecy. *The Antioch Review, 8*(2), 193-210.
Merton, R. (1949/2012). On sociological theories of the middle range. In C. Calhoun, J. Moody, S. Pfaff , J. Gerteis, & I. Virk (Eds.), *Classical Sociological Theory* (3rd ed., pp. 531-542): Wiley-Blackwell.
Merton, R. (1968). *Social theory and social structure*: Simon and Schuster.
Merton, R. K. (1948). The self-fulfilling prophecy. *The Antioch Review, 8*(2), 193-210.
Miao, C.-Y., & Ni, J.-R. (2009). Variation of natural streamflow since 1470 in the Middle Yellow River, China. *International journal of environmental research and public health, 6*(11), 2849-2864.
Miguel, E., Satyanath, S., & Sergenti, E. (2004). Economic shocks and civil conflict: An instrumental variables approach. *Journal of political Economy, 112*(4), 725-753.
Mirza, M. M. Q., Warrick, R., Ericksen, N., & Kenny, G. (2001). Are floods getting worse in the Ganges, Brahmaputra and Meghna basins? *Global Environmental Change Part B: Environmental Hazards, 3*(2), 37-48.

Mullainathan, S., & Shafir, E. (2013). *Scarcity: Why having too little means so much*: Macmillan.
Mustafa, D. (2002). To each according to his power? Participation, access, and vulnerability in irrigation and flood management in Pakistan. *Environment and planning D: Society and space, 20*(6), 737-752.
Mustafa, D. (2007). Social construction of hydropolitics: The geographical scales of water and security in the Indus Basin. *Geographical Review, 97*(4), 484-501. doi:10.1111/j.1931-0846.2007.tb00408.x
Mustafa, D. (2010). *Hydropolitics in Pakistan's Indus Basin*. Retrieved from Washington DC:
Mustafa, D., Akhter, M., & Nasrallah, N. (2013). *Understanding Pakistan's water-security nexus*. Retrieved from Washington DC:
Nielsen, J. Ø., & Reenberg, A. (2010). Temporality and the problem with singling out climate as a current driver of change in a small West African village. *Journal of Arid Environments, 74*(4), 464-474.
Nielsen, J. Ø., & Vigh, H. (2012). Adaptive lives. Navigating the global food crisis in a changing climate. *Global Environmental Change, 22*(3), 659-669.
Nijssen, B., O'Donnell, G. M., Hamlet, A. F., & Lettenmaier, D. P. (2001). Hydrologic Sensitivity of Global Rivers to Climate Change. *50*(1), 143-175.
Novotny, E. V., & Stefan, H. G. (2007). Stream flow in Minnesota: Indicator of climate change. *334*(3), 319-333.
O'Brien, K., & Barnett, J. (2013). Global environmental change and human security. *Annual Review of Environment and Resources, 38*, 373-391.
O'Brien, K., Eriksen, S., Nygaard, L. P., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate policy, 7*(1), 73-88.
OCHA. (1996). *Pakistan - Floods Information Report No. 1, 27 August 1996* (1). Retrieved from
Olson, M. (1965). *The logic of collective action*: Harvard University Press.
Oppenheimer, M. (2013). Climate change impacts: accounting for the human response. *Climatic Change, 117*(3), 439-449.
Ostrom, E. (1998). A behavioral approach to the rational choice theory of collective action: Presidential address, American Political Science Association, 1997. *American political science review, 92*(1), 1-22.
Ostrom, E. (1999). Coping with tragedies of the commons. *Annual review of political science, 2*(1), 493-535.
Ostrom, E. (2000). Collective action and the evolution of social norms. *Journal of economic perspectives, 14*(3), 137-158.
Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science, 325*(5939), 419-422.
Ostrom, E., Walker, J., & Gardner, R. (1992). Covenants with and without a sword: Self-governance is possible. *American political science Review, 86*(2), 404-417.
O'Brien, K., Hayward, B., & Berkes, F. (2009). Rethinking social contracts: building resilience in a changing climate. *Ecology and Society, 14*(2), 12.

