Title
Smallholder farmer welfare in a time of changing climate: the role of cropping decisions in local food security in the Nainital District of Uttarakhand, India

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Publication Date
2013

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Los Angeles

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A thesis submitted in partial satisfaction

of the requirements for the degree Master

in Urban and Regional Planning

by

Marena Lin

2013

ABSTRACT OF THE THESIS

Smallholder farmer welfare in a time of changing climate: the role of cropping decisions in local food security in the Nainital District of Uttarakhand, India

by

Marena Lin

Master in Urban and Regional Planning
University of California, Los Angeles, 2013
Professor Christopher C. Tilly, Chair

Smallholder farmers in the Himalayan district of Nainital in Uttarakhand, India depend on predictable weather patterns for both food and cash crop cultivation. The manifestation of climate change in changing weather patterns is expected to endanger rural food security, as many of these farmers operate at subsistence-level. In an analysis of a 307-household survey of smallholder farmers, I find that respondents perceive changes in weather patterns and report adverse effects on their agricultural productivity. Despite describing traditional grains as crops best suited to adverse weather, respondents still choose to grow cash crops that they believe to be the most vulnerable to these weather patterns. The competing motivations of sustainability and profitability are explained by the growing prominence of the Indian Public Distribution System, which has created a buffer against drought-precipitated famine by providing heavily subsidized grain but, in turn, diminished the profitability of locally produced grain. I argue that overall food security and sustainability can be improved by reorienting the objectives of agricultural policy and welfare policy to value local preferences and to treat smallholder farmers as agents rather than welfare recipients.

The thesis of Marena Lin is approved.

Susanna B. Hecht

Vinit Mukhija

Christopher C. Tilly, Committee Chair

University of California, Los Angeles
2013

Dedication

I dedicate this work to the memory of Douglas Raymond Chain (1987-2012), whose sense of humor, exceptional brilliance and deep empathy I will always miss.

Contents

List of Figures

List of Tables

Acknowledgements

I am deeply grateful to Prof. Chris Tilly for his critical support, depth of knowledge of all matters statistical and related to international development, and incredible patience in advising. This thesis would not have been possible without our many conversations and exchange of ideas. I am very thankful to Profs. Vinit Mukhija and Susanna Hecht for their guidance and wisdom. I credit Prof. Hecht's vast understanding of environmentalisms, environmental justice, and food systems for much of my knowledge of the global food and agriculture system, and Prof. Mukhija's academic support and guidance have been indispensable to my completion of this master's program. The continued support and advising of Prof. Peter Huybers have shaped my understanding of the role of statistics in epistemology, a critical lens that informs much of this work. Altogether, working with Profs. Tilly, Hecht, Mukhija and Huybers has allowed me to realize an interdisciplinary piece of research fundamentally driven by an interest in social justice.

The financial and administrative support of the UCLA Urban and Regional Planning Department and of the Luskin School of Public Affairs, particularly through the Julie Roque Fellowship and the Torang Jahan Globalization Fellowship have been crucial to my scholarship. Access to the villages in the Nainital District during the summer of 2012 was only possible through Dr. Suman Sahai of the Gene Campaign, and I am grateful for having been able to analyze the raw survey data from the Gene Campaign for this research. I will always appreciate Dr. Sahai and the Gene Campaign for facilitating the formative experiences with rural smallholder agriculturalists in Jharkhand and Uttarakhand that continue to motivate my work. Collection of the primary 307-household survey data was undertaken by Gene Campaign staff members:

Deepa Lodhiyal, Harendra Singh Lodhiyal, Tulsi Bisht, Geeta Mer, Deepa Rana, Ganesh Singh Bisht, Pavan Kumar Dhaila.

I am greatly indebted to Eric Stansifer for always finding the time to hear out and critique the many arguments contained within this thesis. Emily Gorbaty, Michael Sin, Naveena Naqvi, Keith Grogan, Kim Repecka, and Eric Stansifer—I can only hope that my support and friendship matches that which you have shown me. My parents and their unconditional love are the singular reason for the continued privilege to follow my dreams.

Chapter 1

Introduction

1.1 Climate change and Indian agriculture

Recent years of erratic and weak monsoons during the summer seasons in India (India Meteorological Department, 2013) corroborate past predictions by global circulation models, which have suggested that the future of Indian climate will comprise rising temperatures, higher frequencies of extreme weather events, and, on average, wetter conditions (Mitra et al., 2002). Furthermore, the observed and predicted effects of climate change in melting glaciers and disrupting the monsoon pattern throughout Asia will endanger 25% of the global grain production (Chakraborty and Newton, 2011). Lobell et al. (2013b) have found that wheat senescence in India has been hastened by extreme temperatures. In particular, Indian agricultural productivity is closely tied to the timing and intensity of the summer monsoons, the arrival of which is a key determinant of planting times (O'Brien et al., 2004; Giné et al., 2008).

In developing countries throughout Asia and Africa, where a large proportion of the population relies on rainfed agriculture for their food supply, farmers have lim-

ited capacity to adapt to changing variability in climate variables, such as rainfall and temperature; this has a direct effect on the projections of local food supply and consequent market prices, which, in turn, have adverse effects on food security (Sen, 1981; Ericksen, 2008; Kristjanson et al., 2012). Given that over two-thirds of the Indian population—about 800 million people—are employed in the agricultural sector, and among these, more than 80% are landless agricultural laborers or subsistence-level smallholder farmers (Chand et al., 2011), climate change is expected to have direct negative effects on the great majority of Indian livelihoods and food security.

1.2 Coping, adaptation, vulnerability and resilience to changing climate

As is evident with the reliance of Indian agriculture on a predictable annual monsoon, the increase in adverse weather events from changing climate can more generally be expected to have a direct negative impact on agriculture, ecology, and related socio-economic institutions (Adger, 2009; Berman et al., 2012; Arbuckle et al., 2013). While the immediate effects of adverse weather on animal and plant life and natural ecosystems have been empirically measured, the interconnected influence of these effects on human society is less frequently studied (Berman et al., 2012). Understanding these effects can inform measures taken to both mitigate and adapt to climate change. Adger (2009) names four primary challenges to adapting to climate change, summarized below:

1. There is a limited temporal window for adapting to climate change because of the scale and interconnectedness of impacts.

2. Even though the capacity to adapt may exist, it may not translate to action.

3. Institutions and infrastructure currently in place may be maladapted and not sustainable.

4. The ways of measuring the effects of climate change and the goals of adaptation—i.e. in terms of greenhouse gas emissions and the cost of relocating affected populations—do not adequately encompass the social and cultural context.

Adger (2009) conceives of climate change as a phenomenon with largely environmental effects; his concept of interconnectedness describes ecosystems and climate and does not extend to equally complex relations between human society and climate. This claim may appear to be negated by Adger (2009)'s fourth point, which highlights the effects of climate change on environmental resources and ways that different cultures may value them. However, the concern of the fourth point is still concentrated on the proximate environmental effects of climate change rather than the linked socio-economic mechanisms that may govern the protracted social effects of changing climate. In an example provided for this fourth point, Adger (2009) describes the problem of rising sea-levels drowning small island nations, and he explains that proposed solutions of population relocation in terms of financial cost do not account for the social and cultural value these affected communities place on the declining environmental resource (in this case, unsubmerged land). However, this example is focused on the varying valuations of unsubmerged land instead of the various mechanistic effects that climate-change-induced submergence of small island nations may have on socio-economic conditions, such as access to food and shelter, wealth, and community coherence. That is, a community's perception of the environmental resource is still a proximate effect of the environmental shift due to climate change and does not describe the extensive socio-economic effects of changing climate.

The view of climate change in terms of only its immediate environmental effects is evident in the variable definitions of coping, adaptation, vulnerability and resilience to climate change. Berman et al. (2012) seeks to clarify the differences between these four elements throughout the literature, identifying an inclination in current climate change literature to focus on short-term coping strategies rather than ways to build longer-term adaptive capacity. Building from past studies, Berman et al. (2012) defines "vulnerability as the extent a system is prone to and unable to cope with shocks and stresses, determined by different social, ecological, and political conditions at multiple levels." Resilience, as Berman et al. (2012) abstracts from an amalgam of previous work, is the ability of a system to persist through adverse events and to transform coping into adaptive capacity.

Coping and adaptation have been variously defined as ways in which a system can apprehend and survive the adverse effects of climate change—coping is the set of immediate reactions to specific weather disasters whereas adaptation is a change in the system to limit future adverse effects of climate change (Berman et al., 2012). Socio-economic institutions in terms of laws and social power structures determine the degrees to which different parts of society endure the effects of changing climate (Berman et al., 2012). However, absent from these methods of conceptualizing adaptation are clear definitions of the negative effects of climate change that are the targets of such coping and adaptation.

For example, the physical effects of changing climate are evident in rising sea-levels and temperatures and increased frequencies of extreme weather events like cloudbursts and "once-in-a-century" tornadoes. The influence of these events on physical infras-

tructure is measureable in terms of dollars, but these effects are far less legible in terms of damage to social welfare. Even the number of lives lost is not immediately comprehensible in terms of its magnifying effects on the community and resulting disruptions of social institutions. Effects of climate variability on agricultural productivity can be empirically interpreted (Butler and Huybers, 2012; Lobell et al., 2013a; Wang et al., 2009), but the cascading effects of climate change on the viability of agriculture as livelihood and on overall food security are less transparent. As a result, recent studies of coping and adaptation focus on ameliorating immediate effects of adverse weather (Kristjanson et al., 2012; Berman et al., 2012; Cooper and Coe, 2011; Arbuckle et al., 2013), and there is much additional work to be done to understand the web of climate-change effects on society.

1.3 Agricultural adaptation to changing climate

In line with the focus of agricultural research on the immediate physiological effects of changing climate on crop productivity, agricultural adaptation to changing climate is most commonly envisioned as changes in cultivation practices—for example, increased drainage, rainwater harvesting, soil management, and selection of cultivars suitable to the regional climate (Butler and Huybers, 2012; Arbuckle et al., 2013; Kristjanson et al., 2012). In a study of smallholder farmers in Kenya, Ethiopia, Tanzania, and Uganda, Kristjanson et al. (2012) finds that a lower number of months spent hungry correlates with the greater willingness of a household to take adaptive measures to adverse weather. Arbuckle et al. (2013) shows that Iowa farmers with larger landholdings were more supportive of increased government investment in drainage systems, the implementation of which in the late 1800s had "unlocked extraordinary productivity

and made Iowa a leading agricultural state." These drainage systems are also seen as good buffers to changing climate, given expected increases in mean rainfall (Arbuckle et al., 2013).

Immediate adaptations are more tractable, whereas understanding the broader context governing whether agriculture can adapt to changing climate is riddled with much greater uncertainty. Thus, although most research on the ability of agriculture to adapt to climate change is motivated by maintaining food security, few studies reach beyond the immediate effects of climate variables on agricultural productivity to treat food access. Arbuckle et al. (2013) and Kristjanson et al. (2012), though they treat vastly different scales of agriculture—many of the West African farmers struggled to feed themselves while Iowan farmers produced entirely for middlemen—find that the relative wealth of the farmer was indicative of the extent to which the farmer expressed an ability take adaptive measures against the adverse weather conditions of changing climate. This suggests that understanding the economic inequality among farmers and types of farming, interpreted in terms of variables such as landholding size, productivity, or level of food access, merits greater attention to understand the adaptive capacity of agriculture to changing climate.

1.4 Tracking the impact of climate variability on food security

The preceding discussion reveals roughly three major areas of study that may be expected to treat the effects of changing climate on food: agricultural productivity

and climate, adaptation to the environmental effects of climate change, and climate change and food security. The third appears to be commonly subsumed by the former two as a leading motivation rather than as an actual research subject—we care about agricultural productivity because it is a primary factor in the ability of society to feed a burgeoning population. Consequently, studies of the first two categories do not examine the intervening mechanisms between changing climate and food security, such as the viability of farmer livelihoods, their land tenure, and more generally, the full range of actions that they are able to take in response to changing climate.

In this work, I make an attempt to probe this gap through an exploration of these intervening mechanisms; if agricultural adaptation to changing climate does not manifest in changing cultivation methods, then what other factors may be in play? In particular, my thesis examines the ways that perceptions of changing weather patterns have influenced local food security among smallholder farmers in the Ramgarh and Dhari Blocks in the Uttarakhand Himalayas. Given that these farmers operate on the border of subsistence, the increasingly volatile weather patterns have an adverse effect on food security, which the United Nations Food and Agricultural Organization defines as existing "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle" (Food and Agriculture Organization of the United Nations, 2003). This definition broadens the nature of food security to encompass the preferences and nutritional needs of a population, as well as the long term sustainability and accessibility of the food source.

The negative influence of adverse and unpredictable weather patterns on agricultural productivity is clear. In recent years, late monsoons (India Meteorological De-

partment, 2013) have reduced yields by forcing smallholder farmers to sow late or abandon certain crops, exacerbating food insecurity. By September of 2012, the annual monsoon rainfall was as much as 72% below average in some regions, and rainfall is expected to become less frequent but more intense, inhibiting groundwater recharge and adversely affecting irrigation prospects for the dry *rabi* season, which begins in mid-October and ends in mid-April (Bajaj, 2012). The Himalayan mountain ecosystems are particularly vulnerable, with mean temperature projected to rise 3^{o} C over the next century (Intergovernmental Panel on Climate Change, 2007). Understanding the role that perception of climate change plays in rural Himalayan food security is invaluable to informing agricultural and climate change adaptation policy.

In certain regions of the Central Himalayas, fruit cultivation has become a major income-generating activity for smallholder farmers. Historically, these areas have grown grains and vegetables for household consumption, but the need for grain cultivation has been partially offset by the increasing prominence of the Targeted Public Distribution System (TPDS), a government food security program which provides heavily subsidized wheat flour, rice, sugar, and kerosene at a small fraction of the market price (Nakkiran, 2004). Khera (2011a) classifies Uttarakhand as a 'reviving state,' or one in which an increasing proportion of TPDS grain is reaching intended beneficiaries. While the combination of inexpensive government grain and increased income from fruit cultivation has eliminated hunger in the Nainital district, these factors have interacted with climate change to affect planting choices and alter the nutritional profile of local diets.

In this thesis, I aim to show that the confluence of these factors have affected food security in an unintended way—bringing about higher incomes and dependent food

sufficiency at the expense of the fulfillment of preferences and agricultural viability given the challenges of climate change. The Ramgarh and Dhari Blocks present a valuable case-study for the interaction between perceptions of climate change, government policies, such as the Indian Public Distribution System, and economic factors, such as the introduction of income-generating fruit production, on local food security. This is a scenario of government welfare and agricultural support and rural markets that is found throughout the developing world. A detailed study of perceptions of weather patterns and their relation to cropping decisions can yield a set of policy objectives for improving rural economic livelihoods and strengthening food security by ensuring basic sustenance while increasing the sustainability of agricultural practices and aiding farmers in adapting to the effects of climate change.

1.4.1 Is food security defined by linear causality or a network of factors?

The Ramgarh and Dhari Blocks of the Nainital District of Uttarakhand are just two of hundreds of thousands of agricultural communities in India, and their farming practices are dependent on the weather patterns and changing climate of the Himalayan foothills. However, as in much of rural India, smallholder agriculture defines both local food consumption and income-generating capacities, and weather is a frequent determinant of agricultural productivity. The terms smallholder farmer and subsistence-level agriculture mask the broader category of agriculturalists that worry about fulfilling their caloric and nutritional needs, whether through their own cultivation or purchases after income-generation.

When probing the effects of changing weather patterns on subsistence-level agriculture, it is conceivable at first blush that better agricultural technology and resources are the core tools of adapting food security to adverse weather. However, the nature of the solution often depends on the way the problem is defined. Framing the question of food security in terms of the influence of weather patterns on agriculture omits other, possibly more dominant, factors that might affect food access in the region, such as government welfare programs, local tastes and preferences, prioritization of sustainability, and profitability of different crops. In order to interpret the interaction of this milieu of variables with local food security, the normative and context-dependent definition of food security and its role in the field of international development require clarification:

Is food security a matter of ensuring enough calories for the region, and at what scale should the amount of calories produced match the needs of the contained population? Are we concerned more with the sustainability of the food source or with environmental sustainability, and how might they be aligned? How are local preferences and international standards of nutrition valued in judging the quality of the food supply? How do local food security and sustainability fit in with broader objectives of international poverty alleviation? These questions have been treated extensively, though often separately and without explicit description as normative components of social justice.

1.4.2 Thesis structure

In the first four chapters, I explain the rationale behind my research lens, describe the origin and present function of the Public Distribution System, an Indian government program that procures and distributes grain to alleviate poverty and improve welfare, and present a theoretical framework for the study of smallholder farmer food security. In the fifth through seventh chapters, I present the findings of my research and implications, as they are informed by first half of this thesis.

Specifically, in Chapter 2, I discuss the major modes of thought in international development to explain the approach of this study. The subject of international development may appear to be an especially broad beginning for a study of smallholder farmer adaptations to changing weather patterns, but given the ultimate purpose of this study in contributing to poverty alleviation, the prior research methodology on international development merits scrutiny. I then consider, in Chapter 3, the historical and present purpose of the Indian Targeted Public Distribution System, a program for grain procurement and welfare distribution. Although this program appears tangential to an analysis of the effects of weather perceptions on cropping patterns, it comprises the primary policy treatment of food security in India and can therefore be expected to influence subsistence-level crop cultivation. In Chapter 4, I build a theoretical framework for understanding food and livelihood security in Indian smallholder agriculture, and I supplement this by considering the roles of adverse weather patterns, environmental and agricultural sustainability, a public grain procurement and distribution program, and the decisions of smallholder farmers. In Chapter 5, I present my primary data, and in Chapter 6, by synthesizing interviews, quantitative data and analyses, and working within the framework established in Chapter 4, I construct a narrative

of how food security in the Nainital District of Uttarakand is responding to the various factors of changing weather patterns, government welfare programs, profitability of crop production, and food preferences. Finally, Chapter 7 is a broader discussion of my findings and notes on further work in this area.

Chapter 2

Thinking about International Development

2.1 Introduction

Through an international lens, poverty evokes myriad images—a child living in a Mumbai slum working in a sweatshop or sorting refuse, a village of smallholder farmers in Malawi with maize fields wilting in a drought, or perhaps a developing nation with a flagging manufacturing industry and depressed wages. At its most general, poverty is deprivation: some combination of insufficient means and reduced capability. Theories of international development aim to explain and alleviate this deprivation, whether it manifests in low economic growth, poor public health, lack of access to education, unsustainable development, or food insecurity.

These theories differ in their geographic scales of analysis, their objectives, and their methods of interpretation. As a result, their explanatory strength also varies by geographic scale, and subsequent policy or management recommendations are not

necessarily comparable, in spite of their common goal in poverty elimination. Reconciling these differing conclusions thus requires first understanding the ways in which international development thinkers depart from one another in their methodology and in the objectives and normative components of their analysis.

Separately, Elinor Ostrom, Amartya Sen, and Judith Tendler analyze specific case studies and construct frameworks for thinking about, respectively, management of common pool resources, the local mechanisms of food insecurity, and successful community-level government-led development. They aim to abstract the mechanisms of observed international development situations—for Ostrom, in *Governing the Commons*, these situations include small-scale commons ranging from meadows in Japan and Switzerland and irrigation systems in Spain and the Phillippines, to groundwater basins in the Los Angeles metropolitan area; Amartya Sen, in *Poverty and Famines: An Essay on Entitlements and Deprivation* and, with Jean Drèze, in *Hunger and Public Action*, analyzes food insecurity and famines, in particular, using both those that have transpired and ones that have been averted, to examine whether food supply levels have a direct effect on famine occurrence; Judith Tendler, in *Good Government in the Tropics*, parses the feedback systems and mechanisms for successful agricultural and public health development in Brazil, finding that neither public nor private institutions can be uniformly characterized as more productive or efficient than the other—both have the capacity to build trust with their constituents and cultivate an instrumental sense of commitment among their workers. These qualities of workers and their interactions with clients comprise a key and unquantifiable ingredient of governance that is often ignored by the mainstream development community, in spite of the ease of noting and characterizing such rapport (Tendler, 1997)[1].

[1] p. 136

Tendler, Ostrom, and Sen are unified in their methodology of drawing insight and building their frameworks from both failed and successful instances of the phenomena they explore. They note the importance of examining the hidden absences of failed development: averted disasters are often silent against the backdrop of alarming tragedies of the commons, famines, and poor governance. As a result, the crucial mechanisms for successful development are frequently forgotten and unexplored. By approaching the problem of international development with the objective of building a framework and nuancing existing economic development theory, Tendler, Ostrom, and Sen open their inquiry to the various mechanisms that may determine a situation, rather than binding themselves to a narrow research question meant to lead to a specific result. Below, I start by assessing the approaches of Jeffrey Sachs, William Easterly, Abhijit Banerjee and Esther Duflo, before contrasting them with the framework-based approaches of Sen, Ostrom, and Tendler.

With an eye toward the problem of global poverty, development economists Jeffrey Sachs, in *The End of Poverty* and William Easterly, in *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*, model international development in terms of per capita national GDP growth and apply these models in crafting international policy recommendations. Abhijit Banerjee and Esther Duflo, in *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty*, extend Easterly and Sachs' analyses to the local community-level by examining and experimenting with the conditions of economic growth given varied incentives and modifications to institutions. Employing narratives punctuated by vignettes that expose the wrenching global problems of hunger, disease, and low life-expectancy, Easterly, Sachs, Banerjee and Duflo slice through the Gordian Knot of international development with empirically-derived

relationships between capital infusion and development.

2.2 Small-scale motivations for large-scale questions

Sachs and Easterly focus on GDP growth and largely nation-level metrics in judging the success of international aid efforts, while Banerjee and Duflo use nutrition, health, and access to insurance and credit as the pre-conditions of, and even proxies for, economic development. Like Sen, Ostrom, and Tendler, on one hand, Sachs, Easterly, Banerjee and Duflo are motivated by a deep sense of duty and compassion, and a desire to improve lives, right injustices, and find solutions to the perennially frustrating problem of poverty. It also seems fair to take a global perspective on poverty, with wealthier Northern countries as actors, if these Northern countries comprise the intended audience. Sachs and Easterly's critical insights on the global nature of poverty facilitate an understanding of the larger-scale correspondences between per capita GDP and nation-wide metrics, including those for infant mortality and life-expectancy, and forms of international aid, the contentious levers of international development. It is less clear, however, whether their advice for manipulating national economies can translate to poverty alleviation at the household- and community-levels, a scale that they frequently cite as motivation for their work. Furthermore, it is unlikely that international action is the exclusive means of effecting change within these communities.

In spite of the disagreements between their proposed international policies, Sachs and Easterly share an understanding of the nature of the problem and a general type of solution. According to Easterly, "the improvement in hunger, mortality, and poverty as GDP per capita rises over time motivates us on our quest for growth. Poverty is

not just low GDP; it is dying babies, starving children, and oppression of women and the downtrodden. The well-being of the next generation in poor countries depends on whether our quest to make poor countries rich is successful" (Easterly, 2002)[2]. In clarifying the nature of the solution, Easterly states that "economic growth frees the poor from hunger and disease," and "economy-wide GDP growth per capita translates into rising incomes for the poorest of the poor, lifting them out of poverty"[3].

Sachs's objectives and solution space are none too different: "When I speak of the 'end of poverty,' therefore, I will be speaking of two closely related objectives. The first is to end the plight of one sixth of humanity that lives in extreme poverty and struggles daily for survival. Everybody on Earth can and should enjoy basic standards of nutrition, health, water and sanitation, shelter, and other minimum needs for survival, well-being, and participation in society. The second is to ensure that all of the world's poor, including those in moderate poverty, have a chance to climb the ladder of development"(Sachs, 2005)[4]. In providing the solution, Sachs states, "The main objective of economic development for the poorest countries is to help these countries to gain a foothold on the ladder. The rich countries do not have to invest enough in the poorest countries to make them rich; they need to invest enough so that these countries can get their foot on the ladder. After that, the tremendous dynamism of self-sustaining economic growth can take hold"(Sachs, 2005)[5].

[2]p. 14-5
[3]p. 13
[4]p. 24
[5]p. 73

2.2.1 Institutions as black boxes

Their distinct proposed solutions emerge from the belief that per capita GDP growth corresponds with poverty elimination. Easterly's refrain is that incentives drive behavior, and he concludes that "we should tie aid to past country performance, not promises, giving the country's government an incentive to pursue growth-creating policies"[6]. Here, Easterly measures the success of a policy by its apparent impact on economic growth: "as countries' incomes rise because of their favorable policies for economic growth, aid should increase in matching fashion"[7].

Here, governance is treated as a black box that should only be funded if it appears to correspond with positive economic growth. Furthermore, Easterly posits that the success or failure of governance manifests primarily in economic growth, and good governance is encouraged by continued international monetary aid, although Easterly adds that good governance cannot be sparked by an initial influx of aid. Easterly's theory does not provide specific reasons that governance fails, nor does it define the mechanisms of a form of good governance that alleviates poverty. As evidence for his proposed causal relationship between poorly-conditioned aid and stagnant economic growth, Easterly describes how debt forgiveness supported the continuation of poor national policies and subsequent stunting of economies of developing countries. Easterly's exploration of the quality of governance and policies extends only as far as its impact on private investment and its consequent effects on economic growth.

This proposed solution for aid distribution emerges naturally from Easterly's conception of the problem: in what way does the supply of international aid affect national

[6] p. 118
[7] p. 119

economic growth? This question already assumes an answer in the form of some discernible causal relationship between international aid and economic growth. Posing this question necessarily ignores all intervening factors of community-level poverty alleviation—the local policies and institutions that effect better livelihoods and health outcomes. Indeed, the single 'rival hypothesis' that Easterly accounts for is "luck. . . Luck makes us ask ourselves whether we would see the same association between our favorite factor X and economic growth if the true cause was sheer luck" [8]. By positing that the only alternative hypothesis to his theory on the determination of economic growth is 'luck,' Easterly omits an array of community- and national-level factors that may determine economic growth, let alone poverty alleviation. If Easterly's objective in raising economic growth is to eliminate the injustice of poverty, then it seems necessary that his theory be tested against more proximate factors of poverty-institutions for public health, food access, and capital distribution.

2.2.2 Normative assumptions and constrained inquiries

Accounting for these elements is sensible in light of Easterly and Sachs's focus on household-level situations of gross economic deprivation. To both Easterly and Sachs, the individual injustices of extreme global poverty are self-evident and do not require explication. Easterly intersperses his argument with 'intermezzos,' anecdotes of poverty that suggest helplessness of the poor against the tides of bad luck and large-scale economic trends. In one instance, after describing the misfortunes that have befallen Parmila, Easterly notes that she "has great self-respect and despite her woes refuses to be looked at with sympathy"[9]. That Easterly's purpose in this work is to

[8] p. 200
[9] p. 45

discuss the effects of aid suggests that "sympathy"refers to aid, itself. It takes little inference to see the overlaid normative argument that aid should not be given out of sympathy. These 'intermezzos' evince the helplessness but the romanticized aura of nobility among those mired in extreme poverty; the poor are victims of bad luck and inexplicable disasters.