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., . . . Nygaard, L. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global environmental change, 14*(4), 303-313.
Pakistan, G. o. (1994). *Policy framework and package of incentives for private sector power generation projects in Pakistan*. Islamabad, Pakistan
Pakistan, G. o. (2017). *Economic Survey of Pakistan 2016-2017*. Islamabad, Pakistan: Government of Pakistan Retrieved from http://www.finance.gov.pk/survey/chapters_17/Pakistan_ES_2016_17_pdf.pdf
Pakistan, G. o. (2018). *Economic Survey of Pakistan 2017-2018*. Islamabad, Pakistan
Papiez, C. (2009). *Climate change implications for the Quileute and Hoh Tribes of Washington: A multidisciplinary approach to assessing climatic disruptions to coastal indigenous communities.* Citeseer,
Patomäki, H., & Wight, C. (2000). After postpositivism? The promises of critical realism. *International Studies Quarterly, 44*(2), 213-237.
Peluso, N. L., & Watts, M. (2001). *Violent environments*: Cornell University Press.
Petersen, R. D. (2001). *Resistance and rebellion: lessons from Eastern Europe*: Cambridge University Press.
Phuong, L. T. H. (2011). *Climate Change and Farmers' Adaptation: A Case Study of Mixed-Farming Systems in the Coastal Area in Trieu Van Commune, Trieu Phong District, Quang Tri Province, Vietnam.* MSc thesis, HUAF,
Pinckney, T. C. (1989). *The demand for public storage of wheat in Pakistan*. Retrieved from Washington, D.C.:
Pingali, P. L. (2012). Green Revolution: Impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences, 109*(31), 12302-12308.
Podgorski, J. E., Eqani, S. A. M. A. S., Khanam, T., Ullah, R., Shen, H., & Berg, M. (2017). Extensive arsenic contamination in high-pH unconfined aquifers in the Indus Valley. *Science Advances, 3*(8), e1700935. doi:10.1126/sciadv.1700935
Polletta, F. (2009). *It was like a fever: Storytelling in protest and politics*: University of Chicago Press.
Popper, K. (1959). *The logic of scientific discovery*: Routledge.
Qian, W., Fu, J., & Yan, Z. (2007). Decrease of light rain events in summer associated with a warming environment in China during 1961–2005. *Geophysical Research Letters, 34*(11).
Qureshi, A. S. (2015). Improving food security and livelihood resilience through groundwater management in Pakistan. *Global Advanced Research Journal of Agricultural Science, 4*(10), 678-710.
Qureshi, A. S., McCornick, P. G., Sarwar, A., & Sharma, B. R. (2010). Challenges and prospects of sustainable groundwater management in the Indus Basin, Pakistan. *Water resources management, 24*(8), 1551-1569.
Rafail, P., McCarthy, J. D., & Sullivan, S. (2019). Local Receptivity Climates and the Dynamics of Media Attention to Protest. *Mobilization: An International Quarterly, 24*(1), 1-18.
Raleigh, C., Linke, A., Hegre, H., & Karlsen, J. (2010). Introducing ACLED: Armed conflict location and event data. *Journal of peace research, 47*(5), 651-660.
Raleigh, C., & Urdal, H. (2007). Climate change, environmental degradation and armed conflict. *Political geography, 26*(6), 674-694.

Ribot, J. C. (2010). Vulnerability does not fall from the sky: toward multiscale, pro-poor climate policy. *Social dimensions of climate change: Equity and vulnerability in a warming world*, 47-74.

Rind, D. (1999). Complexity and climate. *science, 284*(5411), 105-107.

Rizk, N. (2011). Bread, Freedom, and Social Justice: A Report from Egypt. Retrieved from http://www.huffingtonpost.com/david-weinberger/bread-freedom-social-just_b_1114936.html

Rizvi, H.-A. (1999). Pakistan in 1998: The polity under pressure. *Asian Survey, 39*(1), 177-184.

Robson, A., Bardossy, A., Jones, D., & Kundzewicz, Z. (2000). Statistical methods for testing for change. *Detecting trends and other changes in hydrological data. World Climate Programme-Water, World Climate Programme Data and Monitoring, WCDMP-45, WMO/TD*(1013), 49-88.

Ross, M. L. (2004). How do natural resources influence civil war? Evidence from thirteen cases. *International organization, 58*(1), 35-67.

Salam, A. (2017). Prices of food grains and farm inputs in Pakistan: Empirical analysis of farmers' incentives and terms of trade. *Pakistan Economic and Social Review, 5 5*(Winter 201 7), 4 35 - 34 72.

Salehyan, I. (2008). From climate change to conflict? No consensus yet. *Journal of Peace Research, 45*(3), 315-326.