In *The End of Poverty: Economic Possibilities for Our Time*, Sachs's theories on the salve of debt forgiveness and the lever of international aid to raise the poor out of the "poverty trap" comprise an alternative answer to the same constrained question of the influence of aid on economic growth explored by Easterly [10]. Like Easterly, Sachs confronts his reader with harrowing stories of impoverished agricultural villages in Malawi, statistics of the AIDS epidemic and the depths of food insecurity throughout developing countries. However, it is harder to picture the link between their proposed theories of international aid and their anecdotes of poverty. Their theories are based on correlations drawn between nation-level aggregate indicators of economic growth, while the scenes of poverty that they decry are arguably influenced most directly by local governance and institutions. Like Easterly's support of prior-performance-based international aid delivery, the major instruments of international aid and national debt cancellation that Sachs recommends are several steps removed from the community-level scenes of deprivation that he seeks to solve.

Both Sachs and Easterly believe poverty to stem from the initial conditions of 'bad luck,' whether it results from geography and resource base, as Sachs suggests, or simply because "they started off poor"and "are stuck in vicious circles," according to Easterly

[10] p. 128

[11]. Like Easterly's hypothesis, Sachs's theory is limited by the attribution of deviations from proposed theory to initial conditions and circumstance. As Banerjee and Duflo note, India is one of many countries that do not strictly follow Easterly's and Sach's theories, given that aid is just one small component of government budgets; India spent $31 billion in 2004-5 on primary school education alone (Banerjee and Duflo, 2011)[12]. By treating the national-level deviations from the positive causal relationship between aid provision and economic growth to be noise or the result of unchangeable circumstance, Sachs's proposal does not explain and cannot be expected to change national economic growth, let alone the community-level variability in poverty.

2.3 Limits to solution spaces

2.3.1 Technology as the answer

In addition to being confined by the framing of their initial research questions, Sach's and Easterly's recommendations are rooted in normative arguments, beyond the initial normative claim that rich countries have an obligation to effect some change in global poverty: not only should richer countries try to change global poverty, but they should do so through technology. Sachs notes that "Africa's problems... are especially difficult but still solvable with practical and proven technologies. Diseases can be controlled, crop yields can be sharply increased, and basic infrastructure such as paved roads and electricity can be extended to the villages"(Sachs, 2005)[13]. However, alternatives using established technologies rather than new ones are conceivable:

[11] p. 169
[12] p. 5
[13] p. 208

programs to eliminate standing pools of water can reduce the malarial mosquito population; traditional agro-biodiversity conservation can add to the versatility of local cropping practices and may raise overall productivity; or more generally, existing local public health institutions can be strengthened to nip epidemics at the bud. Sachs' and Easterly's focus on technology is an artifact of believing economic growth to be the driver of poverty alleviation, where economic growth is measured by proxy of technological progress and adoption (Easterly, 2002)[14]. This is not to say that Easterly and Sachs are wrong to believe technology to be important but rather that technological progress is one of several factors that should be considered in economic growth and poverty alleviation. In their cases, the normative emphasis on technology precludes exploration of non-technological factors of poverty such as the nature of good governance and institutions.

Framing the question as merely an issue of aid provision and economic growth thus limits the scope of explanations and subsequent solutions. Banerjee and Duflo note one of the problems with framing poverty as a large-scale question of the effect of international aid: "Instead of discussing how best to fight diarrhea or dengue, many of the most vocal experts (Sachs and Easterly) tend to be fixated on the 'big questions'," relying on 'multicountry comparisons' that cannot explain "individual examples like Rwanda" (Banerjee and Duflo, 2011)[15]. In contrast to the large abstract questions posed by Easterly and Sachs, Banerjee and Duflo aim to explore "concrete problems which can have specific answers"[16]. They conduct experiments in the field, examining how the behavior of the poor in improving their socio-economic and health metrics changes with respect to different incentives. However, although Banerjee and Duflo

[14] p. 199
[15] p. 4
[16] p. 6

focus on concrete questions at a smaller-scale and focus on incentives and directly observable results, the framing of their research questions still gives rise to a limited set of solutions.

In discussing improving the diets of the poor, Banerjee and Duflo assume, reasonably, that complete nutrition and access to education are prerequisites for escaping poverty, and their conjectured solutions are framed in terms of these quantifiable measures—i.e. whether their subjects are accessing sufficient and healthful calories or obtaining the level of education purported by their official schooling. Such empirical relationships may be more descriptive than prescriptive, as they still rely on a fixed set of assumptions about both the nature of the problem—that a specific group of immunizations should be administered or that a set of nutritional and caloric guidelines should be fulfilled—and the constant nature of reactions to incentives—that the poor will always behave a certain way for a given set of quantifiable conditions. Their experiments display the behavior of the poor, ceteris paribus, given a change in a variable, but their data do not necessarily explain *why* the poor behave in the observed manner and how the different parameterization of the experiment may have changed observations.

More generally, while Banerjee and Duflo's experiments show what occurs with respect to one variable—how use of mosquito bed-nets changes when they are subsidized or free—their method of framing the problems does not allow exploration of the full solution space, which can include changing the appreciation of the community for public health measures. In another example, Banerjee and Duflo's work explores the way that nutrition and calories purchased change with respect to marginal increases in income: even if they experience hunger, the poor will only spend a portion of an increase in

their income on food, and taste of the food is more important than nutrition[17]. But this finding does not yield a single unequivocal solution to the problem of low levels of nutrition and insufficient calories, and it is also based on the normative argument that the tastes and preferences of a population are less important than scientifically judged nutrition and sufficient calories.

With this emphasis, Banerjee and Duflo's suggested solution is the following: "developing ways to pack foods that people like to eat with additional nutrients, and coming up with new strains of nutritious and tasty crops that can be grown in a wider range of environments need to become priorities for food technology, on an equal footing with raising productivity"[18]. By supposing that the tastes of the poor cannot be changed and are less important than their nutrition levels, measured in calories, Banerjee and Duflo's analysis of food security defaults to a technocratic solution. Their proposed answer does not account for an alternative normative argument that local food preferences are being undervalued or even the possibility that the problem of nutrition is structural and can be changed—that, for example, mainstream tastes should shift to take advantage of existing nutritious crops. It is worth noting that this technocratic focus would never be an exclusive consideration for domestic issues. In a similar instance, the obesity and the diabetes epidemics in the United States were popularly traced to the ubiquity of high-calorie junk foods, but the solution was not constrained to fortifying hamburgers, chips and soda with vitamins. Instead, the main tools have included education and limited bans on unhealthy foods, something that policymakers, chefs and celebrities have since promoted.

[17] p. 34
[18] p. 40

2.3.2 Paternalism abroad

Banerjee and Duflo's analysis reflects a common tenor of the international development community, and some introspection yields the following: that we, as outsiders, tend to have different, more intrusive, ideas for the same problems abroad than we do at home suggests that while we are capable of conceptualizing the way that people in other countries behave, we are not finding solutions on their terms and trusting their capacity to change the intrinsic nature of their behavior; we instead assume that we know better than they do. Banerjee and Duflo defend these paternalistic tendencies abroad by stating that the poor are responsible for too many aspects of their lives. They argue that the poor deserve the same comforts that we take for granted in the U.S., among them clean running water, clean streets, and widespread immunization. The right to health is indisputable. However, there are two differences: (1) our decisions to pass minimum water safety measures and to submit ourselves to required immunizations came from within our communities, whereas we do not have the same trust in the ability of communities abroad to decide on these issues on their own terms, and (2) minimum water quality and immunizations are but small technocratic components of a larger array of public health initiatives that can be effected with community participation and consent rather than paternalistic incentive structures.

As is the risk with any outsider looking into these communities, we instead tie our offers of aid to our own normative beliefs. This is not to say that the United States is a stranger to paternalism or technocracy in its domestic welfare programs (Mead 1998). Referring back to the problem of obesity in the U.S., the previously mentioned bans on unhealthy foods can be considered paternalistic, especially if such bans originate from a socio-economic class that is wealthier than the poorer classes that they most

affect. Relying on education places some amount of trust in the agency of the people expected to change their behavior. Nonetheless, the United States does not limit itself to paternalism and technocracy in improving public health and food security and relieving poverty.

This returns us to the original point of the limitations that the framing of a question places on its solution space: reduction of a complex problem like poverty to a specific question supposes particular normative beliefs and a finite set of possible answers—limits that are not often aired when the answers to these questions are presented. Banerjee and Duflo's focus on calories is already a reduction of the concept of food security, which (as described in Chapter 1) the Food and Agriculture Organization of the United Nations defines as "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle"(Food and Agriculture Organization of the United Nations, 2003). In focusing primarily on calories and looking toward technocratic solutions, Banerjee and Duflo omit attention to food preferences and the nature of economic access, two areas that are consequential to the proposed solution of introducing new crops to the market and integral components of the FAO definition of food security.

It is important to note, however, that Banerjee and Duflo are not trying to find comprehensive solutions to any of the problems in poverty; they recognize the value of these experiments in improving "institutions and policy at the margin. Careful understanding of the motivations and the constraints of everyone. . . can lead to policies and institutions that are better designed, and less likely to be perverted by corruption or

dereliction of duty" (Banerjee and Duflo, 2011)[19]. There is great value in determining the relationship between various economic variables, related incentives, and proxies for poverty alleviation, at all geographic scales, but the extent to which these studies provide the unequivocal solutions to the problem of poverty that they claim to at their respective scales is unclear. Sachs, Easterly, and Banerjee and Duflo are all development economists who seek to ameliorate global poverty, and in spite of their differences in conclusions and geographic scales, their work is predicated on the same normative argument of global social justice—that the fortunate have a responsibility to come to the aid of the poor in some capacity. The underlying normative arguments of their research questions further constrain the array of possible solutions (i.e. interventions should be technological, or direct monetary aid to developing country governments is a viable instrument of development). Easterly, Sachs, Duflo, and Banerjee's inquiries are based upon analyzing and using market-based approaches to bring about social justice through the elimination of extreme poverty.

2.4 Framework-building as an alternative

In *The Idea of Justice*, Amartya Sen offers this comment on basing assessments of justice and subsequent policies on economic metrics: "the economic procedure of national income aggregation draws only on information about what was bought and sold at what prices, and nothing else... But for an adequate understanding of the demands of justice, the needs of social organization and institutions, and the satisfactory making of public policies, we have to seek much more information and scrutinized evidence[20]." This statement can be extended to the relationship between normative ideals and any

[19] p. 264
[20] p. 94

broad quantitative measure—the exclusive use of numerical data cannot capture everything about how the milieu of local institutions affecting poverty works and should work. The selection of the numerical data, itself, already sets a normative basis. Sachs and Easterly examine aid because they believe that the amounts of aid provided should affect the poverty level of the recipient nation, and Banerjee and Duflo are focused on nutrition-levels and caloric-intake because they assume that food security should be defined by biological sufficiency, rather than local food preferences or the sustainability of the food source. Aside from their common inclusion in definitions of food security, local food preferences and sustainability are arguably integral to the concept of food security, given the enormous interpersonal diversity of humanity (Sen, 2009, 1995) and the challenges of climate change and non-renewable resource depletion, respectively.

If treating the problem of poverty suffers from its reduction to a single research question comprising unexplored normative arguments and value-laden quantitative measures, then an improved alternative approach to poverty alleviation may be to first construct a framework for understanding its various mechanisms and elements. By analyzing issues of international development with the objective of building a framework—but not necessarily finding a singular solution—the researcher retains the flexibility to account for the broader social, behavioral, and institutional context of a particular issue in international development. Such an approach engenders explanations of fundamental assumptions and the multiple possible exceptions and caveats. This proclivity of framework-building is evident, at times explicitly, in Elinor Ostrom, Amartya Sen, and Judith Tendler's studies.

2.5 Fixing a problem or averting failure

Another marked and perhaps more philosophical difference between the approach of seeking a singular research question and that of framework-building appears to be the nature of the data used: the former is motivated by a series of failed outcomes—poverty—that require novel solutions for their elimination, while the latter is equally interested in both these failed outcomes and less conspicuous situations in which such failed outcomes have been averted.

2.5.1 Elinor Ostrom and the tragedy of the commons

Ostrom introduces her analysis in contrast to the plethora of articles focusing on failures in the collective conservation of common pool resources (CPRs)—i.e. a shared aquifer, a community pasture, the stocks of cod in the ocean—and she removes from obscurity the abundance of research analyzing successful collective conservation of these CPRs. Ostrom aims to explain CPR conservation outcomes that do not follow Garrett Hardin's tragedy of the commons, a model defined by actors that derive direct benefit from the resource and experience only a share of the costs, therefore facing no clear incentive to conserve it. Hardin's 'tragedy of the commons' is a frequently employed metaphor for the depletion of environmental resources, though it has been applied to scenarios as diverse as the organization of the Mormon Church and the Sahelian famines of the 1970s (Ostrom, 1990)[21]. As Ostrom explains, a second related model for the inevitable failures of CPR conservation is that of the prisoner's dilemma—that in a situation where two prisoners given the option to cooperate or defect, in which defecting will always lead to at least as good an individual outcome as that for the other

[21] p. 2

prisoner, the rational choice is to defect, even if cooperating when the other prisoner cooperates will lead to greater benefit for both prisoners in total. This model has long fascinated economists, says Ostrom, due to the seeming paradox that "individually rational strategies lead to collectively irrational outcomes"(Ostrom, 1990)[22].

For Ostrom, however, the march of the commons toward ruin is neither inexorable nor analogous to incarceration, and she seeks to reframe the research around CPRs from one of why CPR management fails to the question of how it might succeed. The focus on failure in the 'tragedy of the commons' and prisoner's dilemma models frequently lead to solutions of privatization or placing these resources under a central authority, two methods of resource allocation that assume that the actors have no agency and will always act purely to maximize their individual benefit; Ostrom states that these solutions are not exclusive: "a competitive market—the epitome of private institutions—is itself a public good,"and would require a central authority to maintain (Ostrom, 1990)[23]. The other basic assumptions of the prisoner's dilemma and 'tragedy of the commons' models do not hold for all real-life CPRs. Both models assume that (1) the actors do not communicate and (2) there are no within-community institutions, other than central authority or privatization, available to govern the management of the CPR. Ostrom finds that, across hundreds of examples of successfully maintained CPRs, neither of these assumptions is appropriate. Furthermore, assuming that actors are bereft of agency, communication, and the ability to form their own institutions leads to policies that do not credit these capacities when they can very well exist:

"The prisoners in the famous dilemma cannot change the constraints imposed on

[22]p. 5
[23]p. 15

them by the district attorney; they are in jail. Not all users of natural resources are similarly incapable of changing their constraints. As long as individuals are viewed as prisoners, policy prescriptions will address this metaphor. I would rather address the question of how to enhance the capabilities of those involved to change the constraining rules of the game to lead to outcomes other than remorseless tragedies"(Ostrom, 1990)[24].

In addition to prefacing her own inquiry with an assessment of existing theories and the limitations of their assumptions and data selection, she is explicit about the normative basis of her analysis—that she "would rather address the question of how to enhance the capabilities of those involved to change the constraining rules of the game"(Ostrom, 1990)[25]. Her normative presumption is that appropriators of a CPR should have the potential to successfully manage and conserve it. Ostrom's take on the capabilities of actors in defining the terms of their situation is a sharp contrast to Banerjee and Duflo's defense of paternalism in seeking solutions to poverty. Banerjee and Duflo assume that the poor have too much to worry about to choose the best outcome for themselves and therefore require a central authority to reorganize the incentives for the greater common good. Here, the concept that the poor do not have the brain-space to make informed public health decisions is functionally equivalent to one suggesting that the poor have no agency and are incapable of deciding their lives without the help of external actors.

[24] p. 7
[25] p. 7

2.5.2 Internal actions or external forces

A more subtle difference emerges here—while Ostrom distinguishes internal within-community actions from external forces in determining CPR management outcomes, Banerjee and Duflo, in *Poor Economics*, only ever discuss the external forces, omitting situations of successful poverty alleviation that result from actions originating within the community. To Banerjee and Duflo, poverty is a problem, a set of constant parameters with "accessible solutions"(Banerjee and Duflo, 2011)[26]. Considering poverty as a problem with a solution rather than one possible state among many is analogous to believing the central dilemma of CPRs to be the 'tragedy of the commons,' itself, rather than the conservation of the commons. A focus on the 'tragedy of the commons' as the problem to be solved would not have allowed for attention to the ways that such tragedies have been averted and more generally, processes through which CPRs have been conserved. Similarly, treating poverty as an extant problem ignores situations where it has been avoided or alleviated through community-borne institutions. The same mechanisms for preventing or internally reforming poverty can arguably inform efforts to alleviate it as an external actor.

Ostrom shows interest in these instances of internal institution-building, and she demonstrates that the agency and capabilities of actors in CPRs are instrumental to producing the observed successes in the conservation of commons. Ostrom decomposes the problem of CPR conservation into a framework that addresses three main issues: "(1) the problem of supplying a new set of institutions, (2) the problem of making credible commitments, and (3) the problem of mutual monitoring;" these three issues are addressed in a set of design principles that successfully managed CPRs tend to

[26] p. 6

share (Ostrom, 1990)[27]. Among these principles are that the resource have clearly defined boundaries with known appropriators, that there is a collective-choice agreement that appropriators can modify, that monitors are accountable to appropriators or are appropriators themselves, that there is some recognition of the right to organize without being challenged by external governmental authorities, and that there are graduated sanctions and a conflict-resolution mechanism (Ostrom, 1990)[28]. In contrast to Easterly, Sachs, Banerjee and Duflo's theories, none of these principles can be characterized solely through quantitative measures, and their plurality cannot be captured by a narrow question seeking a single driver of common pool resource conservation. Each of these principles was arrived at through assessing qualitative variables among multiple case studies and consideration of the variety of motivators and checks for CPR conservation. This is not, by any means, a dismissal of the enormous value of quantitative analyses; it is a critique of the inappropriate reduction of a complex multifactorial situation into a single relationship between two quantitative variables—without acknowledgement of the other variables.

In contrast to the reduction of explanatory data and subsequent solution space by initially isolating a single independent variable and specific dependent phenomenon, starting an inquiry with a more expansive question, as Ostrom does, can also increase the precision of subsequent research questions, without detracting from their combined capacity to explain outcomes. Ostrom, for example, further decomposes the question of how CPRs can be managed into (1) the process of creating the institutions to manage a CPR and (2) the mechanisms governing the continued success of CPR management. In the initial case studies, Ostrom's focus is on continuing successful

[27] p. 42,90
[28] p. 90

CPRs, whose possibly fraught processes of origin are unknown. At that point, she clarifies that, for these early case studies, "we do not know who originated or opposed various proposals or anything about the process of change itself"(Ostrom, 1990)[29]. As she explains, supplying the institutions necessary to conserve a CPR is subject to a set of incentives that are different from those incentives that govern actors already operating within an institution that sustainably manages the CPR, and she decouples these two dilemmas—that of conserving the resource and that of creating the institution to govern conservation of that resource—through an analysis of the successful management of groundwater basins in the Los Angeles metropolitan area (Ostrom, 1990)[30]. In spite of having "a dominant strategy to pump as much water as is privately profitable and to ignore the long-term consequences on water levels and quality,"the groundwater pumpers in the case study of the Los Angeles-area water basins incrementally created a CPR-governing institution through steps with low individual costs:

"These groundwater pumpers invested heavily in the supply of institutions. They created new private associations. They paid for costly litigation to allocate water rights. They drafted legislation, had it introduced to the state legislature, and gained sufficient support from other water enterprises to get the legislation passed. They created special districts to tax all the water they withdrew from the basins, as well as the property overlying the area. They spent seemingly endless hours informing themselves about the structures of their basins, the various concerns and intentions of all parties, and future possibilities"(Ostrom, 1990)[31].

The actions taken by these pumpers are not explicable through stylized models

[29] p. 103
[30] p. 137
[31] p. 137

with single actions that resolve a problem; rather their incremental nature only becomes treatable, perhaps even visible, through Ostrom's inquiry into the conservation of CPRs (rather than only examining situations in which tragedies of commons have transpired) and the subsequent distinction between the two questions of how CPR management begins and how it is sustained.

2.5.3 Judith Tendler and leveling polarized perspectives

However, the framework and replicable set of design principles are not crucial for raising the visibility of institutions in CPR conservation or any other type of development scenario. There is already value derived from detailed attention paid to the role of internal action and internal institutions, whether in CPR conservation, economic development, or improvements to public health. As discussed earlier, a nation-level model of economic development cannot be expected to explain the activity at a smaller geographic scale, but the absence of such generalizability does not preclude the value of that model in explaining activity at the scale at which it was originally devised. Ostrom is clear that her conclusions have not been shown to hold for larger geographic scales, particularly in terms of replicating the successes of the Los Angeles water basin management case study: "what worked as an incremental bottom-up strategy at the basin level did not work when attempted at the regional level"(Ostrom, 1990)[32]. In addition, the detailed functioning of institutions can sometimes be overlooked in an analysis aiming to generalize across multiple scales and case studies. Judith Tendler, in *Good Government in the Tropics*, analyzes four case studies to show that such details of institutional governance can run counter to mainstream development thought, in part to show that polarized considerations—i.e. 'public institutions are full of rent-seeking

[32] p. 210

employees' and 'NGOs are good'—do not always explain observed governance.

She prefaces her analysis by detailing the prejudices of the mainstream development community against the public sector, characterized by "the disappointing inability of many governments to deliver good public services and to cope with persistent problems of corruption, poverty, and macroeconomic mismanagement"(Tendler, 1997)[33]. Tendler explains that these findings reflect the tendency of researchers to discriminate for failed development initiatives rather than even-handedly analyzing development scenarios of a range of success levels. Her critique is not unlike Ostrom's comment that the majority of existing literature on CPR management had described only the tragedies of commons that had transpired, omitting CPRs that had been successfully managed:

"The mainstream donor community's advice about public sector reform arises from a literature that looked mainly at poor performance. Although this literature has advanced our understanding of why governments often do badly, it has provided nowhere near the same insights and case material on the circumstances under which governments perform well. This means that countries and the experts that advise them have few models of good government that are grounded in these countries' own experiences." (Tendler, 1997)[34]

Tender and Ostrom's works are as much analyses of specific development issues as they are incisive commentary on the shortcomings of existing research methodology in economic development, and their critiques encompass both the inadequate selection

[33] p. 1
[34] p. 2

of data and the inapplicability of models at different scales and with different sets of fixed parameters. Like Ostrom's complaint about an overemphasis on the solution of privatization as the best way to deflect a 'tragedy of the commons,' Tendler decries the mainstream development community's "strong belief in the superiority of the market mechanism for solving many problems of government, economic stagnation, and poverty"(Tendler, 1997)[35]. Tendler's analysis is instead about the cultivated trust and other social feedbacks that accompanied good governance in agricultural extension, drought relief and other rural development projects, in which centralized governance engendered good local decision-making, rather than one uniformly eclipsing the other in positive performance (Tendler, 1997)[36]. In particular, she finds that worker-satisfaction and worker-client relationships, though frequently dismissed as constants in economic analysis (constant in the sense that workers are believed to be invariably self-interested and rent-seeking), prove to be powerful determinants of the success of institutions of governance and of greater significance than the usual demarcations of public and private sectors, central and local government, and the prescribed duties of specific jobs.

As in Ostrom's work, Tendler's analysis is trained on the internal functioning of institutions, rather "than to the matter of outside pressures to perform,"which Tendler states have been thoroughly scrutinized in existing development literature (Tendler, 1997)[37]. In summarizing the effects of local circumstances on good governance, Tendler notes that "whether local elites will be public-minded or mean-spirited depends on the political, social, and economic dynamics of each particular locale. Decentralization and increased consumer sovereignty, in other words, may sometimes lead to better and

[35] p. 4
[36] p. 68
[37] p. 20

fairer government service provisions, but not always"(Tendler, 1997)[38]. Neither Tendler nor Ostrom is intent on extracting unequivocal rules for good governance, whether of a development initiative or a CPR. Rather, they characterize the commonly ignored conditions of successful governance while understanding that other variables can always interfere with the observed relationship between any two variables. Although Tendler does not explicitly name a framework of analysis for good governance through the four case studies, her method of inquiry yields an implied framework for connecting the variables of worker-satisfaction and worker-client relationships to quality of governance in development.

2.6 Amartya Sen and the mechanisms of famine

Like Ostrom and Tendler, Amartya Sen embarks on an inward search for the convergence of multiple mechanisms that may precipitate famine. In *Poverty and Famines: An Essay on Entitlement and Deprivation* and his work with Jean Drèze in *Hunger and Public Action,* Sen seeks to nuance the connection between level of food supply and famine, questioning the commonly held belief that a sudden decline in the former directly causes the latter (a hypothesis titled food availability decline, or FAD). Sen, too, uses case studies of famines in Africa and India to illustrate that deaths from famine were more clearly a function of what he terms exchange-entitlements than overall food supply. Specifically, Sen defines exchange-entitlements as the full set of resources a person can acquire by exchanging things that he or she owns—inclusive of 'labor power'—and these exchange-entitlements define the totality of a person's access to food.

[38] p. 69

That is, the degree of suffering endured by one individual during a famine is less dependent on the amount of food that is available in a region at a particular point in time than on the nature of an individual's access to that food. In discussing this proposed mechanism, Sen echoes Ostrom and Tendler's criticism of the theoretical belief in the power of the market mechanism in correcting or averting famines: "Adam Smith's proposition is, in fact, concerned with efficiency in meeting a market demand, but it says nothing on meeting a need that has not been translated into effective demand because of lack of market based entitlement and shortage of purchasing power. . . Market demands are not reflections of biological needs or psychological desires, but choices based on exchange entitlement relations. If one doesn't have much to exchange, one can't demand very much, and may thus lose out in competition with others whose needs may be a good deal less acute, but whose entitlements are stronger"(Sen, 1981)[39]. This work, like those of Ostrom and Tendler, is as much a positing of alternative causal mechanisms in famine and, more generally, access to food as it is a critique of the methodological limitations of earlier work: "But what emerges irresistibly from the preceding analysis is the danger of concentrating only on the aggregative issues, overlooking the details of the entitlement system on which the survival of millions of Bangladeshi people crucially depends. The focus on population and food supply would have been innocuous but for what it does to hide the realities that determine who can command how much food"(Sen, 1981)[40].

[39] p. 161
[40] p. 150

2.7 A "family of models" as a research lens

I will return to detailed discussion of Sen's framework in Chapters 4 and 7, as it relates to food security and livelihood. It is worth noting that Ostrom and Sen conclude their works with critiques of research methodology of preceding research in their respective areas. They are also both deliberate in their choice to use a framework-building approach rather "than one particular hypothesis about their causation"(Sen, 1981)[41]. Ostrom explains this at length:

"The reason for presenting this complex array of variables as framework rather than as a model is precisely because one cannot encompass (at least with current methods) this degree of complexity within a single model. When one chooses to model relationships, one can include only a subset of variables, and even then it is usually necessary to set some of these equal to zero or to an absolute value. The typical assumptions of complete information, independent action, perfect symmetry or interests, no human error, no norms of reciprocity, zero monitoring and enforcement costs, and no capacity to transform the situation itself will lead to highly particularized models, not universal theories. It is as essential to map the terrain for a family of models as it is to develop specific models"(Ostrom, 1990)[42].

I open this work with this discussion of research methodology in development literature in order to explain my approach to the problem of food security given the growing challenges of climate change. Like the questions of good governance and common pool resource conservation, the multifaceted nature of food security, given the separate but interrelated issues of food access, sustainability, and fulfillment of food preferences, is

[41] p. 162
[42] p. 124

better treated through a framework for a "family of models," than reduced to a simpler question of an isolated causal mechanism (Ostrom, 1990)[43]. Furthermore, food security is governed by community-level institutions, which cannot be understood solely through larger-scale variables. As Sen demonstrates, food supply is separated from food security by several intervening variables that influence individual access to food, and as the preceding discussion has revealed, isolating the scope of research to only two variables can lead not only to correlations that are spuriously mistaken to indicate causation but also to unexplored normative assumptions.

While my research began by examining perceptions of weather patterns and cropping decisions, I soon realized that it was unreasonable to expect cropping decisions to only reflect perceptions of weather patterns. Furthermore, this relationship alone revealed very little about the interaction between climate change perceptions and local food security, as the latter is in large part influenced by India's Public Distribution System (PDS). In the next two chapters, I first discuss the history of the Indian PDS and its present-day role, and I then construct a framework for analyzing food security with respect to issues of sustainability and local preferences.

[43] p. 214

Chapter 3

The Public Distribution System in India

3.1 Introduction

Every village in rural India can identify the specific week that they expect the monsoon to arrive or 'break.' In the Indian state of Jharkhand, smallholder farmers interpret the tardiness and strength of the monsoon or, in its absence, the ferocity of the drought in terms of the number of months they will spend hungry. Left alone, crop failure from drought not only "reduce[s] food availability in the affected region, but also (more importantly)... shatter[s] the rural economy" (Drèze, 1988). The panic-driven rises in food prices and reduction in agricultural labor employment coincide to restrict access to food by landless laborers and artisanal tradesmen, often leaving them the first victims of famine, whether or not actual aggregate food supplies are insufficient (Sen, 1981). In these famines, vulnerability results from the decline in an individual's command over resources that can be exchanged for food, their "exchange-entitlements," (i.e. labor and other saleable assets) rather than the immediate reduction in food supply (Sen,

1981). In contrast to chronic hunger, famines are defined by the "acute starvation and a sharp increase of mortality" that result from the reduction of exchange-entitlements brought on by droughts and ensuing crop failure (Drèze and Sen, 1989).

Famines plagued British-administered India throughout the 19th century, leading to deaths that climbed into the millions (Drèze, 1988). Repeated famines—with their calamitous loss of human life, the recurring correspondences between high food prices and starvation, and the consistent inadequacy of ad-hoc famine relief—precipitated the 1880 British Famine Codes, which prescribed localized relief measures to stem the tide of casualties. These policies relied less on the direct distribution of food, instead advocating public works programs that paid subsistence wages. Drèze (1988) suggests that this reticence in direct food provision resulted from an ideological aversion to interference with private trade (the free market) and the belief that gratuitous doles would corrupt the moral economy of starving famine victims.

3.2 From wartime rationing to a Public Distribution System

During World War II, rationing of grains and price control measures were used to combat food scarcity in urban areas. The 1943 Bengal Famine, with an estimated three million deaths, further sped the expansion of rationing, and Sen (1981) found that most of the casualties occurred in the rural countryside where such rationing was absent and related exchange-entitlements were the most meager (Swaminathan, 2000). After rationing was made permanent during the 1960s, in reaction to major crop fail-

ures during 1965-66 and 1966-67, it has persisted and grown as the Public Distribution System (PDS) (Swaminathan, 2000; Ganesh-Kumar et al., 2007). The PDS graduated from depending on frequently-delayed grain imports from the United States to relying on domestic production as buffer stocks grew from the late 1970s through 1991 (Drèze, 1988; Swaminathan, 2000; Shankar, 2004). The reach of the PDS waxed with the onset of crop failures, with grain distribution rising from 1.74 million tons to 2.33 million tons during the severe drought of 1972-3 in Maharashtra (see Jean Drèze and Amartya Sen's *Hunger and Public Action* for detailed discussion of the role of public action in averting famines and alleviating hunger).

Since Indian Independence from the British in 1943, however, these massive droughts and subsequent crop failures have not resulted in the same magnitude of losses that characterized 19th century famines of British India, in part due to "the open journalism and adversarial politics" and consequently responsive famine relief measures and the PDS (Drèze, 1988; Drèze and Sen, 1989). Nonetheless, these droughts have left severe nutritional damage and catastrophic livelihood losses in their wake. Hunger and malnutrition remain persistent problems in 21st century India: there are an estimated 230 million hungry people among India's population of 1.2 billion (Food and Agriculture Organization of the United Nations, 2012).

The PDS has historically aimed to keep food prices stable, provide rations during scarcity, alleviate poverty, and moderate trade in private commodities (Swaminathan, 2000; Ganesh-Kumar et al., 2007). Although the development of the PDS was spurred by periodic famines, it is a mainstay in alleviating chronic hunger by providing, in theory, dependable and regular access to grains. Sen (1981) states that solving the dual problems of chronic hunger and famine will entail "not ensuring food availabil-

ity, but guaranteeing food entitlement," a need that the PDS is intended to meet. Since the mid-1960s, the Food Corporation of India (FCI) has centrally administered the PDS and is responsible for guarantee of "minimum support prices" (MSP) for grain, procurement of commodities from farmers and for grain storage, transportation, and distribution to state governments, who pay a uniform "central issue price" (CIP) (Swaminathan, 2000; Kochar, 2005; Bhattacharyya and Rana, 2008). These "minimum support prices" reduce the risk borne by farmers in cultivating wheat and rice—they know that they will have a buyer at a previously guaranteed price at the end of the season. Each Indian state purchases these commodities from the FCI and independently administers distribution (Swaminathan, 2000). At the local level, PDS commodities are made available at heavily subsidized prices through Fair Price Shops, privately-run distribution centers with government-defined commissions and prices (Swaminathan, 2000; Khera, 2011b).

PDS commodities principally comprise rice and wheat, though they included kerosene, edible oil, and sugar (Swaminathan, 2000; Khera, 2011b). I refer to the commodities received by a PDS household as their entitlements. Recently, however, some states have supplemented these rations with legumes, or *daal* (Khera, 2011b). Due the degree to which states determine the terms of their PDS, there is tremendous variation between the entitlements provided and the populations reached by each state PDS (Bhattacharyya and Rana, 2008). For example, Tamil Nadu and Himachal Pradesh have made their PDSs universal—that is, accessible to anyone regardless of income. Other states further raise the grain subsidy provided to households or provide additional commodities; in particular, Jharkhand provides rice at one rupee per kilogram (Khera, 2011b). The monthly provisions can be substantial, the difference between extreme hunger and the ability to work as a day laborer. Across Indian states, the av-

erage BPL family of four receives on 27 kilograms of grain each month (Khera, 2011b). In their survey of BPL households, Khera (2011b) found that households were, on average less than three kilometers from their nearest FPS, and the average distance in some states was well under one kilometer.

The PDS has undergone major policy shifts over the past twenty years. These include the transition to building buffer stocks of grain, while reducing distribution since 1991 and the revision of the PDS as the Revamped Public Distribution System (RPDS) in 1992, which extended the reach of the PDS to drought-prone, desert and tribal areas (Bhalotra 2002). In 1997, targeting of the PDS was introduced (officially, the Targeted Public Distribution System replaced the RPDS), which formally limited the distribution of grain to only those below the poverty line (BPL) with the goal of reducing expenditures, and the subsidy differences between BPL recipients and those above the poverty line (APL) began to grow, with APL food prices becoming similar to market prices (Swaminathan, 2000; Bhattacharyya and Rana, 2008). Furthermore, in 2000, all non-BPL families were essentially receiving no subsidy on their grains (Bhalotra, 2002). However, over the last decade, TPDS has moved toward universalization, with the APL subsidies having risen far enough to reduce the prices of APL grain from the PDS far below the market cost (Khera, 2011b).

It is important to distinguish between the effects of targeting as a stable mechanism and the effects of transitioning from a nearly universal system to a targeting one. Swaminathan (2000) decried the severe reduction in distribution of grain to the needy as a result of the transition to targeting, whereas Khera (2011b) has pointed out that the 1997 transition to targeting (formally, the Targeted Public Distribution System) significantly reduced the income of FPS owners by decreasing their customer

base and their commission, therefore heightening the incentive to steal. Swaminathan (2000) and Khera (2011b) present two different perspectives on the same problem that the subsidy provided per household served has increased while reducing the number of needy people who are served. However, Khera (2011b) suggested that the revision of FPS commission rates upward as well as the expanding customer base brought on by state transitions toward universalization over the past decade have contributed to reductions in corruption and increases in the number of the needy receiving their entitlements.

Bhattacharyya and Rana (2008), in analyzing the civil unrest toward PDS Fair Price Shop dealers in West Bengal, found that these dealers perhaps unfairly bore the brunt of protests and consequent monetary costs when grain market prices surged and caused more households to demand PDS rations from Fair Price Shops. Whether or not they steal, the dealers are constrained by the prices set by federal and state governments, and the structural problems against which people were protesting were not necessarily the fault of individual Fair Price Shop dealers; in the words of Bhattacharyya and Rana (2008): "Sixth, though the dealer is invariably the immediate target of public wrath in these incidents, most of them have little option other than indulging in corrupt practices due to many reasons, including the small margin of profit that they are expected to operate with. Moreover, they being just cogs in a larger wheel of numerous pilferages are compelled to conform to certain internal norms of transaction." This lays bare tangled institutional roots to problems incurred in both targeting of the PDS and endemic theft from the PDS. It is worth noting, however, that these protests manifest a crucial component of very extant public action in India—that of an active heterogeneous citizenry that acts as "an agent and not merely as a passive patient" in pursuing social security and justice, as Drèze and Sen (1989) denote.

3.3 Identifying need

Those entitled to PDS commodities are identified by state-issued ration cards that indicate whether they are BPL or APL. Lists noting BPL households are imperfect, inconsistent, and long outdated, often determined arbitrarily, further hindering transparency and hampering access by the neediest (Khera, 2011b; Sen, 1992). In addition, the costs of both administration for the state and participation for recipients rise with targeting (Swaminathan, 2000; Sen, 1992). Sen (1992) argues against the use of an income-based definition of poverty, stating that "it is important to see human beings not merely as recipients of income but as people attempting to live satisfactory lives and to see poverty not simply as low income but as the lack of real opportunities to have minimally adequate lives."

In *Poverty and Famines: An Essay on Entitlement and Deprivation*, Sen remarks that different measures of poverty present "alternative conceptions of poverty," rather than simply providing different quantities. In particular, Sen (1995) differentiates between assessing capabilities, primary goods, and achievement in judging poverty: an individual with lowered capability will need more primary goods to reach the same level of achievement as another individual with higher capability. Therefore, assessments of poverty cannot only account for those primary goods, inclusive of income, nor can they expect achievement levels to reflect the substantial differences in capabilities.

Adding to the gross imperfections in defining poverty through income (Sen, 1981, 1995, 2009), Swaminathan (2000) demonstrates that "the proportion of persons suffer-

ing deprivations in food and nutrition is higher than the proportion defined as being income-poor or below the poverty line." In a survey of public distribution systems in Mexico, Sri Lanka, Zambia, Jamaica, and Tunisia, Swaminathan (2000) shows that targeting and the functional reduction in food subsidies, at the advice of the International Monetary Fund to reduce federal budget deficits, have invariably reduced welfare access by the neediest, in spite of the explicit intent to ensure their access (Swaminathan, 2000; Sen, 1992). Inadequate infrastructure for identification and the underlying motive to reduce total supply simply increase the barriers to access as well as raise the incentives to cheat (Swaminathan, 2000). Sen (1992) also argues that targeting applies social stigma to accepting aid, reduces the quality of the benefits ("benefits for the poor end up being poor benefits"), and threatens the political support of the excluded upper classes for welfare programs, endangering the long-term viability of state-support for the most disadvantaged members of society.

3.3.1 Universal or targeted welfare

In addition to the clear challenges of identifying and reaching targeted recipients, the Indian PDS has historically been racked by theft at all levels of administration, from corrupt politicians stealing $14.5 billion worth of grain (Srivastava and MacAskill, 2012) to falsified ration cards and other forms of criminal leakage at ration shops (Khera, 2011a; Swaminathan, 2000). Venugopal (1992) explained that much of the PDS procurement subsidy went toward subsidizing the private market, as FCI-procured grain was sent to private flour mills whose output did not reenter the PDS. Although they are connected, these are distinct issues: (1) large-scale theft at the highest levels, (2) theft within the supply chain from the FCI to state government, (3) theft and overcharging at the Fair Price Shops, and (4) the general issue of whether or not intended recipients

receive their entitlements.

Whether the conundrum is 'to target or not to target' or how to staunch different levels of theft or 'leakage,' these issues can be broadly grouped into two categories, as explored by both Swaminathan (2000) and Sen (1995): errors of inclusion and errors of exclusion. The errors of inclusion are the acts of serving more people than intended, incurring financial costs. This can range from maliciously obtained inclusion (outright theft of grain) to the hazier 'inaccurate' designation of entitlements to a household that does not 'need' PDS provisions. The errors of exclusion are the inadequate provision of services and failing to reach the needy, thereby incurring welfare costs, possibly reducing financial expenditure, and perhaps falling short of the main welfare objectives of the PDS. A universal welfare system suffers from arguably more errors of inclusion, as the concern is that those who do not need welfare will be accessing it. A targeted welfare system excludes needy individuals and therefore creates many more errors of exclusion, although the greater incentive to cheat resulting from a more limited resource may generate errors of inclusion.

The choice between a universal welfare system and a targeted welfare system becomes a normative one: is it better to serve everyone, even the undeserving, at potentially higher financial cost or is it preferable to save money while possibly failing in the provision of welfare to all of the deserving? Sen (1992) provides support for the former, especially as the direct provision of grains rather than cash leads recipients to self-select: "These services typically cannot be shifted or sold, and are not of much use to a person unless he or she actually needs them. There is, thus, some built-in matching in such provisioning, which makes it more incentive-compatible than the transfer of generalized purchase power in the form of income." A universal welfare

system also does not depend on the aforementioned problematic distinctions between the deserving and the undeserving, and as touched upon earlier, the explicit administrative and implicit social costs of targeting can exceed the money saved by limiting the original subsidy, especially when scaled by the population actually reached by the welfare initiative and when accounting for the public health costs of an underserved disadvantaged population. Deciding between a targeted and universal welfare system therefore relies on being able to speak of welfare costs in terms of financial costs, and it is difficult to put a price on the former.

Nonetheless, studies of the PDS and its associated procurement of wheat and rice often interpret its actions primarily in terms of financial (i.e. Ganesh-Kumar et al. (2007) and Shankar (2004)) or welfare-based (i.e. Tarozzi (2005) and Kochar (2005)) cost-benefit analyses and do not reconcile the very different values implied by each; Tarozzi (2005) and Kochar (2005) use estimated calories as a proxy for welfare, whereas Ganesh-Kumar et al. (2007) and Shankar (2004) focus on the effective subsidy per household. In a purely financial calculation, one can conclude that a targeted PDS is the best way to achieve reduced financial burden and increased meeting of need, reasoning that the International Monetary Fund had used to recommend targeting for developing nations in the 1990s (Swaminathan, 2000).

3.3.2 Measuring welfare in dollars

Regarding the Indian PDS, Ganesh-Kumar et al. (2007) complained that "the dominance of the government, armed with a whole host of self-serving regulations and preferential access to credit and rail services, in the supply chain has inhibited private

sector participation in grain management in the state, even though available evidence points to the cost-efficiency of the latter." This statement is founded on the normative belief that efficiency is measured in dollars and profit margins and that government intervention only ever depresses these, strangling market forces that would otherwise further reduce income-inequality. The little weight given to welfare in their calculations barely registers in their mention of lowered income-inequality that theoretically results from market forces. Ganesh-Kumar et al. (2007) also suggested that the fierce historical famines of pre-Independence India would be rendered impossible with the availability of infrastructure in modern India, but not every village has proper transportation infrastructure, let alone any reasonable proximity to market centers, a fact demonstrated by Khera (2011b).

In all, Ganesh-Kumar et al. (2007) underestimated the extreme poverty that would prevent the needs of the poor from manifesting as economic demand and limit their exchange-entitlements during droughts and consequent crop failure; extreme weather events, such as droughts, are expected to only increase in frequency with climate change (Intergovernmental Panel on Climate Change, 2007). The effects of opening the PDS to private players are far more complicated than the theoretical reduced prices that Ganesh-Kumar et al. (2007) claim will result from consequently increased economic efficiency: Bhattacharyya and Rana (2008) note that the FCI is no longer the only major procurer of grain, as private companies such as Wal-mart, Monsanto, Reliance, and Mahindra have also begun to purchase this grain. This has, in turn, raised market prices and made government-offered minimum support prices less competitive. These higher prices for grain are a boon for these wheat and rice producers, but the subsequent higher government expenditures for grain procurement could be partially shifted to state governments who then bear the cost of providing nearly free grain for the

welfare of the poor. In all, financial expenditures are higher, but so are the increases in welfare conferred to both grain producers and recipients of PDS aid—at the expense of the Indian federal and state governments. Measuring the value of this aid entails comparing these financial expenditures with both the welfare of grain producers and that of those served by the PDS, a task that cannot be completed through a reduction to monetary sums. Specifically, private players may provide higher prices on average, but these private firms are unable to provide farmers with the financial and social security offered by non-volatile government minimum support prices against the risk of unpredictable adverse weather on their crops.

3.3.3 Grain, food stamps, or cash?

Further comparison between different types of state-provided amenities is also worthwhile: food stamps, cash, and direct food provision. The provision of cash aid subjects recipients to the volatility of local food prices and may in fact fuel the rise in food prices, as it allows otherwise-invisible biological need to manifest in economic demand for what is construed to be a scarce resource during times of drought (Sen, 1981; Suryanarayana, 1995). Swaminathan (2000) argues that neither cash aid nor provision of food stamps guarantees access to food, as they are both eroded by inflation and rising food prices, and the latter is further subject to the distrust that sellers may have for the government's ability to pay subsidies on their demanded price. For famines in particular, Sen (1981) remarked that, "no matter how a famine is caused, methods of breaking it call for a large supply of food in the public distribution system. This applies not only to organizing rationing and control, but also to undertaking work programmes and other methods of increasing purchasing power for those hit by shifts in exchange entitlements in a general inflationary situation." Sen (1981) acknowledges that this

may appear counterintuitive, in light of his argument that famines are precipitated by a reduction of exchange-entitlements rather than the decline in food availability, but it is sensible if the reduction in exchange-entitlements results from *perceptions* of impending food scarcity—immediate injection of food into the area that is at risk of famine can calm food prices by relieving these perceptions and projections of food shortage. It is similarly conceivable that dependable and regular weather-independent supplies of food to the area can preclude food price volatility and alleviate long-term starvation.

Khera (2011b) found that, when asked whether they would prefer direct cash subsidy rather than the grain provided through the PDS, over two-thirds of all respondents preferred food, and these respondents tended to be located farther away from bulk markets and infrastructure that would better facilitate their use of cash. Reasons given for preference for cash also related to the poor quality of grain provided and frustration with the corruption in the PDS (Khera, 2011b). These reasons suggest that the choice between food and cash is a matter of the quality and reliability of receiving the food; if those two factors are poor, then cash, described as a regular monthly bank account deposit, would appear preferable, even if the reality of implementing cash payments were improbable. Khera (2011b) concludes:

"The PDS performs a very useful role in ensuring food security for the rural poor in another important sense: it ensures a regular supply of food-grains even in the remotest parts of the country. As things stand, rural markets are under-developed and private markets seem to fail at the last mile in many areas."

Interstate comparisons show that the functioning of the PDS has been largely successful at meeting the needs of those on BPL lists, and basic improvements, inclusive

of publicized and transparent BPL lists, have limited the potential for leakage (Khera, 2011b). In addition, official BPL recipients in states with universal PDS were more likely to receive their full entitlement than those in states with more restrictive quotas, even though BPL recipients were the targeted group in all states (Khera, 2011b). The evidence presented by Khera (2011b), though confined to households on the targeted BPL list, supports the argument that universal welfare systems are possibly better equipped than targeted welfare systems to serve the most disadvantaged population, although a major confounding factor is the high relative poverty and comparatively limited infrastructure of states with targeted welfare systems. The apparent success of the PDS in delivering the promised entitlements to BPL households, as presented by Khera (2011b), suggests that the $14.5 billion theft of grain by politicians is a separate matter from the localized theft at Fair Price Shops. The latter might directly deprive a family of its entitlement while the influence of the former on whether a family receives its entitlement is much more challenging to trace. This is not meant to excuse the unethical thievery of grain by politicians but rather to suggest that the performance of the PDS system should be assessed at a variety of scales, rather than agglomerated into a single metric.

Furthermore, the fact that the great majority of surveyed BPL households in Khera (2011b) receive their entitlement demonstrates that the success of a welfare program cannot be judged purely by aggregate financial balances or solely at one scale. The preceding discussion illustrates that the PDS is unfairly cast as an irreparably corrupt government scheme, a characterization that is wholly believable when only examining large-scale variables: the rates of hunger and childhood malnutrition, the rates of grain spoilage and epic scale of grain theft (Swaminathan, 2011; Srivastava and MacAskill, 2012; Shankar, 2004). However, when judged against its normative goal of improving

rural food security at the household level and given the fact that financial and welfare goals not only require different metrics but require disparate conceptions of the problem of food security, the PDS appears at least functional. This is not intended to discount the severity of the problems of hunger and child malnutrition or the systematic injustices of exclusion and outright theft, but rather to demonstrate the difference between the conception of the PDS system as a welfare instrument that can be reformed and a financial expenditure that is inappropriate by the reckoning of aggregate statistics.

In addition to averting famines and ameliorating chronic hunger, the PDS has a second major objective of stabilizing food prices, given unpredictable environmental conditions—both through guaranteed procurement of commodities from farmers and the distribution of these commodities in rural areas. However, these are typically viewed as disparate objectives with different intended populations, even though they are easily linked. In one instance, Sen (1981) showed that food prices were intertwined with the overall picture of food security, as prices determined the value of exchange-entitlements. As a result, agriculturalists, whose entitlements comprised both the edible and saleable commodities, had lower vulnerability than those whose entitlements were purely monetary.

3.4 Effects of public welfare programs on livelihood choices

Given that the great majority of rural PDS recipients are farmers, they are capable of growing the food that they are interested in eating, and these preferences likely vary

by location. Khera (2011b) finds that PDS recipients would like grains such as *ragi* (finger millet) and other millets to be distributed through the PDS; these are grains that are grown in dry-land, rainfed agriculture and that have traditionally formed local diets. Barring difficulties in implementation, it is therefore conceivable that the population from which the PDS procures grain can be the same to which it distributes. Since a commodity that is provided at a very low price or for free will in turn reduce the market prices of substitutes (and perhaps eliminate their economic viability), a system that both procures and distributes within the same population would more meaningfully address the following immediate factors of the PDS:

(1) The foods grown and available in local agricultural markets
(2) The local preferences and conceptions of nutrition
(3) Local livelihoods and consequent exchange-entitlements

These three considerations are seldom treated in depth by current literature on the PDS, which envisions those served by the PDS more as welfare recipients than farmers who do produce some of their own food. Indeed, seeing them as welfare recipients is crucial to understanding the fulfillment of economic and social justice objectives by the PDS (Bhalotra, 2002; Bhattacharyya and Rana, 2008; Swaminathan, 2000; Kochar, 2005, 2008; Khera, 2011b). However, understanding their decision-making as farmers is also helpful for grasping the broader welfare effects of the PDS, as these effects can very well exacerbate the conditions of endemic hunger and poverty that the PDS has been developed to alleviate. Kochar (2008) points out the dearth of literature about the effect of welfare programs on the non-poor and on broader livelihood choices, and this can be extended to the absence of consideration of the effects of welfare programs on overall food security—the elements of sustainability of the food source, fulfillment of

preferences, and sufficiency of calories and nutrition. Livelihood support by the PDS is more frequently spoken of in terms of minimum support prices offered in procurement of PDS grain and the impeding of private market forces brought about by grain provision (Ganesh-Kumar et al., 2007; Umali-Deininger and Deininger, 2001), rather than the economic versatility afforded by the entitlements provided from the distribution of grain to rural households, an observation that Kochar (2008) makes.

In particular, not much has been discussed about the capacity of the PDS to facilitate income diversification—that is, if households worry less about meeting minimum food requirements, they can shift their attention from agricultural activities to other occupations, or simply diversify their agricultural activities toward cash crop production. Using the exchange-entitlements framework established in Sen's *Poverty and Famines,* Drèze and Sen (1989) remarked that such income diversification increases an individual's exchange-entitlements: "Durable elimination of vulnerability requires promotional policies such as the expansion of general prosperity, the reduction of insecurity through economic diversification, and the creation of secure earning arrangements."

However, "economic diversification" and "secure earning arrangements" should be contrasted with versions of economic diversification that simply shift the bulk of an individual's vulnerability from weather patterns onto similarly unpredictable local market forces, subsequently reducing exchange-entitlements relative to those that would have been derived from food crops. Sen (1981) provides the example of the effects of cash cropping during the Sahel famine—cash crops failed during the drought, but even the meager cash crop production was neither saleable nor suitable for meeting caloric needs in a substantial way, whereas edible food crops would have at least comprised some direct food source or entitlements, independent of the market. In addition, the

storage of food crops from the preceding year's harvest would equip farmers better than would an inedible cash crop. Fruits and vegetables, when considered in terms of shelf life and storage may as well be categorized as inedible cash crops, whereas grains can be stored over the course of months. More generally, these dynamics suggest that additional work is necessary to understand the influence of the PDS on crop production choices and the associated effects on livelihoods.

The beginning of this discussion of the PDS emphasizes its development as a buffer against the ravaging effects of drought-precipitated famines, in particular the Bengal Famine of 1943. Droughts are unpredictable extreme weather events that are predicted to grow more frequent with climate change (Intergovernmental Panel on Climate Change, 2007). When examined with respect to its founding purpose, the PDS becomes a welfare program that is a safety net for populations with food supplies that are vulnerable to adverse weather effects. Given the host of environmental effects expected from climate change and the concerns about sustainable use of agricultural resources, it is necessary to include consideration of the PDS in any analysis of the effects of changing climate on agriculture and subsequent food security. In the next chapter, I describe a framework for understanding the effects of smallholder farmers' perceptions of weather patterns on local food security, accounting for the ways in which farmers' cropping patterns may interact with the presence of a grain distribution system, such as the Indian PDS.