Sambanis, N. (2002). A review of recent advances and future directions in the quantitative literature on civil war. *Defence and Peace Economics, 13*(3), 215-243.

Sanghi, A., Mendelsohn, R., & Dinar, A. (1998). The climate sensitivity of Indian agriculture. *Measuring the impact of climate change on Indian agriculture*, 69.139.

Santer, B. D., Po-Chedley, S., Zelinka, M. D., Cvijanovic, I., Bonfils, C., Durack, P. J., . . . Painter, J. (2018). Human influence on the seasonal cycle of tropospheric temperature. *Science, 361*(6399), eaas8806.

Sartori, G. (1970). Concept misformation in comparative politics. *American political science review, 64*(4), 1033-1053.

Savo, V., Lepofsky, D., Benner, J. P., Kohfeld, K. E., Bailey, J., & Lertzman, K. (2016). Observations of climate change among subsistence-oriented communities around the world. *6*, 462.

Sayer, A. (2000). *Realism and social science*. London: Sage Publications.

Sayer, A. (2010). *Method in social science: revised 2nd edition*: Routledge.

Schelling, T. (1998). Social mechanisms and social dynamics. In P. Hedström & R. Swedberg (Eds.), *Social mechanisms: An analytical approach to social theory* (pp. 32-44).

Schelling, T. C. (1971). Dynamic models of segregation. *Journal of mathematical sociology, 1*(2), 143-186.

Schelling, T. C. (1978). *Micromotives and macrobehavior*: WW Norton & Company.

Schiermeier, Q. (2018). Clear signs of global warming will hit poorer countries first. *Nature, 556*(7700), 415-417.

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences, 104*(50), 19703-19708.

Schneider, M. (2008). *We are hungry! A summary report of food riots, government responses, and states of democracy in 2008*. Department of Development Sociology. Cornell University.

Selby, J. (2014). Positivist climate conflict research: a critique. *Geopolitics, 19*(4), 829-856.

Selby, J., Dahi, O. S., Fröhlich, C., & Hulme, M. (2017). Climate change and the Syrian civil war revisited. *Political Geography*.

Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall's tau. *Journal of the American Statistical Association, 63*(324), 1379-1389.

Sewell, W. H. (1996). Historical events as transformations of structures: Inventing revolution at the Bastille. *Theory and society, 25*(6), 841-881.

Sharif, M., Archer, D., Fowler, H., & Forsythe, N. (2013). Trends in timing and magnitude of flow in the Upper Indus Basin.

Shimola, K., & Krishnaveni, M. (2013). A Study on Farmers' Perception to Climate Variability and Change in a Semi-arid Basin. In *On a Sustainable Future of the Earth's Natural Resources* (pp. 509-516): Springer.

Siddique, M., & Hashmi, D. (2012). *Recent trends in high altitude temperatures and river flows in Upper Indus Basin.* Paper presented at the Centenary celebration (1912-2012).

Silva, J. A., Eriksen, S., & Ombe, Z. A. (2010). Double exposure in Mozambique's Limpopo River basin. *The Geographical Journal, 176*(1), 6-24.

Simon, J. L. (1989). Lebensraum Paradoxically, Population Growth May Eventually End Wars. *Journal of Conflict Resolution, 33*(1), 164-180.

Singh, P., Jain, S., & Kumar, N. (1997). Estimation of snow and glacier-melt contribution to the Chenab River, Western Himalaya. *Mountain Research and Development*, 49-56.

Singh, R. K., Bhowmik, S., & Pandey, C. (2011). Biocultural diversity, climate change and livelihood security of Adi community: Grassroots conservators of eastern Himalaya Arunachal Pradesh.

Smit, B., Burton, I., Klein, R. J., & Street, R. (1999). The science of adaptation: a framework for assessment. *Mitigation and adaptation strategies for global change, 4*(3-4), 199-213.

Smit, B., Burton, I., Klein, R. J., & Wandel, J. (2000). An anatomy of adaptation to climate change and variability. *Climatic change, 45*(1), 223-251.

Smithers, J., & Smit, B. (1997). Human adaptation to climatic variability and change. *Global environmental change, 7*(2), 129-146.

Solow, A. R. (2013). Global warming: A call for peace on climate and conflict. *Nature, 497*(7448), 179-180.

Spielman, D. J., Malik, S. J., Dorosh, P., & Ahmad, N. (2016a). *Agriculture and the Rural Economy in Pakistan: Issues, Outlooks, and Policy Priorities*: University of Pennsylvania Press.

Spielman, D. J., Malik, S. J., Dorosh, P., & Ahmad, N. (2016b). Food agriculture and rural development in Pakistan. In *Agriculture and the rural economy in Pakistan* (pp. 1-40). Philadelphia, Pennsylvania: University of Pennsylvania Press.

Steinbruner, J. D. (1974). *The cybernetic theory of decision: New dimensions of political analysis*: Princeton University Press.

Steinbruner, J. D., Stern, P. C., & Husbands, J. L. (2013). *Climate and social stress: Implications for security analysis*: National Academies Press.
Stern, J. J., & Falcon, W. P. (1970). *Growth and development in Pakistan, 1955-1969*: Center for International Affairs, Harvard University.
Sternberg, T. (2012). Chinese drought, bread and the Arab Spring. *Applied Geography, 34*, 519-524.
Sternberg, T. (Producer). (2013a). China, drought and the Arab Spring: the globalisation of climate hazards. Retrieved from https://www.iiss.org/en/events/events/archive/2013-5126/november-fc4b/china-drought-and-the-arab-spring-8dd7
Sternberg, T. (2013b). Chinese drought, wheat, and the Egyptian uprising: how a localized hazard became globalized. *The Arab Spring and Climate Change: A Climate and Security Correlations Series. Center for American Progress*.
Stinchcombe, A. L. (1991). The conditions of fruitfulness of theorizing about mechanisms in social science. *Philosophy of the social sciences, 21*(3), 367-388.
Stouffer, S. A., Suchman, E. A., DeVinney, L. C., Star, S. A., & Williams Jr, R. M. (1949). The American soldier: Adjustment during army life.(Studies in social psychology in World War II), Vol. 1.
Svenning, J. C., & Sandel, B. (2013). Disequilibrium vegetation dynamics under future climate change. *American Journal of Botany, 100*(7), 1266-1286.
Szerszynski, B., & Urry, J. o. (2010). Changing climates: Introduction. *Theory, culture & society, 27*(2-3), 1-8.
Tarrow, S. (2007). Inside insurgencies: Politics and violence in an age of civil war. *Perspectives on Politics, 5*(3), 587-600.
Tarrow, S., & Tilly, C. (2007). Contentious politics and social movements. In *The Oxford handbook of comparative politics*.
Taylor, M. (2014). *The political ecology of climate change adaptation: Livelihoods, agrarian change and the conflicts of development*: Routledge.
Theisen, O. M. (2012). Climate clashes? Weather variability, land pressure, and organized violence in Kenya, 1989–2004. *Journal of peace research, 49*(1), 81-96.
Theisen, O. M. (2018). Climate change and violence: The case for mechanisms.
Theisen, O. M., Gleditsch, N. P., & Buhaug, H. (2017). Climate change and armed conflict: Reviewing the evidence. In M. Stohl, M. I. Lichbach, & P. N. Grabosky (Eds.), *States and peoples in conflict: Transformations of conflict studies* (pp. 113-129). New York: Routledge.
Thomson, L. J., Macfadyen, S., & Hoffmann, A. A. (2010). Predicting the effects of climate change on natural enemies of agricultural pests. *Biological control, 52*(3), 296-306.
Tilly, C. (1978). *From mobilization to contention*: McGraw-Hill.
Tilly, C. (1984). *Big structures, large processes, huge comparisons*: Russell Sage Foundation.
Tilly, C. (2001). Mechanisms in political processes. *Annual review of political science, 4*(1), 21-41.
Tilly, C. (2008). *Contentious performances*: Cambridge University Press.

Tilly, C., & Goodin, R. E. (2006). It depends. *The Oxford handbook of contextual political analysis*, 3-32.

Trenberth, K. E., Cheng, L., Jacobs, P., Zhang, Y., & Fasullo, J. (2018). Hurricane Harvey links to Ocean Heat Content and Climate Change Adaptation. *Earth's Future*.

Trenberth, K. E., & Fasullo, J. T. (2012). Climate extremes and climate change: The Russian heat wave and other climate extremes of 2010. *Journal of Geophysical Research: Atmospheres, 117*(D17).

Trenberth, K. E., Fasullo, J. T., & Shepherd, T. G. (2015). Attribution of climate extreme events. *Nature Climate Change, 5*(8), 725.