Chapter 4

A Framework for Food Security among Smallholder Farmers

In exploring major theories of international development in Chapter 2, I argued that examining a development issue as a framework with multiple mechanisms rather than as a clearly defined problem with a limited number of solutions allowed for a more comprehensive understanding of the issue and a broader solution space. In Chapter 3, I showed that the Indian Public Distribution System has been developed with the objectives of allowing rural populations to cope with adverse weather and of generally raising their welfare and alleviating poverty by providing a reliable grain supply. The costs of the Indian Public Distribution System can therefore be measured both financially and in terms of welfare and social justice, and its effects beyond the level of caloric provision to its influences on agricultural and subsequent livelihood choices have thus far seldom been studied. Building upon the consideration of smallholder farmers as both welfare recipients and agents, I also argue that the PDS is a crucial component of smallholder farmer food security–in terms of both the foods that they receive and the crops that they choose to cultivate.

4.1 Background

In this chapter, I outline a framework for interpreting the perceptions of changing weather patterns on rural smallholder food security. Smallholder farmers are defined as those who cultivate less than two hectares of land. In particular, I treat smallholder farmers as subsistence-level farmers, defining them both generally as agricultural populations that are at risk of malnutrition and hunger, whether or not they obtain all of their calories from their own cultivation. As Drèze and Sen (1989) discuss, the common economic diversification of subsistence-level agriculturalists is often underappreciated—a farmer may grow cash crops if they find the income derived more valuable for obtaining food than if they were to dedicate the same resources to cultivating their own food. I also include the influence of government grain distribution programs, such as the Indian Public Distribution System. Swaminathan (2000) has described the welfare effects of these systems in several nations, and I expect them to be relevant for various contexts as grain distribution is a common tool for famine relief and prevention as well as long-term poverty and hunger alleviation.

In presenting this framework, I first define the desirable outcomes of a system of public grain distribution, those of smallholder agriculture production, the tenets of food security, and the goals of agricultural sustainability. These listed desirable outcomes are deduced from a wide range of work that includes environmental science and justice literature, food systems frameworks (i.e. Ericksen (2008), Hammond and Dubé (2012)) and literature from inter-governmental organizations that frame internationally agreed-upon goals for development (i.e. the Food and Agriculture Organization

of the United Nations, the Commission on Sustainable Development). For example, I define agricultural sustainability with respect to the general definition of sustainable development provided in the World Commission on Environment and Development's 1987 report, *Our Common Future*: "development which meets the needs of the present without compromising the ability of the future generations to meet their needs" (on Environment and Development, 1987).

Each action within the framework established below can then be judged according to the way it fulfills these at-times conflicting goals. For example, a chosen cultivation method or crop type may be a poor choice in terms of sustainability, but it may fulfill local preferences and perceptions of nutrition. Each actor, whether they are a smallholder farmer or government policymaker, may rank the importance of these objectives differently, perhaps even having other objectives entirely.

I then describe three major categories of variables and their possible range of mechanisms in achieving the named goals: a system of public grain procurement and distribution, the adverse weather patterns that are becoming more common with changing climate, and smallholder farmer decisions. The effects of these described mechanisms may be better understood once qualified by the listed desirable outcomes. In order to link income-generating activities and agricultural production for household consumption to local food security, I apply Sen's exchange-entitlements framework, which considers the vector of commodities that are food or that can be exchanged for food (Sen, 1981). Other than edible food, these commodities may include cash, labor, and goods. In *Poverty and Famines* and in *Hunger and Public Action* with Jean Drèze, this framework is primarily applied to famines, "acute starvation and sharp increase in mortality," brought about by the reduction in an individual's exchange-entitlements

during times of drought and subsequent crop failure. Drèze and Sen (1989) posit that solving endemic hunger depends on an individual's long-term capability in avoiding undernourishment, in contrast to the much clearer solutions to famines, which chiefly comprise increasing an individual's exchange-entitlements during that brief temporal window of acute deprivation.

To nuance the difference between capabilities and exchange-entitlements, Drèze and Sen (1989) provide an example of a pregnant mother possessing different capability than an adult male in utilizing the same amount of calories; she will require more calories and nutrients to achieve the same level of functioning because she and the adult male have different capabilities of utilizing that nutrition. Capability, as Drèze and Sen (1989) explain, is as much a function of access to food (as continued access to food can improve one's nutrition and health capability) as it is influenced by other forms of public action and provisioning, inclusive of education and health services. These can further facilitate utilization of food and other primary goods; a mother educated about iodine deficiencies and the individual-level and community-wide benefits of herd immunity has greater capability to take advantage of resources for her child than she would without this education. According to Drèze and Sen (1989), avoiding endemic hunger therefore involves increasing both capability and raising individual exchange-entitlements, both of which can be strengthened through public action that includes programs such as the Indian Public Distribution System. These are two factors of social welfare that I elaborate on in Chapter 7, in the discussion of the findings.

In addition to ensuring social welfare, solving endemic hunger among smallholder farmers also requires consideration of agricultural sustainability, which is tied to capability, exchange-entitlements, and overall social welfare. Agricultural sustainability is,

most explicitly, the ability of agricultural production to be sustained into the future with present methods of cultivation and given its interaction with environmental conditions. Such environmental conditions can include adverse weather and non-renewable resource depletion. Sustainability of present agricultural cultivation influences the future value of a smallholder farmer household's exchange-entitlements, in terms of the value of inputs and produced commodities from agriculture, and these cultivation practices can directly influence the capabilities of members of the smallholder agricultural household (i.e. pesticide use adversely affects health outcomes). It can therefore be seen that agricultural sustainability merits consideration in the alleviation of endemic hunger among smallholder farmers, if that deprivation is to be sustainably eliminated.

4.2 Framework components

4.2.1 Desirable outcomes

Desirable outcomes of a system of public grain procurement and distribution

- Food prices for farmers should be stabilized in order to ensure provide reliable income.
- Regular and dependable food distribution should contribute to poverty alleviation.

Desirable outcomes of smallholder agricultural production

- Agricultural production should contribute to household caloric consumption.

- Agricultural production should follow local tastes and preferences.
- Agricultural produce should at least in part be sold to generate income instead of being consumed by the smallholder farmer household.
- Agricultural production should be sustainable, both in terms of feasibility into the future and avoidance of non-renewable depletion of natural resources.

Objectives of food security

- Caloric consumption should be sufficient.
- Local preferences and nutrition should be fulfilled.
- A food source should be regular, reliable, and sustainable.

Objectives of agricultural sustainability

- Non-renewable depletion of natural resources, inclusive of groundwater, soil nutrients, and agricultural biodiversity, should be avoided.
- Agricultural practices, inclusive of types of crops cultivated and chosen method of cultivation, should be resilient against changing weather patterns and unpredictable weather.

4.2.2 Mechanisms

Effects of a system of public grain procurement and distribution

- Types of crops grown
  - Farmers may choose to grow the types of foods for which the government guarantees a minimum purchase price.

  - Farmers may choose not grow the types of foods that are distributed locally at subsidized prices, and the local market for those foods declines as the subsidized government distribution of these foods grows more prominent in the region.
  - Farmers may rely less on household consumption preferences in deciding which crops to grow.

- Dependability of caloric intake in rural areas
  - The system of public grain distribution could provide a welfare safety net in times of adverse-weather-induced food insecurity.
  - The system of public grain distribution could affect the farmer's ability to diversify economic endeavors by reducing a smallholder farmer's reliance on their own production for their own consumption.
  - The system of public grain distribution could shift farmer household food preferences away from personally cultivated foods to those which are distributed by the government.

Effects of changing weather patterns

- Changing weather patterns may affect the reliability of environmental resources.
- Changing weather patterns may affect crop production.
  - Farmers may choose to plant different crops in response to their perceptions of changing weather patterns.
  - Changing weather patterns may affect crop physiology and subsequent crop production.

Effects of smallholder farmer cultivation decisions, inclusive of changes in crop types planted and changes in cultivation methods

- Cultivation decisions interact with agricultural sustainability.
- Cultivation decisions interact with overall smallholder farmer welfare.
  - Cultivation decisions interact with the sufficiency of calories and nutrition.
  - Cultivation decisions interact with the fulfillment of smallholder farmer preferences.
  - Cultivation decisions interact with the financial profitability of the crop produced.

Chapter 5

Data and Methods

Using the framework described in Chapter 4, I am interested in determining how perceptions of weather patterns have affected cropping decisions and local food security in the Ramgarh and Dhari Blocks of the Nainital District of Uttarakhand, India. The framework established in the previous section distinguishes between changing weather patterns and smallholder farmer perceptions of changing weather patterns. I use the latter as a proxy for weather patterns, themselves, given that the focus of this study is smallholder farmer decisions and the actions that farmers have or have not taken in response to changing weather patterns. I then examine the listed mechanisms in Chapter 4 through two primary data sets, a 307-household survey of weather pattern perceptions and related agricultural adaptations and a set of in-depth interviews about access to the Indian Public Distribution System. Below, I first describe the region studied and then both the data sets and the methods of data collection. I then elaborate on the methods used in these analyses.

5.1 Data

5.1.1 Standardized survey on perceptions of weather patterns

From May through August of 2012, employees of the Gene Campaign surveyed 307 randomly selected agricultural households in order to investigate the connection between changes in weather patterns and cropping decisions. Each year, Indian farmers rely upon the arrival and duration of the monsoon to decide which crops and when to plant. In the Garhwal region of the Uttarakhand Himalayas, for example, the timely arrival of the monsoon in June is met with maize cultivation, but if the monsoon is late or the growth of the maize is poor, farmers then choose to plant different cultivars of millets, which are selected according to the time of the season (Singh et al., 2008). Sufficient rainfall is also necessary for groundwater recharge and for rainwater harvesting for the dry cropping season, which follows the monsoon season and relies on irrigation. In order to capture these close relationships between weather patterns and farmer adaptability, the survey solicited perceptions of changing weather patterns, the measures that farmers have taken in response, and past, present and expected future cropping patterns.

This survey, shown in Hindi and English in Appendix B was initially tested in the Ramgarh Block of the Nainital District for ease of comprehension by respondents, coverage of common responses to questions, and specific relevance to the area (i.e. if comprised a substantial portion of dedicated agricultural land, then questions were revised to differentiate between cash and food crops). Free responses were solicited for open-ended questions, and the appropriate responses were marked in a comprehensive and predefined list, which was not shown to respondents, in order to avoid introducing bias. Households were chosen by going door-to-door within a village, if there was an

adult available at home; the category of adult was not strictly defined by age but by ability to answer these questions. If there was more than one eligible person at home, they would typically self-select a respondent. Villages were visited during late mornings and early afternoons, a wide span of time that allowed for a wide variety of types of household members (based on their responsibilities) to be encountered—those who cooked lunch, had been working in the fields, collected firewood and fodder, ran errands at the market, etc. It is possible that such sampling methods led to a systematic bias toward demographic categories that were rarely home at this hour, located in more obscure and difficult-to-reach areas, or less likely to be selected as respondents in the event that more than one eligible respondent was home. For example, it is possible that the sample is biased toward older members, as they might take precedence over younger members. Although the sampling methodology could have been improved to obtain a more certifiably random sample, the aggregate sampling rendered roughly equal numbers of men and women and proportions of caste members that were close to district census averages. I chose to take this as a random sample in the statistical analyses.

I processed the data from the survey forms by coding and entering responses in a spreadsheet. Using MATLAB, I converted these coded responses into percentages of all respondents and percentages of categories of respondents (by social category, age group, highest achieved education level, gender, and landholding size) who gave each type of answer to each question. For example, over 99% of respondents noted higher temperatures as a recent change in weather (Table 6.1). All calculated percentages and their method of calculation are provided in Appendix A with the results of all questions soliciting binary responses (yes or no, noted or not noted).

The survey was designed in Hindi by Suman Sahai and administered in Hindi and Kumaoni by the following employees of the Gene Campaign, who were also residents in the Ramgarh and Dhari Blocks: Ganesh Singh Bisht, Tulsi Bisht, Pavan Kumar Dhaila, Harendra Singh Lodhiyal, Deepa Lodhiyal, Geeta Mer, and Deepa Rana. Ganesh Bisht and I translated the Hindi form to English.

5.1.2 Individual interviews about the Public Distribution System

I conducted five in-depth interviews of randomly selected villagers in the Ramgarh Block. I asked them open-ended questions about perceptions of the challenges facing agriculture, entitlements received through the Indian Public Distribution System, and the way that participants felt toward both. I undertook these interviews in Hindi and Kumaoni with Geeta Mer and Deepa Rana, employees of the Gene Campaign. I recorded and translated these interviews.

5.2 Background of study population

Using the 307-household survey data, government statistics, maps and journal articles, I discuss the background of the study population in this section.

5.2.1 Location

The study region, the Ramgarh and Dhari Blocks, is located in the southern district of Nainital in the Indian state of Uttarakhand. Uttarakhand is a Himalayan state that

is bordered to the southeast by Nepal, to the northeast by Tibet, to the northwest by the Indian state of Himachal Pradesh, and to the southwest by the Indian state of Uttar Pradesh. Blocks are the subunits of districts, and each block is composed of several villages. Figure 5.1(a) provides the exact locations of the Ramgarh and Dhari Blocks within Uttarakhand while Figure 5.1(b) depicts the location of Uttarakhand in the international context.

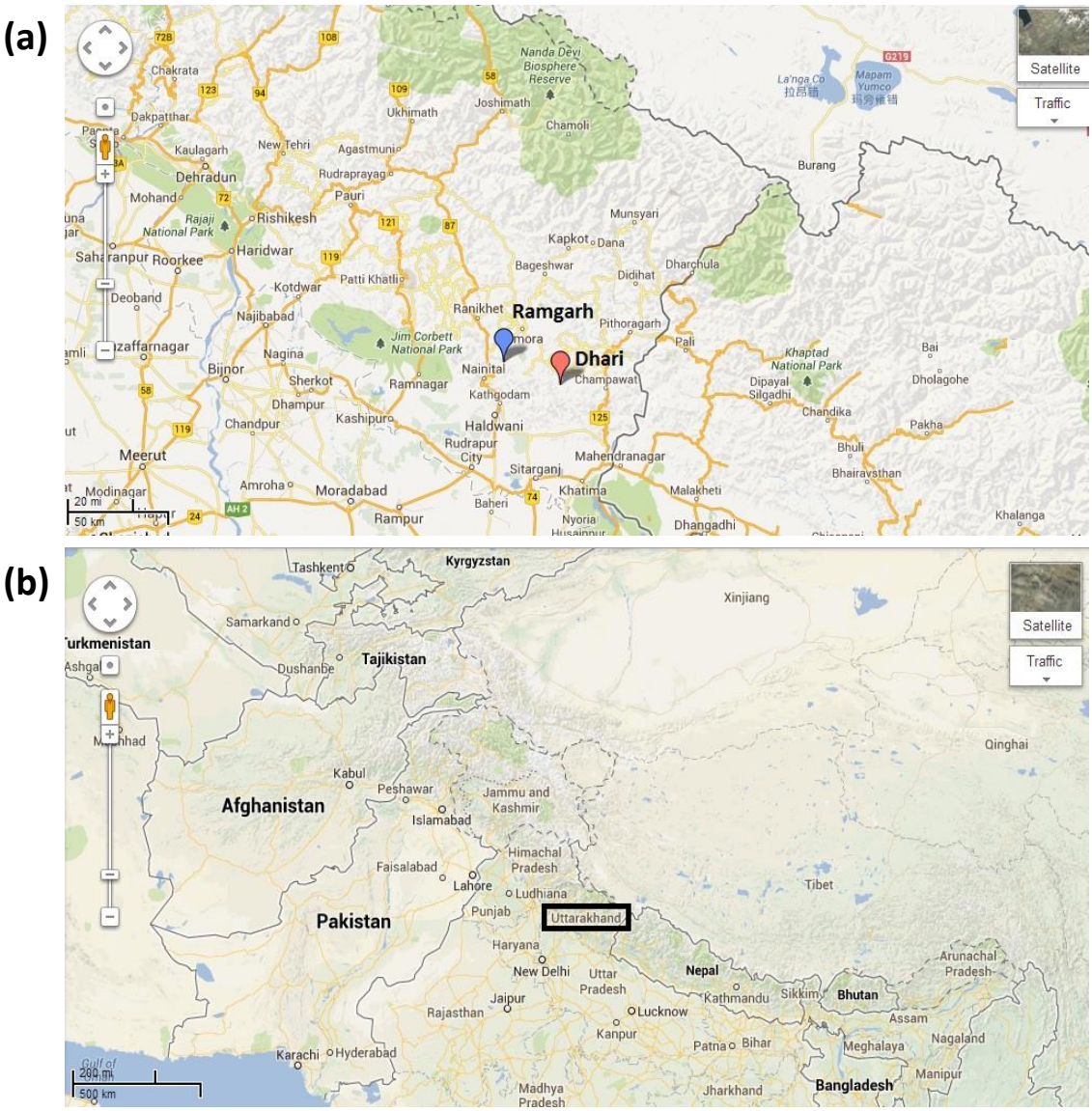

Figure 5.1: (a) location of Ramgarh and Dhari Blocks within Uttarakhand and (b) location of Uttarakhand (name boxed) with respect to the other states of India, Tibet, and Nepal.

5.2.2 Demographics

The study population consisted of 307 individuals, each representing a distinct household. There were 157 men and 150 women surveyed, from 29 different villages in two blocks, Ramgarh and Dhari, in the Nainital District of Uttarkhand. Table 5.1 provides the number of households surveyed for Ramgarh while Table 5.2 provides that for Dhari.

Table 5.1: Number of respondents in each surveyed village of Ramgarh

Village name	# of surveyed households
Badet	15
Bajuthiya	9
Bohara Kot	11
Dadima	20
Gadgaon	6
Galla	10
Harinagar	9
Hartola	8
Jhutiya	11
Lod	10
Loshgyani	9
Mauna	16
Myauda	17
Naikana	6
Nathuwakhan	18
Orakhan	3
Simayal	11
Supi	11
Suralgaon	11
Total	211

Table 5.2: Number of respondents in each surveyed village of Dhari

Village name	# of surveyed households
Aksoda	5
Bana	8
Chaukhuta	10
Gajaar	9
Kaul	10
Kokil Bana	10
Majheda	15
Parbada	9
Pokharad	10
Sunkiya	10
Total	96

The survey form distinguishes between four social categories that are, in part, officially differentiated by the Constitution of India: Scheduled Tribes, Scheduled Castes, Other Backward Classes, and General Castes. Scheduled Tribes and Scheduled Castes comprise groups specified by the Constitution of India that are deemed to be socio-economically disadvantaged and deserving of affirmative action and protection from

the government. Other Backward Castes is a flexible group also provided with affirmative action and protection that is added to at the discretion of the government of India. 16.3% of the survey respondents were in the Scheduled Castes, while 83.4% were in the General Castes; there was one household that described itself as belonging to the Other Backward Classes. These figures are similar to the Uttarakhand government statistic that 19.4% of the Nainital population is in the Scheduled Castes; the figure for the survey is likely lower because Scheduled Castes members are not evenly distributed among villages, as some village population are more than 60% Scheduled Castes (Government of Uttarakhand, 2001). There are nearly equal numbers of men (157) and women (150) in the survey sample.

Table 5.3 depicts the age and education level distributions of the surveyed population. Nearly a third of respondents are under the age of forty, and half of respondents have at most a primary school education. About twelve percent of respondents have reached intermediate school or higher education.

Table 5.3: Percentage of all respondents in each age category and education level

Age range (years)	**% of all respondents**	**Education level**	**% of all respondents**
Age <40	30%	**No formal schooling**	20%
Age 40-49	29%	**Primary school**	30%
Age 50-59	22%	**Secondary school**	38%
Age 60-69	8%	**Intermediate school**	9%
Age >69	11%	**University degree**	3%

Sorting the sample by both age category and education level in Table 5.4 reveals that the great majority of respondents under the age of forty have at least a secondary school education, and as age category increases the average education level declines. This demonstrates the trend that younger generations are increasingly likely to receive a formal education and suggests that the surveyed population is increasingly likely to both see the benefit of and gain access to education. Furthermore, six of nine university

degree recipients in our sample are in the youngest age category, under the age of forty.

Table 5.4: Number of respondents by age (rows) and education level (column)

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Age <40	4	18	54	11	6
Age 40-49	18	25	35	10	1
Age 50-59	18	28	16	4	1
Age 60-69	8	8	6	2	1
Age >69	12	14	6	1	0

Table 5.5 shows that men are more likely to have received at least primary schooling than women, and women are five times as likely as men to not have received any formal education. However, given the fact that only 4 respondents under the age of forty have no formal education (Table 5.4), it is possible that this gulf in attained education between genders is narrowing over time. This possibility is further supported by the fact that the great majority of the women in our sample who have not received a formal education are older than 40 years old, and similar numbers of men and women have reached but not exceeded primary school education. Among respondents under the age of forty, 40 men and 24 women have received up to but not exceeded a secondary school education, which shows increasingly equal access to education for younger generations than for older generations.

Table 5.5: Number of respondents by gender (column) and education level (row).

	Men	Women
No Formal Schooling	9	51
Primary School	45	48
Secondary School	75	42
Intermediate	22	6
University Degree	6	3

5.2.3 Size of household landholdings (*nali*)

Land in the settled agricultural systems of the Nainital district of Uttarakhand is arranged into small terraces carved into the mountainside (Figure 5.2). In Table 5.6,

Figure 5.2: Terraced agriculture in the Himalayan valley of the village of Gadgaon in the Ramgarh Block on August 8, 2012.

reported landholdings are given in *nali*, where roughly 20 *nali* equal one acre. Just 1 of the 307 is missing landholding data, hence the total number of respondents categorized by landholding size reaching only 306. On average, 86% of a household's landholdings are rainfed, and the irrigated portion is typically reserved for vegetables intended for household consumption, which reflects the extent to which the success of smallholder agriculture relies on the predictability of monsoon rainfall. As shown in Table 5.7, total landholdings are much higher for the highest two age categories than for the lowest three, which reflects the division of land among sons with each successive generation after the death of the oldest generation. The average household farmed 22.7 *nali* of rainfed land and 3.6 *nali* of irrigated land (Table 5.6). Female respondents reported average rainfed and irrigated landholding sizes that were ~70% of those reported by male respondents (Table 5.6). Since all respondents were speaking for their entire house-

holds, I had expected no difference in the average landholding size reported by men and women. This systematic gap in landholding size reported by each gender offers a glimpse into the differences in gender roles in land management and also suggests that knowledge of the amount of land owned is imprecise. This imprecision is likely related to the lack of clarity, absence of assured federal records, and the general injustice of Indian land titles (Zasloff, 2011). Although respondents in the Scheduled Castes have total landholdings that are on average 81% the size of landholdings of General Castes respondents, average Scheduled Castes irrigated landholdings are only 41% of the size of those belonging to General Castes respondents. Since irrigated land requires additional water resources and labor for water transportation, this statistic highlights the persisting inequalities in resource access between members of the Scheduled and General Castes.

Table 5.6: Rainfed and irrigated average household landholdings in *nali* (~20 *nali* = 1 acre) by all surveyed, gender, and social category

	All Surveyed	**Men**	**Women**	**Scheduled Castes**	**General**
Rainfed land	22.71	26.47	18.75	20.32	23.23
Irrigated land	3.59	4.48	2.65	1.62	3.99

Table 5.7: Rainfed and irrigated average household landholdings in *nali* (~20 *nali* = 1 acre) by age category

	Age <40	**Age 40-49**	**Age 50-59**	**Age 60-69**	**Age >69**
Rainfed land	21.42	20.16	20.46	29.00	33.00
Irrigated land	3.40	3.80	2.09	7.04	3.97

Table 5.8: Rainfed and irrigated average household landholdings in *nali* (~20 *nali*= 1 acre) by education level

	No Formal Schooling	**Primary School**	**Secondary School**	**Intermediate**	**University Degree**
Rainfed land	19.53	23.22	22.31	29.25	23.75
Irrigated land	2.1	1.78	4.27	8.96	6.88

5.3 Methods

As I previously discussed in Chapters 2 and 4, I chose a framework-based analysis to avoid artificially limiting the set of possible conclusions and causal relationships. The interest here is therefore not the exact size of the effect of a particular variable (i.e. whether or not a particular weather pattern is perceived) but the collection of associations and family of relationships that might lead to the observed result. Thus, the methods used in this study examine associations between variables instead of searching for causality.

5.3.1 Comparing probabilities

The two quantitative methods used in these analyses are comparisons of percentages of respondents giving particular answers and univariate logistic regressions between independent variables and dependent outcome variables, such as the crop type planted or preferred crop for a given condition. Specifically, all data analyzed from the survey are coded to be binary—'yes' or 'no,' or 'mentioned' or 'not mentioned.' Given that many questions were open-ended, allowing participants to freely list responses, a value of 'false' (as opposed to 'true') in these cases simply indicates that the particular statement was not given, not that the respondent did not agree with that statement.

For example, survey question 2.2 asked "Which grain/crop do you consider most nutritious?" for which participants could respond with any crop. Responses to this question were largely either finger millet or wheat, with some respondents noting both or another crop, such as maize, so the variable of 'finger millet is nutritious' was either 'true' or 'false,' depending on whether the respondent had named 'finger millet' as a response. 'False' therefore only indicates that the crop was not mentioned, not that

the respondent felt the crop to be unimportant. This allowed for calculations of percentages of respondents giving each response or belonging to a particular category.

I also used difference in proportion tests to compare probabilities between different baseline categories, since categories would have different numbers of respondents. For example, 70% of the 50 respondents in the Scheduled Castes and 55% of the 256 respondents in the General Castes stated that they had planted new crops altogether to cope with the observed weather patterns. The difference in proportion test, which approximates binomial probabilities with large n as normal distributions. Given two sample probabilities—p_1 from a sample of n_1 (the proportion p_1 of n_1 are true) and p_2 from a sample of n_2—the null hypothesis is that $p_1 \leq p_2$, and the alternative hypothesis is that $p_1 > p_2$. I first calculate the pooled sample proportion, p, and its standard error, SE_p,

$$p = \frac{(p_1 n_1 + p_2 n_2)}{n_1 + n_2} \tag{5.1}$$

$$\text{SE}_p = \sqrt{p(1-p)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}. \tag{5.2}$$

Under the null hypothesis that $p_1 \leq p_2$, I expect any sample proportion drawn from this pool to follow a normal distribution with $\mu = p$ and a standard deviation of SE_p. I also expect differences between two sample proportions to follow this same normal distribution. So, in order to test for whether $p_1 \leq p_2$, I calculate the following z-score,

$$z = \frac{p_1 - p_2}{SE_p}, \tag{5.3}$$

and the one-tailed p-value is given by comparing this z-score against a normal distribution of $\mu = 0$ and standard deviation of 1. Performing this test on the previously presented probabilities that $p_1 = 0.7$, $n_1 = 50$, $p_2 = 0.55$, and $n_2 = 256$, I find that I can reject the null hypothesis that $p_1 \leq p_2$ at $\alpha = 0.05$, as p-value $= 0.025$. I conclude that members of the Scheduled Castes, in the survey, are more likely than members of the General Castes to remark that they had planted new crops altogether in order to cope with adverse weather patterns.

5.3.2 Univariate logistic regressions

In order to probe possible specific correspondences between these binary variables, I performed univariate logistic regressions between them. In Appendix C, I describe this regression, the derivations of the estimated coefficients, and the tests for statistical significance of the estimated coefficient and that of the univariate logistic regression compared to a logistic regression with only a fitted constant and no independent variable.

Given that the data contain an array of binary explanatory variables, it would seem a natural choice to perform multivariate logistic regressions in determining the relative influence of each explanatory variable on a particular dependent variable. However, I chose not to perform multivariate logistic regressions because characteristics of the variables to be tested as either predictor or dependent variables violate key assumptions of multiple logistic regressions.

For example, I expect the smallholder farmer perceptions of whether wheat is the most nutritious crop to also relate to whether they believe that it will be an important crop for the future. I also expect whether a respondent noted that 'rainfall has been unpredictable' to relate to whether they believed that 'rainfall has become reduced,' a characteristic of two or more explanatory variables that is termed multicollinearity. Such variables, though they can play different roles in determining whether or not a respondent stated that they are cultivating wheat, cannot be expected to vary independently, and their relative effects on the dependent variable cannot be abstracted from a multiple regression.

In addition to multicollinearity, the endogeneity of variables in the data violates the independence of explanatory variables assumed in multiple logistic regressions. Specifically, endogeneity characterizes a system in which error terms of the regression model correlate with the dependent variable. Endogeneity can result (1) when there is an omitted influential independent variable, (2) when predictor variables are correlated or dependent on one another, and (3) when the dependent variable influences the supposed predictor variable. Because of positive feedbacks between variables such as expressed preference for a particular crop and whether or not that crop is cultivated, I also expect variables characterized as dependent to also influence variables categorized as independent.

One major purpose of a multivariate logistic regression would be to determine the relative effects of each independent variable on the dependent variable, a capacity that would be partly compromised by the degree to which explanatory variables would be dependent on one another. Together, multicollinearity of predictor variables and endogeneity of the system being studied render a multiple logistic regression inappropriate in

this analysis. Endogeneity remains a problem in conducting a univariate logistic regression, but I use these estimates to show associations between binary variables, rather than to prove causality. Combined with percentage calculations, univariate logistic regressions are therefore sufficient in determining whether each explanatory variable relates to a dependent variable, without indicating potentially spurious causality or relying on the independence of two or more predictor variables.

As I show in the next chapter, straightforward comparison of the groups of crops most commonly described in response to questions such as, "which crops do you believe to be most resilient against changing weather patterns," and "which crops do you believe to be important for the future?" is enough to indicate whether or not respondents believe those crops that are resilient against changing weather patterns to also be important for the future. Statistical regressions have some potential of assigning a numerical value to the relative importance of predictor variables, such as 'importance for generating income' and 'resilience against changing weather,' in determining whether or not the crop was planted, and there is much more work and extensive data collection to be done to assess the relative influences of these different needs and preferences. However, for the purposes of this framework-based analysis, comparing commonly named sets of crops is sufficient for indicating whether a particular concern manifested in the actual cropping decision. As shown in the framework laid out in Chapter 4, further analysis of the relative value of different immediate motives and actions requires qualitative consideration and comparison of the desirable outcomes served—be they sustainability of agricultural production, food security, and broader concerns of social security and welfare.

Chapter 6

Analyses and Framework Application

Using the framework laid out in Chapter 4, I determine whether perceptions of changing weather patterns have affected smallholder farmer cultivation decisions, inclusive of types of crops grown and methods of cultivation, and local food security. As described in the Chapter 4 framework, I expect smallholder agricultural production to be influenced by the extent to which this production (1) contributes to household caloric consumption, (2) fulfills tastes and preferences, (3) is sustainable, and (4) is financially profitable. These are desirable outcomes that may be in conflict if much of the food that is produced is not intended for household consumption and is destined for sale and income-generation, as foods that may be profitable in urban markets may not be the same ones that are locally consumed in cultivation areas. They may also be in conflict if, conversely, the types of food produced are intended mainly for household consumption and fulfill tastes and preferences but are not viable in the marketplace. The types of crops actually planted, those desired for their nutrition and taste, those believed to have declined in cultivation, those believed to be important for the future,

and reasons supplied for each of these perceptions therefore reflect the prioritization of these four major outcomes for smallholder farmers. I start by examining the role of sustainability in smallholder farmer cultivation decisions. It is established that climate change is taking place and that one of its major manifestations is the rise in global mean temperature (Intergovernmental Panel on Climate Change, 2007). These changes in climate result in shifts in local weather patterns, and below, I examine whether the study population notices these changes.

6.1 Perceptions of changing weather and implemented adaptations

6.1.1 Perceived changes in weather patterns

In order to determine whether smallholder farmers should be expected to adjust their cultivation decisions with respect to these changing weather patterns, I first determined whether the study population of smallholder Himalayan farmers has noticed large changes in weather patterns over the preceding few years. The data show that all female farmers and 99% of male farmers stated that they had noticed substantial changes in recent weather patterns compared to those of preceding years. The most common responses for the types of changes in weather included higher temperatures (96% of all respondents), increased unpredictability of weather (65%), a longer summer season (79%), reduced amount of rainfall (62%), and later arrival of rains (77%) (Table 6.1).

These data indicate that the global phenomenon of climate change appears to be

Table 6.1: Major changes in weather, by gender, social category, all surveyed

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
3.1 Major change in weather?	99%	100%	100%	100%	100%
3.2 Increased temperature	97%	95%	96%	96%	96%
3.2 Severe winter	8%	1%	4%	5%	5%
3.2 Mild winter	1%	0%	0%	0%	0%
3.2 Increased unpredictability of weather	57%	74%	76%	63%	65%
3.2 Increased length of winter season	4%	1%	6%	2%	3%
3.2 Reduced length of winter season	4%	4%	0%	5%	4%
3.2 Increased length of summer season	78%	81%	88%	78%	79%
3.2 Reduced length of summer season	1%	3%	0%	2%	2%
3.2 Reduced amount of rainfall	69%	55%	64%	61%	62%
3.2 Increased amount of rainfall	4%	7%	2%	6%	6%
3.2 Rains arrive later	77%	77%	82%	76%	77%
3.2 Land slides	16%	21%	14%	19%	18%

having not just perceptible, but pronounced, effects at the local level. Roughly two-thirds of all respondents stated that weather had become more unpredictable, and combined with the fact that farmers most commonly note the delayed arrival of rainfall and the increases in temperature as the primary manifestations of changing weather, this suggests that their agricultural practices and livelihoods are highly dependent upon the predictability and regularity of rainfall and temperature. This is further corroborated by historical studies of famines, in which the initial rise in food prices was sparked by projections of crop failure from weather that was judged to be adverse with respect to regular and predictable weather patterns (Sen, 1981).

6.1.2 Perceived effects of changing weather patterns

The adaptations of smallholder farmers to these perceived changes in weather patterns depend on the effects they believe to result from these patterns. An open-ended question soliciting effects respondents believed to result from changing weather revealed that their major concerns about these weather patterns related primarily to the immediate physiological effects on crops, to food security, and to environmental resource degradation. Eighty-nine percent of respondents noted a decline in yield; 86% noted decreased grain production, which can be interpreted as a decline in direct agricultural

production for household consumption; 81% noted that these changes had resulted in a change in the length of the growing season; and 67% noted increases in the amount of pests and crop diseases. Environmental resource degradation was less common, with 27% of respondents noting losses of plant and animal species and 12% mentioning soil degradation (Table 6.2). It is possible that given the initially announced focus of this survey on traditional crop production and changes in weather, most respondents limited their responses to factors related to food production rather than including the environmental effects of these weather changes in their accounts. Nonetheless, the tentative, even apprehensive, attitude toward mercurial monsoon weather and its environmental effects is apparent in the detailed interviews and newspaper headings throughout the season. All five randomly selected interviewees named the timeliness of rain as a primary worry. One interviewee, 76 year-old Parvati, said, "without rain, everything is finished." These interviews are discussed in greater detail in Section 6.5

Table 6.2: Impact of changes in weather, by gender, social category, all surveyed

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
3.3 Change in start/end and/or length of growing season	83%	80%	80%	82%	81%
3.3 Decreased grain production	85%	86%	90%	85%	86%
3.3 Land use change	6%	3%	4%	4%	4%
3.3 Pests and diseases	64%	70%	72%	66%	67%
3.3 Soil degradation	15%	8%	4%	13%	12%
3.3 Yield decline	91%	87%	86%	89%	89%
3.3 Loss of species/varieties	29%	24%	30%	26%	27%
3.3 Others	2%	1%	0%	2%	2%

6.1.3 Measures implemented in response to changing weather patterns

In response to the observed negative effects of changing weather patterns on their crop production and food security, smallholder farmers are able to change two main

components of their agriculture: the types of crops planted and the methods of cultivation. As described in the framework, such cultivation decisions can affect agricultural sustainability and smallholder farmer welfare. The next step to understanding the degree to which smallholder farmers prioritize sustainability is to examine the changes in cultivation method and crop types undertaken in response to observed changes in weather patterns. The survey distinguishes between different crop species and different varieties of a particular crop species.

Here, the term 'crop type' refers to a distinct crop species and 'crop variety' refers to a variety of a particular crop species. When asked what they had done to adapt to perceived changes in weather patterns, respondents provided a wide range of responses: 57% of respondents had planted new crops altogether, 52% had planted trees as a type of agro-forestry, 41% had shifted their planting times, 34% had increased the frequency of seed exchange with other farmers, 33% had changed their cropping systems, 24% had planted faster maturing varieties of crops, 21% had planted different varieties of existing crops, and 11% had implemented rainwater harvesting. Only 5% said that they have done nothing in response, and just 2% stated that they did not know what to do in response (Table 6.3).

These adaptations suggest that sustainability is a major concern of this population of smallholder farmers. While these responses highlight the adaptability of farmers to adverse and changing environmental conditions, they also expose the limited palette of resources accessible to farmers. For example, planting different crop types and crop varieties are prominent measures that farmers have taken in response to changing weather patterns, but the use of such knowledge may be hampered by poor seed access and the absence of other agricultural infrastructure, such as irrigation pumps and community

Table 6.3: Implemented adaptations to weather, by gender, social category, all surveyed

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
4.1 Plant different varieties of existing crops	22%	21%	28%	20%	21%
4.1 Plant new crops altogether	57%	58%	70%	55%	57%
4.1 Increase frequency of exchange of seeds among farmers	26%	42%	34%	34%	34%
4.1 Changes in cropping systems	36%	30%	30%	34%	33%
4.1 Plant fast maturing varieties	25%	23%	20%	25%	24%
4.1 Plant disease resistant varieties	5%	0%	0%	3%	3%
4.1 Change planting locations of crops	57%	59%	68%	56%	58%
4.1 Change planting time	42%	39%	44%	40%	41%
4.1 Move across land	13%	1%	6%	8%	7%
4.1 Keep more livestock, instead of crops	4%	0%	6%	0%	0%
4.1 Plant trees	55%	48%	42%	54%	52%
4.1 Do more water harvesting	15%	7%	12%	11%	11%
4.1 Do more off-farm work, instead of farming	6%	0%	2%	3%	3%
4.1 Soil management	5%	3%	0%	5%	4%
4.1 Weather forecasts	0%	1%	0%	0%	0%
4.1 Risk instruments	0%	0%	0%	0%	0%
4.1 Livelihood diversification	10%	3%	2%	7%	7%
4.1 Land use	6%	2%	4%	4%	4%
4.1 Do nothing	6%	4%	6%	5%	5%
4.1 Others	0%	0%	0%	0%	0%
4.1 Do not know	2%	2%	4%	2%	2%

institutions for seed exchange.

6.2 Perceptions of changing weather patterns and cropping patterns

These adaptations also do not indicate the relative prioritizations of sustainability and smallholder farmer welfare in making smallholder farmer cultivation decisions. Even if respondents were to believe that changing crop types is a method of adaptation to changing weather patterns, they may not take this action because they may believe that they will derive greater welfare benefit (in terms of direct household consumption, profitability or fulfillment of taste and preferences, for example) from planting a crop that may fare poorly in changing weather.

In order to interpret the weighting of sustainability and the benefits to welfare, I examine the crops that respondents believe (1) are susceptible to damage from changing weather patterns, (2) are resilient to changing weather patterns, (3) to have declined in the past two years, (4) are important for the future, and (5) are nutritious. The questions soliciting these five categorizations of crop types were all open-ended, wherein respondents were asked to name crops freely rather than choose from any predefined list. Before naming the crops in these categories, I first describe the crops that respondents currently cultivate.

6.2.1 Currently cultivated cash crops and food crops

Figure 6.1: A woman harvesting a cabbage field (*phuulgobhi* and *pattagobhi*) in the village of Majheda in the Dhari Block, on July 3, 2012.

Figure 6.2: Mixed cash and food cropping in the village of Majheda in the Dhari Block, including a small peach (*aaduu*) orchard, an amaranth (*chua* and *chaulai*) field, cabbage, peas, tomatoes, and stinging nettles, on July 17, 2012.

Crops that respondents cultivate can be categorized as food or cash crops, depending on their primary use. For example, fruits and vegetables may be edible, but both are produced for sale to urban centers in the Nainital District. In particular, fruits, such as peaches, apples, plums, apricots, and pears, are grown for wholesale to middlemen who then sell to retailers in the urban centers of Haldwani, Nainital, and Delhi. Over 80% of respondents grow each of these fruits, and among those respondents, most believe apples, plums, pears, and apricots to have declined or remained the same in production (Table 6.4). Peaches, on the other hand, are believed by respondents who grow them to have increased in production (Table 6.4). Because fruit do not comprise a substantial part of household diets, profitability and sustainability can be taken as the primary determinants of the changes in production of these crops, with the former

taking precedence over the latter.

Table 6.4: Observed changes in fruit cultivation: percentages of respondents that grow each crop stating that production of that crop has increased, decreased, or remained the same. the bottom row, '% of respondents,' gives the percentage of all 307 surveyed respondents who grew each fruit.

	Apples	**Plums**	**Pears**	**Peaches**	**Apricots**
increased	23%	26%	31%	56%	11%
decreased	73%	62%	48%	30%	75%
remained the same	4%	12%	21%	14%	15%
% of respondents	80%	90%	88%	90%	84%

Table 6.5: Crops grown and relevance to household consumption and sale

	Household Consumption	**Sale**	**Both**	**Household Consumption**	**Sale**	**Both**
	% of respondents who grow each crop			**# of respondents**		
cabbage	11%	1%	87%	17	2	132
peas	13%	0%	86%	13	1	88
potatoes	13%	0%	86%	28	2	190
wheat	99%	0%	0%	229	0	2
finger millet	99%	0%	1%	215	0	2
legumes	99%	0%	1%	263	0	4
rice	100%	0%	0%	20	0	0
maize	99%	0%	1%	206	0	3

The 307-household survey questions on perceptions of cropping patterns dealt primarily with these grain and vegetable crops, which have the potential to be considered dually as cash and food crops, whereas fruit was purely a cash crop. This is evident in Table 6.5. The primary vegetables grown for both wholesale and household consumption are peas, cabbage[1], and potatoes. 87% of surveyed households who grow these crops do so for both sale and household consumption. 49% of all households volunteered that they grow cabbage, 33% grow peas, and 72% grow potatoes (Table 6.5).

Whereas the previous responses of cultivated vegetables were volunteered by respondents when asked what all they grew, without any suggested answers, responses for wheat, finger millet, legumes, rice, and maize were specifically solicited. We therefore

[1]In the survey, respondents reported planting *phulgobhi*, or cauliflower, and *patagobhi*, or cabbage. I refer to these both as cabbage in this study, as they are closely related cash crops and *gobhi* was used to refer to them both.

expect these percentages to better reflect the true proportion of the surveyed population that grow these crops than the previously described percentages of cultivated vegetables. These grains are grown by the great majority of households and only for household consumption, with less than five respondents also growing them for sale: 75% of all respondents grow wheat, 71% grow finger millet, 87% grow legumes (other than peas), 7% grow rice, and 68% grow maize.

That at least two-thirds of all respondents grow wheat, finger millet, legumes, and maize, and that they only do so for household consumption suggests that grains are primarily food crops, whereas peas, potatoes, and cabbage can be considered as cash crops. In terms of an individual's exchange-entitlements for food access, cash crops generate income for purchasing food while food crops provide both direct access to food and possible exchangeability for other food commodities. Both are subject to the concern of agricultural sustainability, and whether or not a smallholder farmer chooses to plant a particular crop depends on the sum of its perceived benefits relative to those of other crops. A very general categorization of cash and food crops is given in Table 6.6, which differentiates crops by common groupings rather than distinct species; for example, respondents would refer to most legumes as *daal*, and fruits were always a cash crop, whether they were peaches or apples.

Table 6.6: General categories of cash and food crops

Cash crops	**Food crops**
peas	finger millet
potatoes	wheat
cabbage	legumes
fruit	maize

6.2.2 Crops believed to be resilient to observed changing weather patterns

Provided that respondents believe changes in crop types to be their primary method of adaptation to changing weather patterns, it is worth knowing which crop types they believe to be against adverse weather. The crops that are both currently cultivated and resilient against changing weather are primarily grains, which respondents established to be food crops. They comprise finger millet (75% of all respondents), maize (50%), barley (50%), wheat (19%), foxtail millet (18%), and barnyard millet (14%) (Table 6.7).

Table 6.7: Crops that are resilient to adverse weather, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General Castes	All Surveyed
Total # of respondents	157	150	50	256	307
barley	49%	50%	58%	48%	50%
barnyard millet	17%	12%	12%	15%	14%
maize	51%	49%	60%	48%	50%
finger millet	80%	69%	82%	73%	75%
foxtail millet	17%	19%	14%	19%	18%
wheat	22%	15%	14%	20%	19%

When asked which crops that used to be grown would also be resilient against changing weather, respondents named these food crops at lower frequencies, in part because some respondents did not provide any answer to this question: finger millet (48% of all respondents), barley (38%), maize (30%), barnyard millet (21%), and foxtail millet (20%) (Table 6.8). The fact that respondents named the same set of crops for the categories of (1) used to be grown and resilient against changing weather patterns and (2) currently grown and resilient against changing weather patterns suggests that the very crops that smallholder farmers in this region believe to be most suited to perceived changes in weather patterns are the same ones that are declining in cultivation.

Table 6.8: Crops no longer grown named to be resilient to adverse weather, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General Castes	All Surveyed
Total # of respondents	157	150	50	256	307
barley	35%	42%	42%	38%	38%
barnyard millet	25%	16%	12%	22%	21%
maize	29%	30%	32%	29%	30%
finger millet	50%	47%	48%	48%	48%
foxtail millet	22%	19%	14%	21%	20%
rice	11%	11%	8%	12%	11%
rusii	10%	11%	16%	9%	10%

6.2.3 Crops believed to be susceptible to damage from changing weather patterns

Just as it is valuable to know which crops are resilient against changing weather patterns, it is similarly useful to know which crops are susceptible to damage from these observed weather patterns. When asked which crops were most susceptible to damage from observed changes to weather patterns, respondents most frequently named cash crops: tomatoes (76%), peas (67%), cabbage (59%), chiles (47%), French beans (22%) and potatoes (22%) (Table 6.9). As noted previously, peas, cabbage, and potatoes are grown by over 85% of respondents and can be classified as cash crops.

Table 6.9: Crops susceptible to damage from adverse weather, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General Castes	All Surveyed
Total # of respondents	157	150	50	256	307
French beans	21%	23%	28%	21%	22%
cabbage	60%	57%	52%	60%	59%
bell pepper	15%	13%	8%	16%	14%
chiles	45%	49%	52%	46%	47%
eggplant	8%	14%	14%	11%	11%
peas	66%	68%	64%	68%	67%
potato	29%	15%	18%	23%	22%
tomato	78%	75%	68%	78%	76%
wheat	10%	12%	14%	10%	11%

6.2.4 Crops believed to remain stable in cultivation and important for the future

Comparing crops that are believed to be resilient against changing weather patterns against crops that are believed to be important for the future can indicate the perceived importance of meeting the challenges of adverse changes in weather by cultivating more suitable crops. When asked which crops they believed to be important for the future, respondents most frequently mentioned French beans (18%), cabbage (42%), maize (30%), finger millet (31%), peas (36%), potatoes (12%), and other legumes (35%) (Table 6.10). Given that cabbage and peas were also most commonly named to be susceptible to damage from adverse weather patterns in Table 6.10, it is striking that respondents most frequently name them to be important and stable crops for the future. This is a clear indication that susceptibility to adverse weather and, more generally, sustainability are not driving motivators for cropping decisions.

It is also telling that the cash crops, cabbage and peas, were more commonly named than primarily food crops, maize and finger millet. While these crops were all named for their importance as food, about half of all reasons given for the continued importance of peas, cabbage and potatoes, were their value for cash income, whereas only about 5% of all reasons for the importance of maize and finger millet were their value for cash income (Table 6.11). This reinforces the previous categorization of these crops as cash and food crops. Maize and finger millet were also commonly noted for their value as fodder. French beans and other legumes were valued primarily for cash income, soil fertility, and food. Altogether, these results show cabbage and peas to be valued primarily for their profitability, even against their suitability to adverse weather.

Table 6.10: Crops that will remain stable or increase in cultivation in the future, by gender, social category, all surveyed; percentages of respondents in each category that provided each response

	Men	Women	Scheduled Castes	General Castes	All Surveyed
Total # of respondents	157	150	50	256	307
French beans	14%	21%	14%	18%	18%
cabbage	43%	41%	38%	43%	42%
maize	31%	29%	52%	26%	30%
finger millet	30%	33%	46%	29%	31%
legumes	32%	39%	40%	34%	35%
peas	39%	32%	36%	36%	36%
potato	13%	11%	6%	14%	12%

Table 6.11: Percentages of respondents that named each crop (columns) who gave each reason (rows) for believing a crop to remain stable or increase in future cultivation; respondents were able to name multiple reasons.

	French beans	cabbage	maize	finger millet	legumes	peas	potato
Important as food	93%	74%	88%	96%	93%	75%	71%
Important for cash income	65%	95%	12%	3%	38%	93%	89%
Important as fodder	0%	4%	91%	87%	8%	10%	5%
Better for sustaining soil fertility	56%	1%	1%	0%	37%	21%	0%
Good for difficult weather	7%	5%	9%	9%	6%	5%	5%
Total # of respondents	54	128	91	95	108	109	38

The viability of these crops against difficult weather was infrequently mentioned for all of these crops, described by 10% or less of each set of respondents who named the importance of the crop for future cultivation. Rather than indicating whether these crops are resistant to changing weather, this statistic shows that sustainability, or the viability of a crop against difficult weather, is not a defining consideration in whether the smallholder farmer believes the crop to be valuable for the future. It is worth noting, however, that between 20% and 60% of respondents who named each of French beans, peas, and other legumes to be important for future cultivation believed them to be valuable for their contribution to soil fertility; in contrast, at most 1% of respondents naming all non-leguminous crops for their importance described the crop's contribution to soil fertility as a motivator. With the great majority of respondents having completed less than an intermediate school education (the equivalent of American high school), it is unlikely that they learned this element of plant physiology through formal schooling. Therefore, the concurrence between their agricultural knowledge and the scientific understanding that nitrogen fixation occurs in the root

nodules of legumes and therefore enriches the fertility of the soil demonstrates that experiential traditional knowledge can precede (and has often historically preceded) scientific findings of validity and should not be undervalued in its capacity to motivate and inform future scientific work.

6.2.5 Crops believed to have declined over the past five years

When asked which crops had declined over the preceding five years, respondents most often responded with wheat (73%) of respondents, potatoes (43%), finger millet (33%), peas (25%), maize (23%), and cabbage (20%) (Table 6.12). Together, these crops comprise the most common food and cash crops, established earlier in this chapter. Wheat far outstrips the other crops in being named as declining in cultivation, and possible reasons may include the existence of a more affordable substitute (fewer resources may be required for purchase than for cultivation) and poor suitability to changing weather. Susceptibility to adverse weather was named by nearly 78% of all respondents as a reason for the decline of wheat. This perceived susceptibility of wheat to adverse weather may reflect the well-studied heat sensitivity of wheat (Ortiz et al. 2008). Like finger millet, wheat is grown only for household consumption and the noted decline of these two grains in the preceding five years is further evidence that cultivation of crops could be moving away from production for household consumption and toward production for sale.

Reasons explicitly given for the declines in cultivation for these crops also varied widely between crops. Although unfavorable weather was cited by between 68% and 95% of respondents that named the decline of all other crops, this reason was described

by only 55% of respondents who named finger millet (Table 6.13). While over a third of each set of respondents naming each declining grain reasoned that other crops were available, less than 15% of each set of respondents named this reason for the decline in cultivation of peas, potatoes, and cabbage, with 1% of respondents for peas and 3% for cabbage. For peas, potatoes, and cabbage, 3% or fewer respondents for each crop said the existence of a more profitable alternative crop as a reason for its decline, whereas $13 - 19\%$ of each set of respondents stated that a more profitable alternative crop option was to blame for the decline of each grain. This further supports the idea that grains, which are food crops, are more likely to be displaced by other crops than are vegetables, which were previously identified as cash crops. Specifically, profitability emerges prominently as an identifying difference between cultivated grains and vegetables.

Table 6.12: Crops that have declined in the past five years, by gender, social category, and all surveyed; percentages of respondents in each category that provided each response

	Men	Women	Scheduled Castes	General Castes	All Surveyed
Total # of respondents	157	150	50	256	307
barley	28%	23%	12%	28%	26%
cabbage	17%	23%	32%	18%	20%
maize	25%	21%	26%	23%	23%
finger millet	39%	26%	28%	34%	33%
peas	19%	31%	32%	23%	25%
potato	45%	52%	58%	47%	49%
wheat	79%	67%	78%	72%	73%

Table 6.13: Percentage of respondents who named each crop (columns) that gave each reason (rows) for the recent decline of that crop; respondents were able to name multiple reasons

	barley	cabbage	maize	finger millet	peas	potato	wheat
Alternative crop availability	34%	3%	38%	38%	1%	11%	34%
Low yields or returns	24%	2%	15%	21%	3%	9%	17%
Difficulty in obtaining seed	15%	8%	1%	12%	11%	21%	13%
More profitable crop option	16%	0%	14%	19%	0%	3%	10%
Lack of labor	6%	5%	7%	21%	4%	5%	4%
Unfavorable weather	68%	95%	68%	55%	97%	95%	78%
Total # of respondents	79	62	71	100	76	149	223

Grains are also more likely than vegetables to be said to be declining in cultivation

due to low yields or returns. Respondents' statements that yields and returns of grains are low seem to relate more to economic profitability than to resilience to difficult weather, since grains are most frequently described as being hardy against adverse weather. Finger millet was at least three times as likely as other frequently named crops to be declining in cultivation due to the dearth of labor, which may relate to the difficulties in harvesting and processing because of the small size of the grain and the tough husk. It is also conceivable that respondents weight the perceived amount of labor necessary by the perceived returns of the crop.