Trombetta, M. J. (2008). Environmental security and climate change: analysing the discourse. *Cambridge Review of International Affairs, 21*(4), 585-602.

Turner, B. L., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., . . . Luers, A. (2003). Illustrating the coupled human–environment system for vulnerability analysis: three case studies. *Proceedings of the National Academy of Sciences, 100*(14), 8080-8085.

UNFCCC. (2007). *Climate change: Impacts vulnerabilities and adaptation in developing countries*. Retrieved from Bonn:

USAID. (2013). *The Causes and Impacts of Power Sector Circular Debt in Pakistan*. Retrieved from Washington DC:

USDA. (2019). *Production, Supply and Distribution (PS&D) Online, Foreign Agricultural Service*. Retrieved from: https://apps.fas.usda.gov/psdonline/app/index.html

van Geen, A., Farooqi, A., Kumar, A., Khattak, J. A., Mushtaq, N., Hussain, I., . . . Singh, C. K. (2019). Field testing of over 30,000 wells for arsenic across 400 villages of the Punjab plains of Pakistan and India: Implications for prioritizing mitigation. *654*, 1358-1363.

Villar, J. C. E., Guyot, J. L., Ronchail, J., Cochonneau, G., Filizola, N., Fraizy, P., . . . Vauchel, P. (2009). Contrasting regional discharge evolutions in the Amazon basin (1974–2004). *Journal of Hydrology, 375*(3), 297-311.

Walker, B., Holling, C. S., Carpenter, S., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and society, 9*(2).

Walker, B., & Salt, D. (2012). *Resilience thinking: sustaining ecosystems and people in a changing world*: Island Press.

Wang, L. (2012). *The Vulnerability of Social-Environmental Systems and Farmers' Livelihood to Climate Change on China's Loess Plateau.* PhD thesis, Univ. New South Wales,

Watto, M. A., & Mugera, A. W. (2016). Groundwater depletion in the Indus Plains of Pakistan: imperatives, repercussions and management issues. *International Journal of River Basin Management, 14*(4), 447-458.

Wight, C. (2006). *Agents, structures and international relations: politics as ontology* (Vol. 101): Cambridge University Press.

Wilbanks, T. J., & Kates, R. W. (1999). Global change in local places: how scale matters. *Climatic change, 43*(3), 601-628.

Wolf, A. T. (1999). "Water Wars" and Water Reality: Conflict and Cooperation Along International Waterways. In S. C. Lonergan (Ed.), *Environmental Change, Adaptation, and Security* (pp. 251-265). Dordrecht: Springer Netherlands.

World Urbanization Prospects. (2018).

Xu, L., Stige, L. C., Chan, K.-S., Zhou, J., Yang, J., Sang, S., . . . Jiang, T. (2017). Climate variation drives dengue dynamics. *Proceedings of the National Academy of Sciences, 114*(1), 113-118.

Yu, W., Yang, Y.-C., Savitsky, A., Brown, C., & Alford, D. (2013). *The Indus basin of Pakistan: The impacts of climate risks on water and agriculture*: World Bank Publications.

Yue, S., Pilon, P., Phinney, B., & Cavadias, G. (2002). The influence of autocorrelation on the ability to detect trend in hydrological series. *Hydrological Processes, 16*(9), 1807-1829.

Zaheer, K. (2012). Community Vulnerability Assessment: Kharo Chan, Keti Bunder and Jiwani. *World Wide Fund for Nature*.

Zahid, M., & Rasul, G. (2011). Frequency of extreme temperature and precipitation events in Pakistan 1965–2009. *Sci. Int.(Lahore), 23*(4), 313-319.

Zahid, M., & Rasul, G. (2012). Changing trends of thermal extremes in Pakistan. *Climatic Change, 113*(3-4), 883-896.

Zeng, R., Cai, X., Ringler, C., & Zhu, T. (2017). Hydropower versus irrigation—an analysis of global patterns. *Environmental Research Letters, 12*(3), 034006.

Zhang, F. (2018). *In the Dark: How Much Do Power Sector Distortions Cost South Asia?* : The World Bank.

Zscheischler, J., Westra, S., Hurk, B. J., Seneviratne, S. I., Ward, P. J., Pitman, A., . . . Wahl, T. (2018). Future climate risk from compound events. *Nature Climate Change*, 1.