6.3 Preferences, profitability, and agricultural sustainability

Preferences comprise a broad category, but given the limits of the data, I treat crops perceived to be the most nutritious as crops that are also preferred. This particular form of preference is least impeded by other considerations of sustainability and economic profitability. When asked which crop they believed to be the most nutritious, a few respondents named more than one crop, but respondents mainly named wheat and finger millet: 73% of respondents named finger millet, while 28% of respondents named wheat (respondents could name more than one crop) (Table 6.14). These responses appear to systematically change with the amount of education received: the higher the level of formal education received, the greater the likelihood that a respondent named wheat as the most nutritious crop, and the lower the probability that they named finger millet as the most nutritious crop. This might, however, be more indicative of differences in the influence of mainstream culture between socio-economic classes than

of actual formal schooling, since formal school corresponds well with socio-economic class. Studies have indicated that wheat and rice have greater mainstream appeal over traditional coarse grains, such as finger millet, in great part due to the dedication of agricultural research to improving wheat and rice yields (National Research Council, 1996; Rahbari et al., 2012; Muyonga et al., 2008). In this section, I synthesize the data above to describe how cropping patterns have fulfilled the four goals of household caloric consumption, sustainability, fulfillment of tastes and preferences, and financial profitability.

Table 6.14: Most nutritious crop, by gender, social category, and all surveyed

	Men	**Women**	**Scheduled Castes**	**General Castes**	**All Surveyed**
Total # of respondents	157	150	50	256	307
barley	5%	3%	4%	4%	4%
finger millet	76%	70%	68%	74%	73%
wheat	25%	31%	26%	29%	28%

6.3.1 Agricultural sustainability through choice of crop types

Agricultural sustainability can be measured in terms of the ability of cultivation decisions to meet the perceived challenges of changing weather patterns. Respondents frequently described changing crop types when asked to name adaptations to the adverse effects of changing weather patterns, so if sustainability were the primary concern in deciding what to grow, then crop types that respondents believe will continue to be cultivated and remain important for the future would be expected to be the same as those they believe to be resilient against changing weather patterns.

The data show that respondents believe grains, food crops, to be the most resilient against changing weather patterns, and they believe cash crops, inclusive of peas, cabbage, and potatoes, to be the most susceptible to damage from these weather patterns.

If sustainability were the primary determinant of cultivation decisions, then smallholder farmers would be expected to prioritize growing adverse-weather-resistant grains in the future. Instead, smallholder farmers mainly mention cash crops when asked to name crop types that are important for future cultivation, with the exception of maize and finger millet, which are each named by a third of all respondents. However, neither maize nor finger millet is named as an important crop for the future *as a result* of their capacity to withstand the conditions of adverse weather; rather, respondents believe finger millet and wheat to be important for food and fodder. If sustainability were the primary concern, smallholder farmers would be expected to avoid growing those crops that fare poorest against changing weather patterns. However, the crops that respondents commonly name as susceptible to damage from adverse weather are repeated as crops that they believe will remain stable for cultivation and be important for the future. Specifically, cabbage (59% of all respondents), peas (67%), and potatoes (22%) are named as particularly susceptible to damage from adverse weather, but they are also named to be important for the future by large fractions of respondents (42%, 36%, and 12%, respectively) (Table 6.10).

Therefore, the crops that respondents believe to be important for the future do not align with those best suited to the adverse weather patterns that they observe. Respondents instead prioritize crops that they also observe to be poorly suited to changing weather. In addition, wheat cultivation is believed by 73% of all respondents to have declined in the preceding five years. It was also most frequently mentioned among crops described as declining due to adverse weather. This conflicts with assessments by 11% and 19% of all respondents that wheat was, respectively, susceptible to changing weather and resistant to changing weather (Tables 6.10 and 6.7). Given that two-thirds of respondents cultivate wheat, this apparent confusion could be, in part, due to both

the microclimates of the Ramgarh and Dhari Blocks—the local mean temperature vary by as much as 10° F within a few kilometers—leading to contradictory assessments of the suitability of wheat to higher temperatures. Another possibility is that respondents base their perceptions of the hardiness of wheat on the way they access it, and I would expect respondents who grow wheat to be both more knowledgeable about climate and about the weather-hardiness of wheat than those respondents who obtain their wheat from the Public Distribution System—those who rely on weather patterns for their food source are the most likely to notice weather changes as well as the effects of weather on crops. I explore this relationship in Section 6.4 through univariate logistic regressions of perceptions of grain hardiness and nutrition as univariate functions of specific perceptions of weather patterns.

6.3.2 Agricultural sustainability through changes in cultivation methods

Despite frequently stating that changing crop types is an action taken to cope with adverse weather patterns, respondents do not appear to prioritize adverse-weather-resistant crops as important and stable crops for the future. However, this does not detract from the depth to which the effects of adverse weather patterns and general environmental degradation are felt. When asked about changes in availability of natural resources, over three-quarters of respondents observed declines in lumber for fuel, grass for fodder, and spring water. Less than 10% of respondents noted increases in these resources.

Respondents appear to react to changing weather patterns by altering their cul-

tivation methods, such as increasing the frequency of seed exchange among farmers, changing planting locations of crops, planting trees, changing their planting time, planting faster-maturing varieties and, to a lesser degree, doing more water harvesting and livelihood diversification (Table 6.3). It is worth noting that men were three times as likely as women to mention livelihood diversification as an adaptation to changing weather patterns (Table 6.3). However, there appears to be a limit to the extent to which respondents pursue sustainable methods of cultivation, which is already apparent in the absence of a shift in crop types to grains. Such a shift of crop types to grains would be expected if sustainability with respect to changing weather were the primary concern.

Although nearly every respondent states that they use organic manure for crop cultivation, over 80% of all respondents also use chemical fertilizer and chemical pesticides. Less than 10% of respondents use bio-pesticides, which can include naturally-derived substances from stinging nettles and tobacco leaves (Table A.46). Over three-quarters of respondents also noted that pests and crop diseases were becoming more virulent and arriving earlier (Table A.42). Separately from the survey, I asked several villagers about their chemical pesticide use, and their responses were consistent: (1) without it, their fruit orchards would perish and (2) they never use pesticides on the food that they intend on consuming and only use them on produce they intend to sell. This double-standard for a chemical that villagers understand to be poisonous suggests that cash crops are grown, not only without heeding sustainability, but also without the welfare of the end consumer in mind.

Taken together, these results demonstrate that there is no singular determinant of cropping decisions; rather, the crop types believed to be important for the future

reflect a mix of objectives that include, to a very limited degree, sustainability given the perceived challenges of changing weather patterns. Also, while sustainability might not influence decisions on which crops to cultivate, respondents view it as a formidable force in determining cultivation methods (rainwater harvesting, when to plant, etc.) and general agricultural productivity. Next, I first explore the weight given to fulfillment of tastes and preferences and then examine that of profitability in deciding which crops to grow.

6.3.3 Fulfillment of tastes and preferences

Respondents named finger millet and wheat as the most nutritious crops, which can be interpreted as their preferences, least influenced by sustainability or profitability. While a third of respondents believed finger millet to be important for the future, an equal proportion of respondents also believed finger millet to have declined in cultivation over the preceding five years and respondents largely prioritized non-grain cash crops for the future. Finger millet and wheat were each grown by two-thirds of respondents; taste preferences are fulfilled, for most respondents, by household production, since finger millet is a food crop and not grown for sale. Finger millet was also described as being resilient against changing weather patterns. Therefore, whether or not finger millet is grown or believed to be important for the future can be expected to be a product of considerations of preference and sustainability, and the third of respondents that named finger millet to be important for the future did so because of consumption preferences—for household caloric consumption and use as fodder for livestock—but not because of sustainability. Given that a third of respondents also describe finger millet as having declined in cultivation in the preceding five years, finger millet risks being phased out of cultivation, perhaps given the competing interest of profitability,

a calculation into which it does not seem to figure.

6.3.4 Financial profitability

Finger millet and wheat are common denominators in crop types believed to be (1) preferable for their nutrition and (2) important as food and fodder crops. Finger millet is also seen as resilient against adverse weather, but respondents appear mixed on the capacity of wheat to resist adverse weather. However, although a third of respondents named finger millet to be important for future cultivation, respondents seldom describe its adverse-weather hardiness as the motivating reason for its cultivation. As mentioned previously, weather-hardiness is cited as a motivating reason for continued and future cultivation at similarly low rates (less than 5%) for all crops that are described as remaining stable and important for future cultivation. Instead, the appearance of mainly cash crops—peas, potatoes, and cabbage—among crop types described as remaining stable in cultivation and important for future cultivation in spite of their susceptibility to changing weather patterns evidences the overriding importance of profitability in deciding what to grow.

Respondents speak most directly about the motivation of profitability when asked which types of assistance would encourage them to support the continued cultivation of recently abandoned species and varieties of crops. Table 7.3 shows that the most common responses to this were that a higher market price for the crop variety (68% of respondents) and improved access to irrigation (67%) would aid in the continued cultivation of abandoned species. Respondents with larger landholdings were also more likely than those with smaller landholdings to suggest that higher market prices would

motivate their cultivation of these abandoned species[2], and this may relate to the greater flexibility in cultivation choices that comes with greater landholdings and relatedly, better access to resources (Table A.67). In contrast, the common desire for improved access to irrigation suggests that water access is a problem faced by all in the surveyed population.

The survey data minimally covers fruit cultivation in this region, which comprises a major income-generating activity. As described earlier, the increase in production of peaches and declines for all other fruits (plums, apricots, apples, and pears) relates to a combination of market demand and climatic suitability. In several instances, farmers noted that peaches were both more profitable and were better suited for warmer weather than apples, which they said had seen substantial declines in the area. In fact, apples were more common in cooler parts of the surveyed area, like Hartola in the Ramgarh Block. This phenomenon of rising cultivation of peaches and declining cultivation of apples due to climatic suitability has been noted by the Indian Council of Agricultural Research (Indian Council of Agricultural Research – Zonal Project Directorate Kanpur, 2010).

[2]Seventy-six percent of the 165 households with landholdings greater than or equal to 20 *nali* compared to 59% of the 141 households with less than 20 *nali* of land felt that higher market prices would encourage the cultivation of these abandoned varieties; the former is greater than the latter at a p-value of 6.6×10^{-4}.

6.4 Associations between preferences, perceptions of changing weather and current cultivation

The preceding descriptive statistical data show perceptions of changing weather patterns to be distinct from perceptions of future cultivation, but the nature of their relationships to one another is unclear. For example, we know that the majority of respondents believe finger millet to be the most nutritious crop and that the majority of respondents have noted higher temperatures, but are the same respondents who perceive rising temperatures the ones that believe finger millet to be the most nutritious crop? In this section, I aim to test whether correspondences between preferences, perceptions of changing weather and current cultivation practices are statistically significant, through univariate logistic regression. I explain the fitting of the univariate logistic model in Appendix C and a more detailed treatment can be found in Hosmer and Lemeshow (2000).

Reading the univariate logistic regression tables

In the tables below, each row gives the statistics for a particular univariate regression with the variable specified in the first column as the independent variable and the variable $y_i(x_{1i})$ specified in the table heading as the dependent variable. $1 - p_m$ gives the confidence with which we can reject the null hypothesis that the univariate logistic model predicts the dependent variable no better than the constant-only logistic model. p_{β_1} gives the confidence level of the estimator $\hat{\beta}_1$, and $\mathbf{SE}_1$ gives the standard error of the estimator $\hat{\beta}_1$. **OR** gives the odds ratio[3], and $(\mathbf{OR}_-, \mathbf{OR}_+)$ gives the 95% confidence interval for **OR**. The derivation of these statistics is explained in further

[3]The odds ratio, **OR**, gives the ratio of A to B, where A is the odds of $y_i = 1$ given that $x_{1i} = 1$ to $y_i = 0$ given that $x_{1i} = 1$ and B is the odds of $y_i = 1$ given that $x_{1i} = 0$ to $y_i = 0$ given that $x_{1i} = 0$. An odds ratio of c means that y_i is c times more likely to be true if x_{1i} is true than if x_{1i} were false.

detail in Appendix C.

Finger millet and wheat are common denominators between categories of crops believed to be nutritious, important for current and future cultivation, and resilient against or susceptible to damage from adverse weather. The surveys collected data on whether respondents cultivated wheat and millet and whether respondents noted wheat and finger millet to be the most nutritious crops. In the univariate logistic regressions presented in the next two sections, these are used as dependent binary variables:

- **'Wheat grown'** – '1' when respondent cultivates wheat and '0' when respondent does not
- **'Millet grown'** – '1' when respondent cultivates finger millet and '0' when respondent does not
- **'Wheat nutritious'** – '1' when respondent notes wheat to be the most nutritious crop and '0' when respondent does not
- **'Millet nutritious'** – '1' when respondent believes finger millet to be the most nutritious crop and '0' when respondent does not

6.4.1 Does awareness of changing weather correspond with current cultivation?

In the following set of regressions, I examined whether noting particular weather patterns or believing certain crops were more hardy or nutritious than others was a good predictor for whether respondents cultivated, separately, finger millet and wheat ('Millet grown' and 'Wheat grown,' respectively).

Dependent variable, $y_i(x_{1i})$ = finger millet is currently cultivated, 'Millet grown'

In the univariate logistic regressions presented in Table 6.15, the univariate logistic regressions for whether millet was grown with respect to the independent variables 'Millet hardy,' 'Wheat hardy,' 'Millet nutritious,' and 'Wheat nutritious' are significant at the 95% confidence level. Those who noted wheat to be the most nutritious crop were half as likely as those who did not to grow finger millet, whereas those who noted finger millet to be the most nutritious crop were twice as likely as those who did not to grow finger millet. This shows that food preferences do manifest in cultivation decisions, although they might not be the primary consideration in all cultivation decisions, as shown in the descriptive statistics. Those respondents who believed wheat and finger millet to be hardy against adverse weather patterns were also more likely to cultivate finger millet, which is not a surprising result.

It seems, from these regressions, that perceptions of hardiness of crops and food preferences are good predictors for whether finger millet is cultivated. That noting wheat as a nutritious crop corresponded to a lower likelihood of cultivating finger millet is an interesting result, as it suggests the possibility that preferences are shifting from finger millet to wheat, rather than simply growing more inclusive to encompass both. Whether respondents noted certain changes in weather was not a statistically significant predictor at the 95% confidence level for whether they currently cultivated finger millet. Given the knowledge that survey respondents believe finger millet to be resilient against adverse weather, this aligns with the previous findings through comparison of descriptive statistics that respondents do not prioritize sustainability in their selection of crops that they believe to be important for the future.

At the 80% confidence level, whether or not respondents noted a longer summer was a predictor for whether a respondent cultivated finger millet. It is interesting that those who did note the longer summer season were also three times less likely than those who did not to grow finger millet. This may be explained by the fact that finger millet is a monsoon crop, and its cultivation occurs with the end of the summer and the start of the rainy monsoon season. This may appear to throw into doubt the veracity of respondents' assertion that finger millet is resilient against observed adverse weather patterns (Table 6.7), and it appears to contradict the reasoning that a farmer will observe weather patterns only if those weather patterns are relevant to the crop they are interested in growing. However, three points should be clarified here. First, the weather-resilience of a crop does not mean that it is immune to poor weather but that it is less affected; plants will always require water. Second, whether or not respondents note particular weather patterns can be expected to correspond to the relevance of that weather pattern to their desired crops, whether or not these crops are cultivated. Third, and relatedly, cultivation of and preference for a crop are distinct qualities. Therefore, respondents may prefer a crop and be observant of related weather patterns even though the adverse weather patterns noted do not allow for its cultivation and despite the belief that it is better suited to poor weather than other crops.

Table 6.15: Univariate logistic regressions between whether finger millet is currently cultivated and perceptions of changing weather patterns, food preferences, and whether the respondent thought finger millet and wheat were hardy against adverse weather patterns; p values less than 0.2 are denoted by '*.'

x_{1i}	p_m	$\hat{\beta}_1$	$\mathbf{SE}_{\hat{\beta}_1}$	$p_{\hat{\beta}_1}$	$\mathbf{OR}_-$	$\mathbf{OR}_+$	$\mathbf{OR}$
Temp. increase	0.54	-0.46	0.786	0.279	0.135	2.95	0.631
Unpredictable weather	0.823	0.0629	0.281	0.411	0.614	1.85	1.06
Longer summer	0.16*	-1.19	0.828	0.0746*	0.0598	1.54	0.303
Lower rainfall	0.382	0.239	0.273	0.19	0.744	2.17	1.27
Late rains	0.457	0.233	0.31	0.226	0.687	2.32	1.26
Millet nutritious	0.0064*	0.787	0.285	0.0029*	1.26	3.84	2.2
Wheat nutritious	0.0126*	-0.716	0.284	0.0058*	0.28	0.852	0.489
Millet hardy	0.0000*	1.8	0.293	0.0000*	3.41	10.8	6.06
Wheat hardy	0.0052*	1.14	0.455	0.0063*	1.28	7.59	3.11

Dependent variable, $y_i(x_{1i})$ = wheat is currently cultivated, 'Wheat grown'

In the univariate regressions shown in Table 6.16, only the regressions for food preferences and perceptions of hardiness provided a fit that was statistically significantly different from that of the constant-only logistic model at the 95% confidence level. At the 90% confidence level, whether or not respondents noted that the summer was longer was a statistically significant predictor for whether or not they grew wheat.

Respondents who noted wheat as a nutritious crop were less likely to also be cultivating it, which seems a counterintuitive result if we assume smallholder farmers to cultivate crops that they prefer to eat. The previous set of univariate logistic regressions for dependent variable, 'Millet grown,' also showed a lower likelihood of cultivating finger millet if respondents believed wheat to be the most nutritious crop. Together, these results suggest that those who believe wheat to be the most nutritious crop, in general, are not growing grain, and if this is the case, then those farmers who believe wheat to be the most nutritious crop must be obtaining their grains from elsewhere, such as the market or Indian Public Distribution System.

That respondents who note a longer summer are also less likely to be cultivating wheat may be related to the observed heat sensitivity of wheat (Ortiz et al., 2008), but respondents who note a longer summer are also less likely to cultivate finger millet, which suggests that differences in heat sensitivity or drought-resistance may not be the determining factor explaining this lowered probability of cultivating grains when longer summers are noted. The p-values for both the univariate logistic regressions between (1) noting a longer summer and cultivating finger millet and (2) noting a longer summer and cultivating wheat are relatively high, suggesting that any explanatory power

of noting a longer summer on whether either grain is cultivated is low.

Coupled with the finding in the descriptive statistics that professed beliefs in the cultural, nutritional, and weather-related values of grains do not manifest in valuing these crops for cultivation, these univariate logistic regressions demonstrate that the relationship between beliefs about crops and actual cultivation is indirect and that there may be confounding factors leading to the reduced cultivation of these grains. Intervening steps between whether a weather pattern is observed and whether the crop is cultivated are the respondent's preference for the crop and whether noting a particular weather pattern is related to this preference. These relationships between perceptions of weather patterns and whether the grains are preferred are probed in the following section.

Table 6.16: Univariate logistic regressions between whether wheat is currently cultivated and perceptions of changing weather patterns, food preferences, and whether the respondent thought finger millet and wheat were hardy against adverse weather patterns; p values less than 0.2 are denoted by '*.'

x_{1i}	p_m	$\hat{\beta}_1$	$\mathbf{SE}_1$	$p_{\hat{\beta}_1}$	$\mathbf{OR}_-$	$\mathbf{OR}_+$	$\mathbf{OR}$
Temp. increase	0.339	0.585	0.6	0.165*	0.554	5.81	1.79
Unpredictable weather	0.057*	0.497	0.259	0.0277*	0.989	2.73	1.64
Longer summer	0.054*	-1.63	0.875	0.0316*	0.0354	1.09	0.197
Lower rainfall	0.020*	0.598	0.256	0.0097*	1.1	3	1.82
Late rains	0.164*	0.407	0.289	0.0798*	0.852	2.65	1.5
Millet nutritious	0.001*	0.905	0.272	0.0004*	1.45	4.21	2.47
Wheat nutritious	0.002*	-0.825	0.269	0.0011*	0.258	0.743	0.438
Millet hardy	0.000*	1.63	0.281	0.0000*	2.95	8.87	5.11
Wheat hardy	0.408	0.275	0.337	0.208*	0.68	2.55	1.32

6.4.2 Does awareness of changing weather correspond with food preferences?

The following univariate logistic regressions help answer the question of whether particular perceptions of changing weather patterns have any statistically significant relationships with food preferences. I explore this particular relationship because I

expect those who are not aware of weather patterns to be less dependent on them for food. The preceding set of univariate logistic regressions for 'Wheat grown' and 'Millet grown' as the dependent variables suggest that those who believe wheat to be the most nutritious crop are less likely to cultivate either grain (finger millet and wheat). I expect these same respondents to therefore source their grain from the Public Distribution System (PDS) and report wheat, one of two grains (the other being rice) provided by the PDS as the most nutritious crop.

Dependent variable, $y_i(x_{1i})$ = finger millet is the most nutritious crop, 'Millet nutritious'

The univariate logistic regressions with 'Lower rainfall' and 'Late rains,' both of which have to do with decreased rainfall, seem to be good predictors of whether or not finger millet was seen as a nutritious crop, but perceptions of the unpredictability of weather and temperatures were poor predictors of whether respondents would name finger millet as a nutritious crop. The correspondence between perceived reduced and late rainfall and whether the respondent believed millet to be nutritious, could relate to, as mentioned before, the fact that sowing of millet requires the commencement of the monsoon season. Given the preceding finding that those who believe finger millet to be nutritious are also more likely to cultivate it, it is reasonable to expect these respondents to pay attention to weather patterns that would affect the cultivation of finger millet, which is shown in this regression of 'Millet nutritious' against whether rainfall patterns were noted to be changing.

Table 6.17: Univariate logistic regressions between whether finger millet is believed to be nutritious and whether particular changes in weather patterns were noted by respondents; p values less than 0.2 are denoted by '*.'

x_{1i}	p_m	$\hat{\beta}_1$	$\mathbf{SE}_1$	$p_{\hat{\beta}_1}$	$\mathbf{OR}_-$	$\mathbf{OR}_+$	$\mathbf{OR}$
Temp. increase	0.264	0.687	0.6	0.126*	0.613	6.44	1.99
Unpredictable weather	0.717	0.0974	0.269	0.358	0.651	1.87	1.1
Longer summer	0.544	0.627	1.1	0.285	0.215	16.3	1.87
Lower rainfall	0.0139*	0.642	0.261	0.00692*	1.14	3.17	1.9
Late rains	0.0681*	0.539	0.292	0.0322*	0.968	3.04	1.71

Table 6.18: Univariate logistic regressions between whether wheat is believed to be nutritious and whether particular changes in weather patterns were noted by respondents; p values less than 0.2 are denoted by '*.'

x_{1i}	p_m	$\hat{\beta}_1$	$\mathbf{SE}_1$	$p_{\hat{\beta}_1}$	$\mathbf{OR}_-$	$\mathbf{OR}_+$	$\mathbf{OR}$
Temp. increase	0.101*	-0.989	0.592	0.0475*	0.117	1.19	0.372
Unpredictable weather	0.539	-0.163	0.265	0.269	0.506	1.43	0.849
Longer summer[4]	NA	NA	NA	NA	NA	NA	NA
Lower rainfall	0.0326*	-0.553	0.258	0.0161*	0.347	0.954	0.575
Late rains	0.0575*	-0.556	0.289	0.0272*	0.326	1.01	0.574

Dependent variable, $y_i(x_{1i})$ = wheat is the most nutritious crop, 'Wheat nutritious'

It is interesting that those who observed these specific changing weather patterns were less likely than those who did not to name wheat as a nutritious crop. It further supports the hypothesis that those who believe wheat to be nutritious are not as dependent on and therefore aware of changing weather patterns because they are likely more dependent on obtaining grain from the PDS.

6.4.3 Does awareness of changing weather correspond to beliefs in crop resilience to changing weather patterns?

Dependent variable, $y_i(x_{1i})$ = finger millet is resistant to adverse weather patterns, 'Millet hardy'

'Unpredictable weather' and 'Late rains' show some promise in explaining beliefs of the weather-hardiness of finger millet. These variables correspond, respectively, with the increased unpredictability of weather and the late onset of the monsoon. These two

Table 6.19: Univariate logistic regressions between whether finger millet is believed to be resilient against damage from adverse weather and whether particular changes in weather patterns were noted by respondents; p values less than 0.2 are denoted by '*.'

x_{1i}	p_m	$\hat{\beta}_1$	$\mathbf{SE}_1$	$p_{\hat{\beta}_1}$	$\mathbf{OR}_-$	$\mathbf{OR}_+$	**OR**
Temp. increase	0.444	-0.569	0.786	0.235	0.121	2.64	0.566
Unpredictable weather	0.119*	0.421	0.269	0.0586*	0.9	2.58	1.52
Longer summer	0.676	-0.375	0.876	0.334	0.123	3.83	0.688
Lower rainfall	0.612	0.136	0.267	0.306	0.679	1.93	1.15
Late rains	0.0066*	0.804	0.291	0.00291*	1.26	3.95	2.23

univariate logistic regressions show that respondents who noted these two changes in weather patterns were slightly more likely to believe finger millet to be resilient against damage from changing weather patterns.

Dependent variable, $y_i(x_{1i})$ = wheat is resistant to adverse weather patterns, 'Wheat hardy'

Table 6.20: Univariate logistic regressions between whether wheat is believed to be resilient against damage for adverse weather and whether particular changes in weather patterns were noted by respondents; p values less than 0.2 are denoted by '*.'

x_{1i}	p_m	$\hat{\beta}_1$	$\mathbf{SE}_1$	$p_{\hat{\beta}_1}$	$\mathbf{OR}_-$	$\mathbf{OR}_+$	**OR**
Temp. increase	0.0117*	-1.57	0.598	0.0044*	0.0648	0.674	0.209
Unpredictable weather	0.105*	-0.489	0.299	0.0512*	0.341	1.1	0.613
Longer summer[5]	NA	NA	NA	NA	NA	NA	NA
Lower rainfall	0.00564*	-0.821	0.297	0.00287*	0.246	0.788	0.44
Late rains	0.302	-0.348	0.332	0.147	0.368	1.35	0.706

The results in Table 6.20 are fascinating. Both p_m and $p_{\hat{\beta}_1}$ are fairly low across all climate perception variables (with the exception of 'Longer summer'), suggesting that these are good predictors for whether or not the respondent would note wheat as a crop that was especially resistant to changing weather patterns. The fact that **OR** for all variables are less than 1 (the upper bounds of the 95% confidence interval barely exceed 1 for two variables) suggests that respondents that perceived these changes in weather patterns were less likely than those who did not perceive these changes to note wheat as a crop that was resistant to observed adverse weather, which is most frequently characterized by a longer summer and less rain (Table 6.1). The heat-sensitivity of

wheat is well-studied (Ortiz et al., 2008), so this suggests that smallholder farmers who perceive hotter and drier changes in weather are also aware of the unsuitability of wheat to it.

6.4.4 Summary of associations

Through the preceding univariate logistic regressions, I found that respondents who noticed particular weather patterns were less likely to be cultivating grains but more likely to believe that finger millet was hardy against adverse weather patterns and that it was the most nutritious crop. These respondents were also less likely to believe wheat was nutritious and to consider it a crop resilient against adverse weather.

Respondents who believed wheat to be the most nutritious crop were less likely than those who did not to be cultivating either grain at all, and those who believed finger millet to be the nutritious crop were more likely to be cultivating each of the two grains. This mismatch suggests that those who prefer wheat (by noting it as the most nutritious crop) are not obtaining it from their own cultivation while those who prefer finger millet do obtain it through their own cultivation. In contrast to the relationship between noting particular adverse weather patterns and whether or not the respondent cultivated the grain, the relationship between noting these particular weather patterns and whether finger millet and wheat were each believed to be hardy against adverse weather patterns is more consistent. Those who noticed adverse weather patterns were more likely to believe finger millet to be hardy against changing weather and less likely to name wheat as hardy against changing weather, but these respondents were less likely to be cultivating either grain if they noted these weather patterns, in spite of their beliefs in the suitability of these grains for observed weather. Together, these

yield three major points:

1. Respondents who are attuned to adverse weather patterns are more likely to prefer finger millet for nutrition and to believe in its hardiness against these adverse weather patterns; they are also less likely to prefer wheat for nutrition and believe in its hardiness to adverse weather patterns.

2. Respondents who preferred wheat for nutrition are less likely to be cultivating either grain, and those who believed finger millet to be hardy to adverse weather patterns and who preferred finger millet for nutrition were more likely to be cultivating each grain.

3. Respondents are not able to realize their beliefs in the hardiness of crops to adverse weather and their food preferences through their actual cultivation.

These results underscore the gulf between preferences and realized cultivation. In this case, preferences include those for personal consumption—nutrition—and those for sustainability of agriculture—crops that respondents believed suitable for observed adverse weather patterns. They also illustrate that preferences for wheat do not stem from its cultivation and appear to be less likely if respondents are aware of adverse weather patterns. Combined with the findings from descriptive statistics that profitability is a major driver in cropping decisions, these results suggest that there is a factor, outside of household cultivation, that facilitates affordable access to wheat that is not locally cultivated and that is therefore not well understood with respect to local conditions of cultivation. Furthermore, this low-cost grain renders the market for locally cultivated grain inviable.

6.5 An unanticipated factor: the Public Distribution System

The search for the origin of this low-cost grain ends at the Public Distribution System (PDS), which, as described in Chapters 3 and 4, has been historically designed as a welfare and food security buffer against adverse weather patterns that typically lead to drought and subsequently volatile food prices and famine. As such, it is inextricable from any analysis of the effects of adverse weather on food security. In particular, the findings in this chapter suggest that the PDS may be a powerful player in smallholder farmer cropping decisions, as it may interfere with smallholder farmers' capacity to fulfill their food consumption needs and agricultural sustainability preferences through their own crop cultivation. Below, excerpts are taken from the five in-depth interviews administered in the same study region regarding the perceptions of the future of smallholder agriculture and of the PDS. While these interviews provide no definitive characterization of local trends in agriculture, they do inform the preceding statistical findings. These interviews were also conducted in a mix of Kumaoni and Hindi, and I have only been able to translate the Hindi; I provide some of the Hindi transcriptions as footnotes to the paraphrased or translated quotations.

When asked about her household's use of the PDS, 76 year-old Parvati noted that the PDS provided enough food to sustain her household for half of every month. Regarding grain consumption since her household began accessing the PDS, she stated that families were once able to depend on their own grain cultivation for six months of food, but now, all grain was obtained through the market and the Fair Price Shop[6].

[6]Specifically, Parvati referred to the local Fair Price Shop as "society," one of the common names for the PDS, also noted by Khera (2011b). Other names locally used to refer to the PDS include "ration shop" and "control."

Thirty-two year-old Mukesh remarked, "These days, we grow mostly cabbage and grains have been completely forgotten. But when we grow cabbage, the health of the field is finished. After it is planted, a full field of cabbage requires one or two large doses of fertilizer[7]." Mukesh was also asked whether agriculture had changed since the PDS became available in his area; he responded, "The time of the year that we would grow wheat is now being spent growing peas because the production value is more clear. And after this, we plant potatoes, after which we plant maize and finger millet. Then we plant cabbage.[8]"

A third interviewee, 47 year-old Mohan Singh Bisht noted that he started accessing the PDS in 2000, but when asked whether he believed that the PDS had changed the types of crops that were cultivated, Mohan stated that the PDS had no influence on which crops were planted, because wheat and rice had not previously been planted locally. In addition, he said that if they were unable to purchase wheat and rice from the PDS, they would buy it from the market rather than grow it. This reasoning is fair only if other grains were not typically planted in the region, and Mohan, in particular, stated that maize had been the only other grain they had planted. Even then, he said, maize was planted for animal fodder, rather than human consumption. Mohan's interview was one of five that were from the area covered by the 307-household survey, and it provides a glimpse of the spatial heterogeneity of cropping patterns within the survey area: although Mohan had never grown grains for household consumption, survey data show that at least two-thirds of the 307 respondents grow wheat or finger

[7] *"Ab to gobhii zyaadaa lag diiya... anaaj ko bhuul gayaa hai ekdam... anaaj bhi kam ho chukaa hai. Gobhi lagaake saarii kheton kii tabiyat bhi khatam ho chukaa hai. Ek do samay bahut khaad chaahiye"*

[8] *"Jaise jis taaim hamain gahun lagta hai us taaim men matar lagaanaa shuru karte the kyonki utpaadan zyaadaa saaf, hai na? Aur uske baad aaluu to lagta hii hai... uske baad aaluu men makka aur maduwa... to us men gobhii lagaa dete hain."*

millet for household consumption.

Mohan's rejection of a link between grain cultivation and the PDS also reflects the limits to experiential knowledge and possibly a protective affinity toward the PDS, which has provided villagers with a welcome buffer against food insecurity. Respondents cannot be expected to understand the influence of prices of subsidized commodities on those of substitutes, and in this case, Mohan did not see locally cultivated grains as food substitutes to those offered by the PDS. It is also unlikely that respondents would speak out against and consider negatively a government program that they rely on for basic sustenance. Nonetheless, Mohan's statements do demonstrate that the PDS has become more prominent in the area over the last decade. A fourth interviewee, 62 year-old Divan Ram, also did not believe any change to agriculture had occurred with the increased access to PDS, stating that he continued to plant potatoes and maize, in spite of easier access to grain.

Another striking detail is that none of the interviewees complained about their access to the PDS, and all expressed satisfaction with the amounts that they were accessing. In fact, Divan Ram commented that PDS grain had become more affordable over time—just a year before, wheat had cost eight rupees per kilogram and was now five rupees per kilogram[9]. When asked what would happen if the "ration shop" closed, Divan Ram replied simply that they would die of hunger because the same food was several times more expensive at non-PDS shops: "The rice that we pay three rupees a kilogram for (from the PDS) is twenty-two rupees a kilogram from the shopkeeper."[10]

[9] *"Pahle aath rupaye kilo detaa tha."*

[10] *"Phir bhukhe marenge... agar... sarkaarii dukaan band ho jaae, to phir to bhukh marii aanevaalii huii... (dukaandar) das kii chiiz ko pachiis men detii huii... usii chaaval ko hamko tiin rupaye men detaa hai... usii chaaval ko dukaandar... baaiis rupaye ko bechte hain."*

Combined with the 307-household survey data and the other individual interviews, it is clear that the PDS has subsumed much of the need for household cultivation of grain by providing a highly subsidized access to substitutes, wheat and rice.

Largely absent from the statistics and the specific comments regarding access to the PDS is the sense of anxiety that pervaded all of the interviews during the monsoon season. Each of the interviewees was asked what they believed to be the biggest challenge facing agriculture. The responses centered principally on the lack of rain and the declining fertility of the soil. Mukesh said, "The problem is that day by day, it is extremely hot. Our fields depend solely on water... Without water, we cannot do any work." Similarly, Parvati's greatest concern for the future of local agriculture was that the rain was not arriving when expected. Mohan, too, cited the water shortage as the primary problem; to him, the second-most pressing issue was soil fertility.

Divan Ram emphasized that the government-provided chemical fertilizers had dried his soil and that accessing enough manure (*gobar*), which he saw as the best way to produce large and healthy crops, was the major worry[11]. Regardless of the actual efficacy of chemical fertilizers, Divan Ram's experience reveals a disconnect between a government agricultural support program and the ineffective, perhaps even harmful, use seen by its targeted farmers. Divan Ram also complained that he was not receiving his government pension—it was frequently stolen in transit; he would be notified of its arrival at the mail office but it would be gone by the time he tried to collect it. In contrast, 28 year-old Hira Devi, the fifth interviewee, was unable to volunteer a

[11] *"Gobar kii (samasya) yahii hai. Gobar kii khaad kii kamii hai. Jab sarkaarii khaad daalte hain, tab us se kuchh hotaa nahiin hai... gobar kii khaad padtii thii pahle. Zamiin men namii rahatii thii. Jab ham apne haath se apne bachpan se hain gobar hii* use *karte the... itnee badii makkaa! Itnii lambii!* (motioning the height of the plant)*... Jabse hamne rasaayaanik khaad... tabse hamare zamiin khatam ho gayii usse. Jal gayii mittii, bilkul. Jal."*

response when asked for the most pressing problem facing agriculture, but when asked for her family's source of water, she stated that their water was piped in; that is, her fields were irrigated and therefore did not rely on rainfall.

In all, the expressed anxieties of interviewees and respondents emphasize the immediacy of the challenges of unpredictable weather patterns, and they also show that heightened and reliable access to resources, whether they be irrigation or grain for food, lessens individual dependence on weather patterns and the subsequent level of risk faced by smallholder farmers. However, poorly implemented access to resources, such as grain provisions or fertilizer, can have unintended and harmful consequences for smallholder farmer welfare by reducing the sustainability of their agricultural operations.

6.6 Fitting the framework

The preceding analyses cover a wide range of concerns involving smallholder agriculture, inclusive of sustainability, food preferences, overall welfare, and profitability. The data in this thesis are not sufficient to meaningfully evaluate whether the objectives of smallholder agricultural production or the PDS are fulfilled in the Nainital District of Uttarakhand. Given the focus of this thesis on smallholder farmer welfare and food security, I primarily consider the preceding conclusions within the food security component of the framework described in Chapter 4, although the roles of smallholder agricultural production, the PDS, and agricultural sustainability are integrated below.

6.6.1 Sufficient calories

As Divan Ram, one of the five interviewed about the PDS, said without hesitation, if the PDS were to suddenly close its distribution shops, "*phir, bhukhe marenge*," or "we would die of hunger." True to its historical roots, the PDS provides a caloric buffer against the uncertainties of adverse weather and environmental resources. However, the threats of poor weather to local access to food are still widely felt—86% of all 307 households surveyed volunteered that observed adverse weather patterns had led to decreased household grain production (Table 6.2). Concurrently, with the increasing importance of the PDS, deliberate household production of grain has declined, and smallholder farmers report preferring to plant cash crops, which, by their own reckoning, are most poorly suited to the adverse weather patterns. However, the cash income from these crops can be used to fulfill their caloric needs, provided that local food prices remain affordable. In addition, it is not clear that the landholdings and resources possessed by each family, on average 26.3 *nali* or 1.3 acres, would be sufficient for producing all of the calories needed to sustain each family.

According to Amartya Sen's exchange-entitlements framework, in times of drought, direct food provisions are more effective than cash availability for ensuring access to sufficient calories. In addition, cash crops, as a source of cash income, may be especially unreliable as a source of exchange-entitlements, given that surveyed respondents believed these crops to fare worse than food crops against observed adverse weather.

6.6.2 Regular, reliable, and sustainable food source

The food source of this region is regular and reliable so long as the PDS remains so, and according to the five interviewees, the PDS has become more reliable and af-

fordable over the preceding decade. However, the provision of wheat and rice by the PDS has diminished the local market for traditional grains such as finger millet, which respondents believe to be best suited to observed adverse weather. In this sense, the PDS has shifted the risks felt by smallholder farmers: smallholders now depend on PDS grain for household consumption and their household food supply is less reliant on weather. In fact, the univariate logistic regressions show that those respondents that believe wheat, a primary provision from the PDS, to be the most nutritious crop are less likely than those who do not to note adverse weather patterns.

However, because traditional grains are made less profitable by the availability of heavily subsidized substitutes through the PDS, the surveyed population chooses not to grow the crops best suited to observed weather. As the five interviewees have said, while the PDS is an invaluable food source, it does not fulfill their total food requirements. Therefore, the stability of additional income is important for continued access to food. With much of household income generated through weather-vulnerable cash crops, it is conceivable that the PDS has, on the whole, prevented smallholder farmers from meeting the challenges posed by changing weather patterns on their agriculture, thereby decreasing agricultural sustainability. While this decline in sustainability is not desirable, the PDS has been key to the reduction of the short-term food insecurity generated by unpredictable weather. Nonetheless, the shelving of sustainability concerns underscores the overall short-term nature of decision-making among the surveyed population and raises the question of whether all factors in decision-making can be balanced to focus on long-term survival—can the PDS be changed to buttress long-term food security? I revisit this question in Chapter 7.

6.6.3 A food source that fulfills local preferences

The reliable support of the PDS may be the reason that smallholder farmers are not able to grow finger millet and wheat for income-generation and have observed both crops to have declined in cultivation over the preceding five years. If age category were used as a crude proxy for time, it appears that preference for wheat is increasing, as younger respondents are more likely to prefer wheat than older respondents[12] (Table A.2). This illustrates that the preferences of a population, along with their fulfillment, can shift over time. However, the ability of preferences to shift does not imply that they should not be fulfilled. Preferences and their fulfillment are components of agency and are tied to the realization of other needs. In the case of these smallholder farmers, their food preference for finger millet coincides with the needs of agricultural sustainability, which they believe are best met with grain cultivation. Wheat, on the other hand, is a crop that is declining in cultivation (as described by the great majority of respondents) while rising in preferability as food, a phenomenon that may result from increasing access to PDS provisions.

In general, household consumption is relying less and less on household grain cultivation, as evidenced by the cash crops that respondents believed to be important for cultivation in the future. As discussed previously in Section 6.3.3, although respondents named finger millet as one of the crops most resilient to poor weather, their belief in its continued and future importance for cultivation is based on its value as food and animal fodder. In all, the choice to cultivate finger millet is based at the nexus of the competing objectives of profitability, ephemeral but definitive food consumption preferences, and agricultural sustainability. And the data show that profitability is the

[12]Forty-seven percent of the 93 respondents under the age of forty compared to 19% of the 214 respondents over the age of forty believed wheat to be the most nutritious crop; the former is greater than the latter at a p-value of 3.4×10^{-7}.

dominant motivator for cropping decisions, at the expense of the latter two factors.

Chapter 7

Results and Discussion

7.1 Summary of results

For the surveyed smallholder farming population of the Ramgarh and Dhari Blocks of the Nainital District of Uttarakhand, the needs of sustainability align with nutritional preferences, with respondents most frequently describing local grains such as finger millet as being best suited to the observed adverse weather patterns as well as the preferred grain for consumption. Although the negative effects of changing weather patterns are felt and respondents are forced to change their cultivation methods, adaptation to these adverse weather patterns does not manifest in changing cropping patterns; resilience of a particular crop type against changing weather is not a dominant factor in deciding what to plant.

Instead, respondents focus on cultivating cash crops, in spite of their vulnerability to observed adverse weather patterns. This reveals profitability as the primary motivator for crop cultivation. If profitability is the dominant factor, then finger millet and wheat must not be profitable. This is already apparent from the finding that they are

primarily cultivated for household consumption, but this alone does not explain why these two grains are not economically viable. The Public Distribution System emerges as a factor in the low profitability of finger millet and wheat—according to the five in-depth interviews and existing literature (Khera, 2011b), wheat is reliably provided at prices between 3-5 rupees per kilogram by the Indian Public Distribution System. This decreases demand for close substitutes, such as household-cultivated grain.

In addition, univariate logistic regressions detail the ways in which respondents do not realize their sustainability needs and their food preferences through their crop cultivation choices. Preferences for crop types seemed to correspond with whether or not respondents noticed weather patterns, suggesting that interest in particular crops was not tied to access through household cultivation but through other means. In particular, the univariate logistic regressions show that those who observed particular adverse weather patterns were less likely than those who did not to believe wheat to be the most nutritious crop and resilient against adverse weather; in contrast, those who noticed particular weather patterns were more likely to believe finger millet to be the most nutritious crop and to be resilient against changing weather patterns. Also, those who believed in the hardiness of finger millet to changing weather and in its nutritiousness were more likely to be cultivating grains, whereas those who believed in the hardiness of wheat to changing weather were less likely to cultivate grains. In addition to suggesting that respondents were accessing wheat through the market or other sources independent of household cultivation, these results suggest that the nature of access to food may influence community preferences and understandings of sustainability.

The distinctions between food preferences, sustainability needs, and actual cul-

tivation decisions are most apparent in the finding that those who noticed adverse weather patterns were less likely to be cultivating wheat and finger millet, in spite of the descriptive statistics that show respondents to believe in the weather-resilience of finger millet and their preference for it as food. Overall, income-generation through weather-vulnerable and unsustainable cash crops appears to be the main priority of the surveyed population. Perhaps cash crops are seen as the best short-term welfare solution to the uncertainties created by adverse and unpredictable weather. It is also clear that the PDS, which reduces the burden on agriculture to produce sufficient food for household consumption, has a role in shifting food preferences and facilitating the focus of subsistence-level agriculture on cash crops rather than food crops for household consumption.

Several tensions emerge from the network of relationships that precipitates cultivation decisions that do not address local food preferences and sustainability needs. Among these are the value placed on the agency of a community to choose their food source and the proportionate amount of environmental risk borne by smallholder farming communities, compared to that endured by non-farming communities, which still rely on sufficient food production. The relative values of community-level preferences that are arguably ephemeral and the ability of communities to decide on methods to sustainably conserve and utilize the environmental resources upon which their livelihoods depend can be related to the tenets of common pool resource (CPR) conservation in Elinor Ostrom's *Governing the Commons*. Ostrom's analysis is, as explored in Chapter 2, as much about CPR conservation as it is the capacity of within-community institutions to avert failure rather than rely on externally forced incentives to "fix" an existing problem. Ostrom also emphasizes the need to the value the agency within the community in forming these institutions. This concept is applicable to the small-

holder farmers of the Nainital District, whose agency can be credited by heeding their preferences and conceptions of sustainability in the types of aid that are provided to them. These choices of smallholder farmers can also be cast in terms of long-term and short-term considerations, with sustainability being based among the former and profitability or income-generation being centered among the latter. I explore these tensions, below.

7.2 Answering the original question

The original purpose of this study, as suggested by the title of the Gene Campaign survey shown in Appendix B[1], was to determine whether smallholder farmers notice and have been able to adapt to changing climate. This study shows, unequivocally, that the smallholder farmers of the Nainital District of Uttarkhand are noticing substantial shifts in weather patterns, inclusive of warmer temperatures and less predictable rains. Unexpectedly, in spite of their awareness of changing weather patterns and of the specific crops that would be most hardy to these weather patterns, these subsistence-level farmers are not meeting the needs of agricultural sustainability by growing crop types that they believe to be more suitable to observed weather patterns. Respondents also believe traditional food crops to be better suited to these weather patterns than cash crops. The intervening role of the Public Distribution System in facilitating the diversion of smallholder agricultural resources away from household food cultivation to cash crop production therefore merits more detailed consideration.

[1] "*Paramparaagat Phasalen, Mausam Parivartan, aur Krishi*" or "Traditional Crops, Climate Change, and Farming"

7.3 Exchange-entitlements and sustainability

As described in Chapters 2 and 3, food access can be considered within Amartya Sen's exchange-entitlements framework, as the vector of possessions, including their own labor, that a person can exchange for access to food: "It depends on what he owns, what exchange possibilities are offered to him, what is given to him for free, and what is taken away from him" (Sen, 1981). The short-term and immediate components of exchange-entitlements are clearest—actual food provisions, cash income, and labor. Sen (1981) and Drèze and Sen (1989) also highlight the role of public action and support in compensating for deficits in individual exchange-entitlements, either through direct food provision, public works, and the necessary public agitation for improved state-provided social welfare.

While Sen (1981) remarks specifically about the purpose of public support in buffering any vulnerabilities in exchange-entitlements, the value of environmental resources and their continued sustainable use in enhancing access to this vector of exchange-entitlements is less obvious. Sen (1981)'s focus on the short-term is consistent with his analysis of famines, immediate and acute phenomena, in contrast the long-term afflictions of hunger and chronic food insecurity. However, Sen (1981) does touch upon the dependence on natural resources as a form of insurance against famine, in particular, referring to institutional incentives that led Sahelian pastoralists to individually keep large herds that, in aggregate, exceeded the carrying capacity of the land. These pastoralists would reason that these animals could be sold in times of famine, even though cumulatively large herds would exhaust the future grazing potential of the land—a tragedy of the commons. As discussed in Chapter 2 in the work of Ostrom (1990), supplying the institutions to govern the use of the commons is the first dilemma to

overcome in the conservation of the commons.

Although neither Ostrom (1990) nor Sen (1981) explicitly discusses sustainability or the temporal scale of exchange-entitlements, Sen (1981)'s example of the Sahelian pastoralists is a good illustration of understanding natural resources (and their sustainable conservation) as factors in the durable ability of rural communities avert famines and chronic hunger. Many of the common exchange-entitlements of subsistence-level agriculturalists, inclusive of cash income, labor, and food provisions, are contingent on the quality of environmental resources—agricultural labor employment is available when weather is favorable and the growing season can commence; the potential for crop cultivation for household consumption is dependent on the quality of agricultural resources; even the income-generating cash crops rely on continued availability of local agricultural resources.

The onset of food insecurity in the rural famines studied by Sen (1981) is sparked by the anticipated effects of unpredicted and adverse weather phenomena on environmental and agricultural resources. From this perspective, stability, predictability, and overall sustainability of environmental and agricultural resource access may have as great a role in alleviating weather-precipitated crises as do direct food provisions[2]. Direct food provisions, such as those through the Indian Public Distribution System, have heavily reduced the potential for widespread famine and arguably lessened chronic hunger by raising immediate exchange-entitlements derived from public support. However, as this work suggests, while the PDS has raised exchange-entitlements in the short-term, it may have contributed to the reduction of long-term exchange-entitlements by (1)

[2]Sen (1981) describes direct food provision as the primary method of breaking a famine and more permanently, "public institutions guaranteeing food entitlement."

constraining the capacity of the smallholder farmers to cultivate a sustainable local food supply, given the challenges of changing climate, and (2) by facilitating a shift toward cash-cropping. The conflict between short-term and long-term food security leads to the following question: is there necessarily a trade-off between the direct government distribution of food and the continued sustainability of local agriculture, or is it possible to simultaneously meet both needs through the PDS?

Future work is therefore necessary to better understand the role of public welfare programs in determining exchange-entitlements, both short- and long-term. Given the growing challenges of climate change, it is imperative that considerations of sustainability become institutional components of programs that aim to permanently alleviate chronic hunger.

7.4 Capability and achievement

As described in Chapter 4, the definition of sustainable development, as "development which meets the needs of the present without compromising the ability of the future generations to meet their needs," expands the understanding of sustainability from general avoidance of environmental ruin to encompass the capacity of a community to perpetuate its way of life into the future (on Environment and Development, 1987). However, definitions of the "needs of the present" and "needs of the future" are hardly static through time, let alone across regions or community-boundaries.

The shifting nature of preferences, choices, and their realization over time and across populations is apparent in the results of this study. For example, I found that smallholder farmers under the age of forty considered wheat to be the most nutritious

crop at much higher frequency than those over the age of forty, who more consistently named finger millet as the most nutritious crop. The shifting nature of food preferences that this implies may be taken to indicate that population food preferences do not matter in policy because such preferences are ephemeral. In addition, the contradiction between actual cropping decisions and professed beliefs in cropping decisions necessary to withstand the adverse weather patterns could be interpreted as an overall lack of interest in sustainability, rather than the absence of capability to realize these beliefs in sustainability. However, preferences and the availability of choices, whether or not they are realized or permanent, deserve attention as components of welfare at any point in time. As discussed in Chapter 3, capability is the "real opportunity" that an individual has "to achieve those things that she has reason to value" (Sen, 2009). Sen (2009) explicates the difference between achieved functioning and capability through the following example:

"In terms of being hungry and undernourished, a person who voluntarily fasts, for political or religious reasons, may be just as deprived of food and nourishment as famine-stricken victim. Their manifest undernutrition—their achieved functioning—may be much the same, and yet the capability of the well-off person who *chooses* to fast may be much larger than that of the person who starves involuntarily because of poverty and destitution[3]."

If the opportunities to realize preferences and beliefs are considered a component of welfare—taking the capability-approach—then it becomes clear that the smallholder farmers of the Nainital District are functioning with reduced capability and welfare, perhaps as a collateral consequence of the PDS. Given its purpose in raising and main-

[3]p. 237

taining social security and welfare, the PDS policy should therefore be oriented to facilitate the preferences and needs of the local population, if it is to simultaneously raise overall capability and the well-being of this population. In the next section, I suggest a possible way to revise the PDS to more comprehensively account for welfare, and I provide alternative policy conceptions in supporting smallholder agricultural communities to meet the challenges of changing climate.

7.5 Recommendations for food security and agricultural policy

7.5.1 Reforming the Public Distribution System

As the primary policy treatment of food security and agriculture in India, the Indian Public Distribution System can be revised to account for its influences on the sustainability of local agriculture and on the ability of a population to meet its preferences. As Khera (2011b) also found in her survey of BPL recipients of PDS rations, respondents to the 307-household survey used in this study favored consumption of finger millet, or *ragi*. These respondents also believed traditional grains to be best suited to the adverse weather patterns that they observed, but the lack of economic viability of these grains precluded their cultivation and limited their consumption.

As it is, the FCI procurement of grains for the PDS focuses on rice and wheat, therefore encouraging their cultivation—these are the grains for which farmers are assured a buyer at the end of the growing season. As is clear among the surveyed population (see Chapter 6), profitability overcomes all other motivations in the cultivation of a crop, especially once basic sustenance is assured. One way to ensure

that traditional grains are still profitable for the farmers that cultivate them would be for the government to procure these grains directly from the PDS recipient population, guaranteeing minimum support prices for the cultivation of these grains. The assessment of preferred grains for each particular region, both for food consumption and sustainable agriculture, could be done in a participatory manner through surveys. Such a welfare program would appropriately treat PDS recipients as agents with raised capabilities rather than as passive beneficiaries. It would also solve the dual problem of ensuring basic sustenance while encouraging local sustainable agriculture and fulfilling local preferences. Encouragement of sustainable practices as envisioned by the local population also permits smallholder farmers to meet the environmental risks on their own terms, risks that they bear disproportionately in contrast to non-agricultural populations. The initial administrative costs of this may be high, as this would be a type of targeted program, but it is possible that the localization of procurement with distribution sites could reduce transportation costs.

As described in Chapter 3, the errors of exclusion in targeted welfare programs are arguably worse than errors of inclusion in universal welfare programs, as the former incur mainly additional financial costs but reach intended recipients while the latter may mean reaching fewer of intended recipients and still incur high financial costs due to additional administration. It is possible that tailoring PDS to each region may not be as complex as it seems at the outset: as it is, each Indian state has its own agricultural body and an understanding of the local geographic distribution of agricultural practices; in addition, individual Indian states are already left to administer their own PDS and have been, as Khera (2011b) notes, providing additional commodities through the PDS.

In all, these areas of welfare policy are in need of greater study, as the precise reforms necessary for the PDS are not possible to gauge from analysis of a single region. However, the results of this work suggest that government social security programs should take an approach that incorporates sustainability and food preferences and, more generally, accounts for the collateral effects on welfare that occur through constrained livelihood choices and reduced capability. By including these broader effects, such policy treatments can be expected to aid in ensuring food security and facilitating poverty alleviation over the long-term.

7.5.2 Assistance requested by surveyed farmers

The reforms and considerations above are based upon the preceding analyses of farmer decision-making and preferences, but the surveyed farmers also requested specific agricultural aid. By recommending participatory planning and attention to local preferences in international development, this work would be incomplete without discussion of these expressed preferences.

Seed access and information provision

When asked about the immediate effects of observed adverse weather on their agriculture, respondents noted, as described in Chapter 6, that poor weather had caused yield to decline, changes to the length and timing of the growing season, and decreased grain production (Table 6.2). When asked about the challenges they faced in averting these effects, respondents most frequently volunteered the lack of money, lack of seeds, and lack of proper information (Table 7.1).

The complaints of inadequate funding are harder to meet than the provision of seeds and information, and government provision of additional cash stipends to deal

Table 7.1: Challenges to adapting to weather, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
4.2 Lack of proper information	66%	69%	72%	66%	67%
4.2 Lack of seeds	66%	68%	82%	64%	67%
4.2 Extra burden on farm work	9%	3%	4%	7%	6%
4.2 Lack of money	74%	69%	58%	74%	71%
4.2 Lack of labor	34%	21%	18%	30%	28%
4.2 Do not know	2%	5%	8%	2%	4%

with adverse weather may not be the best way to deal with unpredictable weather, if the volatility of local prices is a result of such weather. When asked where they typically obtain their seeds from (for crops that they believed to be best suited to adverse weather), respondents most commonly stated that they purchased from the market or used their own saved seeds. An alternative to market purchase and self-storage of seeds is the institution of community seed banks and the provision of knowledge to store seeds. The provision of such knowledge and infrastructure is a policy measure that would lessen the risks and impact of adverse weather and also allow these farmers to meet weather-related challenges on their own terms.

Table 7.2: Access to adverse-weather-resistant seeds, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
3.9 Own saved seed	80%	73%	82%	75%	76%
3.9 Relative/friend	51%	59%	54%	55%	55%
3.9 University	0%	0%	0%	0%	0%
3.9 Government	1%	1%	0%	1%	1%
3.9 Community Seed Bank	1%	0%	0%	0%	0%
3.9 Market	50%	63%	62%	55%	57%
3.9 Do not know	9%	11%	12%	10%	10%

Irrigation

Although the lack of water was not a typically noted response among those given for the challenges in adapting to adverse weather patterns, the dearth of water resources was likely interpreted as one of the effects of adverse weather, rather than a

challenge to adapting to it. The focus on shortages in water resources is apparent in the majorities of respondents that noted reduced rainfall, delayed arrival of rains and longer summers as some of the observed adverse weather patterns. Accordingly, better irrigation and rainwater harvesting infrastructure could offset the immediate effects of changing weather.

At present, the national average proportion of Indian agricultural area that is irrigated is 40% (HT Correspondent, 2013), and according to the 307-household survey used in this study, about 15% of smallholder agricultural area in the study region is irrigated (Table 5.6). In addition, when asked for their preferred assistance for cultivation of recently abandoned crops, respondents most frequently named higher market price, improved access to irrigation, assured access to seeds of landraces[4], and training to improve yield and raise income. The request for higher market prices in conserving these grains is consistent with the findings that economic viability of locally produced grains remains a dominant factor in their limited cultivation. Strengthened access to irrigation is therefore a policy that could lessen the direct environmental risk borne by these smallholder farmers and allow them greater flexibility in their crop choices. Of course, no amount of irrigation infrastructure can make up for the shortage and irregularity of local water resources, so the sustainable access and use of the latter would be an immediate priority.

The Ramgarh and Dhari Blocks of the Nainital District are accessible to a number of local rural development non-governmental organizations and government-sponsored agricultural bodies, which may have the resources to facilitate the creation of such infrastructure. However, the results of this study stress that such infrastructure is still

[4]A landrace is another term for a traditional variety of a crop.

Table 7.3: Preferred assistance for culivating abandoned crops, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
3.11 An award	22%	18%	22%	20%	20%
3.11 Improved access to irrigation	69%	66%	62%	69%	67%
3.11 Training to improve yield and value addition to increase income	53%	49%	50%	52%	51%
3.11 Assured access to seeds of landraces	63%	59%	68%	60%	61%
3.11 Access to value-addition infrastructure	27%	7%	6%	20%	18%
3.11 Access to credit/crop loan	11%	3%	4%	7%	7%
3.11 Higher market price	68%	69%	74%	67%	68%
3.11 Fixed sum cash payment for land race conservation	4%	6%	8%	5%	5%
3.11 Other (specify)	1%	1%	0%	1%	1%

lacking. Ultimately, institution-building between community-level organizations and these outside organizations will be crucial to the effective implementation of community seed banks, information provision, and irrigation infrastructure. These are hardly solutions to the immediate problem of climate change, but they are steps toward participatory agricultural adaption to its effects.

7.6 The international development lens

In Chapter 2, I argued that taking a framework-based approach to understanding situations in the developing world broadened the space of possible solutions while laying bare the necessary assumptions. In contrast, narrowing an inquiry to a single question with just one independent variable prohibits a complete understanding of a problem and constrains the solution space. I also reasoned that international development should focus on enabling communities to build their own institutions and to design their own goals rather than on exerting paternalistic forces to achieve externally-prescribed results.

The application of the framework-based approach in this study demonstrates these

claims. While this research began as a study of whether smallholder farmers were responding to changing weather patterns through their choice of crop types, several powerful confounding factors in this presupposed relationship became apparent. The framework-based analysis allowed for the inclusion of other variables, such as the PDS, the motivation of profitability, and the ability of farmers to realize their preferences. Had I strictly followed the line of inquiry that assumed agricultural adaptation to changing climate to manifest in cropping decisions, the resulting answer to this question—that farmers were not adapting to observed changing weather patterns through crop choices—would have been true, but incomplete. Within the constrained inquiry, it may not have become apparent that profitability was a dominant concern, although food preferences and the anxiety over unpredictable weather remained looming factors. A limitation to this framework-based analysis is a lack of any precise quantification of the relative influence of different factors; nonetheless, it is not clear that precise quantification of the influence of each of these factors was possible, as many were correlated with one another—i.e. food preferences could be shaped by the types of food provided in the market, although both are factors in which types of crops to grow. In addition, the inclusion of multiple factors already allowed for dominant ones to emerge, providing sufficiently useful information for policy recommendations.

In Chapter 2, I drew from Sen (1981), Ostrom (1990), and Tendler (1997) to discuss the importance of valuing the agency and institutions of communities that are targeted by international development initiatives. In this study, I placed a great amount of weight on the expressed needs, concerns, and preferences of the surveyed smallholder farmers in Nainital in assessing whether they have been able to adapt to changing climate. The recommended solutions in the preceding section, for reforming the PDS and meeting smallholder farmer agricultural needs, are built on these community pref-

erences rather than purely on underlying conceptions of what I believe this community *should* want. Indeed, it is impossible for this study to fully escape my own convictions that these smallholder farmers deserve opportunities to achieve healthy and sustainable lifestyles. This is a problem for any outsider attempting to understand a community.

In spite of this unavoidable bias, the recommendations have been deliberately based on reconciling the often-conflicting expressed needs of surveyed farmers—i.e. higher agricultural profits, the freedom to grow food that is sustainable and preferred for local consumption. While this study focused on the agency of the community and attempted to tease apart the several mechanisms of rural food security, it was not an exploration of extant community institutions. Future work will need to better understand how rural communities can form institutions that increase their sustainability and their general resilience and adaptation to changing climate. Given its ability to more comprehensively assess a situation, framework-based research that accounts for institutions, the agency of the community, and the multifactorial nature of social phenomena is a better position than studies of linear causality to contribute to the durable elimination of poverty.

7.7 Conclusion

In this study, I demonstrated that the smallholder farmers of the Ramgarh and Dhari Blocks of the Nainital District in Uttarkhand, India have noticed changes in weather patterns that have negatively affected local agriculture. Although they report traditional grains to be better suited to these changing weather patterns, they choose to cultivate cash crops that are less suitable to changing weather but valued for their income-generation. I found that although the PDS is a welcome buffer against the

effects of adverse weather and strengthens food security by ensuring grain access, it contributed to the lack of profitability of local grain cultivation, therefore restricting the capacity of smallholder farmers to meet their sustainability needs.

This thesis is ultimately a study of the multifactorial nature of smallholder farmer food security, given the context of changing climate and a public welfare program. As I complete this work in June 2013 in Delhi, the Government of India is considering passing *The National Food Security Bill, 2013* which maintains some components of the existing PDS, such as targeting, but lists reforms, such as increasing transparency of recipient lists and introducing the use of biometric data to verify the identities of recipients. It is clear that public welfare is at the top of the Indian government agenda and is something that can be expected to change rapidly. However, it remains to be seen whether such reforms will actually transpire and if their effects will be as intended—or if, for example, the attempt at using biometric data will simply exclude needy recipients.

The National Food Security Bill, 2013 illustrates that policymakers have yet to consider the broader effects of food security programs on long-term sustainability and smallholder agricultural livelihoods. Perhaps the underlying challenge in comprehensively understanding rural food security remains the difficulty in understanding the smallholder subsistence-level agriculturalist as an agent rather than welfare recipient. This distinction may prove more crucial as the challenges of changing climate continue to grow and farmers continue to bear the brunt of these environmental risks.

Appendix A

Survey Data

A.1 Data organization

I have organized all data calculations according to the following baseline factors: age category, maximum achieved education level, gender, size of landholding, and social category. For data that has been separated in this way, all percentages reflect the proportion of members of each category. The units and meanings of other numbers are specified for each chart (i.e. average landholding size, number of respondents, etc.). Question numbers and section headings correspond to those in the actual survey form, given in English in Appendix B.

This system allows us to visualize the ways in which baseline factors correspond to obseervations. For example, there are 50 respondents in the Scheduled Castes, so the 4% written next to the row heading, "1.18 Labor Hired?" indicates that 4% of the 50 respondents in the Scheduled Castes hired labor. Table A.26 also shows that 25% of General Caste respondents hired labor, which is much higher than the 4% for Scheduled Caste members. This implies that General Caste members are more likely

than those in Scheduled Castes to have the disposable income to hire labor from outside the household.

A.2 Most nutritious crop

Respondents were asked to name the crop that they believed to be most nutritious. Crops mentioned by over 5% of respondents are named in the charts below.

Table A.1: Most nutritious crop, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	**10-19 nali**	**20-29 nali**	**30-39 nali**	**40 nali <**
Total # of respondents	53	88	60	39	66
barley	0%	2%	7%	3%	8%
finger millet	70%	74%	75%	74%	71%
wheat	32%	32%	22%	28%	26%

Table A.2: Most nutritious crop, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	**Age 40-49**	**Age 50-59**	**Age 60-69**	**Age >69**
Total # of respondents	93	89	67	25	33
barley	0%	6%	1%	8%	12%
finger millet	57%	82%	82%	80%	70%
wheat	47%	20%	22%	8%	21%

Table A.3: Most nutritious crop, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	**Primary School**	**Secondary School**	**Intermediate**	**University Degree**
Total # of respondents	60	93	117	28	9
barley	5%	4%	3%	7%	0%
finger millet	85%	76%	70%	54%	56%
wheat	17%	23%	33%	43%	44%

A.3 Crops that have declined in the past five years

Respondents were asked to name up to five crops that they believed to have declined in the preceding five years, and only crops that are mentioned by over 10% of respondents are listed below.

Table A.4: Crops that have declined in the past five years, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
barley	26%	32%	18%	26%	24%
cabbage	19%	15%	28%	10%	27%
maize	21%	24%	20%	21%	29%
finger millet	11%	41%	30%	49%	33%
peas	23%	24%	35%	21%	21%
potato	45%	41%	63%	41%	52%
wheat	62%	70%	68%	82%	83%

Table A.5: Crops that have declined in the past five years, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
barley	26%	30%	27%	12%	21%
cabbage	26%	13%	24%	16%	18%
maize	19%	21%	33%	20%	24%
finger millet	35%	30%	31%	48%	24%
peas	27%	22%	22%	32%	24%
potato	53%	46%	54%	40%	39%
wheat	72%	79%	78%	60%	61%

Table A.6: Crops that have declined in the past five years, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
barley	13%	34%	25%	25%	0%
cabbage	28%	18%	17%	18%	33%
maize	20%	27%	22%	21%	33%
finger millet	22%	35%	34%	43%	33%
peas	40%	22%	21%	18%	22%
potato	57%	47%	47%	43%	44%
wheat	68%	81%	71%	68%	67%

A.4 Crops that will remain stable or increase in cultivation in the future

Respondents wered asked to name crops that they believed would remain stable to increase in cultivation in the future. Only crops named by over 10% of respondents are listed in the charts below.

Table A.7: Crops that have declined in the past five years, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
French beans	15%	20%	20%	21%	12%
cabbage	34%	45%	43%	46%	39%
maize	30%	31%	37%	15%	32%
finger millet	36%	23%	40%	26%	35%
legumes	30%	33%	35%	36%	42%
peas	30%	39%	38%	28%	38%
potato	9%	16%	12%	10%	12%

Table A.8: Crops that will remain stable or increase in cultivation in the future, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
French beans	14%	24%	24%	8%	6%
cabbage	52%	39%	42%	28%	33%
maize	34%	30%	31%	24%	18%
finger millet	24%	35%	28%	32%	48%
legumes	37%	36%	42%	32%	18%
peas	41%	36%	33%	24%	33%
potato	15%	11%	10%	12%	12%

Table A.9: Crops that will remain stable or increase in cultivation in the future, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
French beans	30%	18%	13%	11%	11%
cabbage	37%	43%	43%	43%	56%
maize	37%	34%	22%	32%	33%
finger millet	42%	34%	26%	21%	33%
legumes	37%	39%	36%	25%	11%
peas	23%	38%	43%	32%	11%
potato	3%	14%	15%	14%	22%

A.5 Crops susceptible to damage from adverse weather

Respondents were asked to name crops that they believed to be susceptible to adverse weather, and only crops that were named by over 10% of respondents are listed in the charts below.

Table A.10: Crops susceptible to damage from adverse weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
French beans	19%	20%	17%	18%	35%
cabbage	38%	59%	63%	59%	70%
bell pepper	13%	17%	15%	21%	8%
chiles	60%	52%	42%	31%	45%
eggplant	8%	15%	13%	10%	8%
peas	55%	66%	70%	62%	79%
potato	13%	17%	30%	15%	30%
tomato	75%	77%	80%	77%	73%
wheat	4%	13%	12%	8%	15%

Table A.11: Crops susceptible to damage from adverse weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
French beans	20%	25%	21%	20%	24%
cabbage	72%	52%	61%	44%	45%
bell pepper	14%	15%	13%	20%	12%
chiles	42%	48%	45%	56%	58%
eggplant	6%	16%	16%	4%	6%
peas	80%	63%	72%	60%	39%
potato	28%	18%	22%	4%	27%
tomato	71%	88%	70%	76%	73%
wheat	9%	3%	24%	12%	9%

Table A.12: Crops susceptible to damage from adverse weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
French beans	23%	19%	21%	36%	22%
cabbage	50%	63%	61%	50%	67%
bell pepper	13%	4%	18%	29%	33%
chiles	52%	54%	44%	36%	22%
eggplant	13%	13%	10%	7%	0%
peas	70%	75%	59%	64%	78%
potato	18%	24%	20%	36%	11%
tomato	72%	76%	76%	86%	78%
wheat	22%	10%	8%	4%	11%

A.6 Crop that are resilient to adverse weather

Respondents were asked which crops they believed to be resilient to adverse weather, and only crops that are named by over 10% of respondents are listed in the charts below.

Table A.13: Crops that are resilient to adverse weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
barley	43%	45%	48%	36%	68%
barnyard millet	13%	10%	15%	23%	15%
maize	36%	52%	48%	51%	58%
finger millet	66%	76%	72%	64%	89%
foxtail millet	17%	18%	18%	23%	15%
wheat	15%	15%	20%	28%	20%

Table A.14: Crops that are resilient to adverse weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
barley	63%	46%	51%	24%	36%
barnyard millet	11%	8%	13%	28%	33%
maize	58%	54%	51%	20%	36%
finger millet	82%	73%	73%	64%	73%
foxtail millet	13%	12%	21%	12%	45%
wheat	18%	25%	16%	12%	12%

Table A.15: Crops that are resilient to adverse weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
barley	45%	53%	51%	39%	56%
barnyard millet	17%	15%	13%	11%	22%
maize	37%	65%	47%	43%	44%
finger millet	73%	82%	72%	71%	67%
foxtail millet	32%	19%	11%	14%	11%
wheat	5%	23%	21%	25%	11%

A.7 Crops no longer grown named to be resilient to adverse weather

Respondents were asked to name crops that were no longer grown that they believed to be resilient to adverse weather, and only crops named by over 10% of respondents are listed in the charts below.

Table A.16: Crops no longer grown named to be resilient to adverse weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
barley	25%	36%	38%	44%	48%
barnyard millet	19%	13%	22%	41%	20%
maize	21%	30%	30%	36%	32%
finger millet	47%	50%	45%	46%	50%
foxtail millet	11%	22%	17%	36%	20%
rice	11%	6%	8%	15%	18%
rusii	8%	8%	12%	8%	17%

Table A.17: Crops no longer grown named to be resilient to adverse weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
barley	44%	40%	37%	28%	27%
barnyard millet	22%	16%	18%	16%	39%
maize	33%	29%	33%	20%	21%
finger millet	56%	39%	51%	36%	55%
foxtail millet	20%	16%	21%	16%	33%
rice	6%	10%	13%	8%	24%
rusii	14%	11%	10%	0%	6%

Table A.18: Crops no longer grown named to be resilient to adverse weather, by educational category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
barley	37%	49%	33%	32%	22%
barnyard millet	23%	24%	17%	14%	33%
maize	28%	38%	25%	21%	44%
finger millet	40%	53%	50%	43%	56%
foxtail millet	28%	19%	18%	14%	22%
rice	12%	14%	10%	7%	0%
rusii	12%	10%	13%	4%	0%

A.8 Other questions

The results of the 307-household survey that have not been presented in previous sections are given below. 'Total # of Respondents' gives the total number of respondents in each category specified by the column heading, and all percentages are proportions of the relevant subcategory answering yes to the question or providing the particular open-ended response when asked the question in the heading. The numbers in the question headings correspond to the question numbers as they appear in the actual survey form.

1.19-1.20 Have you ever been provided with information on climate change and its risks?

Table A.19: Provision of information about climate change, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
1.19 Information provided about climate change	8%	10%	22%	23%	12%
1.20 MOA (Ministry of Agriculture)	0%	1%	0%	0%	2%
1.20 Research	2%	0%	2%	0%	0%
1.20 University	0%	0%	0%	3%	0%
1.20 NGO	2%	1%	2%	0%	0%
1.20 Friend or relative	2%	3%	7%	10%	9%

Table A.20: Provision of information about climate change, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
1.19 Information provided about climate change	11%	13%	16%	20%	15%
1.20 MOA (Ministry of Agriculture)	0%	1%	1%	0%	0%
1.20 Research	0%	0%	1%	0%	3%
1.20 University	0%	1%	0%	0%	0%
1.20 NGO	1%	1%	0%	4%	0%
1.20 Friend or relative	5%	8%	6%	4%	3%

Table A.21: Provision of information about climate change, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
1.19 Information provided about climate change	7%	5%	21%	18%	44%
1.20 MOA (Ministry of Agriculture)	0%	1%	0%	4%	0%
1.20 Research	2%	0%	1%	0%	0%
1.20 University	0%	0%	0%	4%	0%
1.20 NGO	2%	1%	1%	0%	0%
1.20 Friend or relative	2%	1%	11%	7%	11%

Table A.22: Provision of information about climate change, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
1.19 Information provided about climate change	19%	9%	4%	16%	14%
1.20 MOA (Ministry of Agriculture)	1%	1%	0%	1%	1%
1.20 Research	1%	0%	0%	1%	1%
1.20 University	1%	0%	0%	0%	0%
1.20 NGO	1%	1%	0%	1%	1%
1.20 Friend or relative	8%	3%	4%	6%	6%

1.18 Did you hire labor from outside your household?

Table A.23: Labor hired, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
1.18 Labour Hired?	6%	16%	27%	33%	29%

Table A.24: Labor hired, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
1.18 Labour Hired?	18%	15%	22%	36%	33%

Table A.25: Labor hired, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
1.18 Labour Hired?	12%	17%	21%	46%	44%

Table A.26: Labor hired, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
1.18 Labour Hired?	22%	21%	4%	25%	21%

1.21 Have you ever received visits from agricultural extension officers?

Table A.27: Visited by agricultural officer, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
1.21 Have you been visited by agricultural extension officers?	6%	3%	5%	3%	2%

Table A.28: Visited by agricultural officer, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
1.21 Have you been visited by agricultural extension officers?	5%	1%	3%	8%	3%

Table A.29: Visited by agricultural officer, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
1.21 Have you been visited by agricultural extension officers?	3%	0%	6%	7%	0%

Table A.30: Visited by agricultural officer, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
1.21 Have you been visited by agricultural extension officers?	6%	1%	2%	4%	4%

1.22 How do you gain access to neglected and underutilized (NUS) seeds, inclusive of millets?

Table A.31: Access to NUS Seeds, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
1.22 MOA	0%	0%	0%	3%	0%
1.22 Research	2%	0%	0%	0%	0%
1.22 University	0%	0%	0%	0%	0%
1.22 NGO (Specify)	0%	0%	2%	0%	3%
1.22 Friend or relative	9%	28%	27%	31%	20%
1.22 Private seed company	4%	1%	2%	8%	0%
1.22 Own seed	68%	69%	82%	69%	76%

Table A.32: Access to NUS Seeds, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
1.22 MOA	1%	0%	0%	0%	0%
1.22 Research	1%	0%	0%	0%	0%
1.22 University	0%	0%	0%	0%	0%
1.22 NGO (Specify)	2%	0%	0%	0%	3%
1.22 Friend or relative	25%	24%	25%	28%	9%
1.22 Private seed company	2%	0%	3%	4%	6%
1.22 Own seed	72%	72%	76%	76%	70%

Table A.33: Access to NUS Seeds, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
1.22 MOA	0%	0%	0%	4%	0%
1.22 Research	0%	0%	1%	0%	0%
1.22 University	0%	0%	0%	0%	0%
1.22 NGO (Specify)	0%	0%	3%	0%	0%
1.22 Friend or relative	25%	24%	22%	21%	22%
1.22 Private seed company	3%	0%	3%	7%	0%
1.22 Own seed	78%	77%	68%	71%	67%

Table A.34: Access to NUS Seeds, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
1.22 MOA	1%	0%	0%	0%	0%
1.22 Research	0%	1%	0%	0%	0%
1.22 University	0%	0%	0%	0%	0%
1.22 NGO (Specify)	2%	0%	2%	1%	1%
1.22 Friend or relative	22%	24%	12%	25%	23%
1.22 Private seed company	3%	1%	2%	2%	2%
1.22 Own seed	72%	74%	72%	73%	73%

2.5 Have you noticed substantial changes in your fruit production?

Table A.35: Substantial changes to fruit production, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
2.5 Have you noticed substantial changes in fruit production?	79%	94%	92%	97%	97%

Table A.36: Substantial changes to fruit production, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
2.5 Have you noticed substantial changes in fruit production?	98%	89%	93%	96%	82%

Table A.37: Substantial changes to fruit production, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
2.5 Have you noticed substantial changes in fruit production?	88%	92%	92%	96%	100%

Table A.38: Substantial changes to fruit production, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
2.5 Have you noticed substantial changes in fruit production?	92%	92%	100%	91%	92%

2.6 Have you noticed any changes in crop disease and harmful insects?

Table A.39: Changes to pests and disease, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
2.6 More effective	49%	77%	75%	90%	86%
2.6 Less effective	0%	1%	0%	0%	0%
2.6 Come later	0%	0%	0%	3%	2%
2.6 Come earlier	83%	81%	70%	69%	80%
2.6 Not fixed	32%	19%	27%	23%	20%

Table A.40: Changes to pests and disease, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
2.6 More effective	77%	76%	75%	72%	73%
2.6 Less effective	0%	0%	1%	0%	0%
2.6 Come later	1%	0%	0%	4%	0%
2.6 Come earlier	80%	75%	69%	88%	88%
2.6 Not fixed	20%	26%	34%	20%	6%

Table A.41: Changes to pests and disease, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
2.6 More effective	72%	76%	77%	71%	89%
2.6 Less effective	0%	1%	0%	0%	0%
2.6 Come later	0%	1%	0%	4%	0%
2.6 Come earlier	77%	82%	78%	75%	44%
2.6 Not fixed	45%	23%	15%	14%	22%

Table A.42: Changes to pests and disease, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
2.6 More effective	78%	73%	68%	77%	76%
2.6 Less effective	1%	0%	2%	0%	0%
2.6 Come later	1%	1%	0%	1%	1%
2.6 Come earlier	82%	73%	90%	75%	78%
2.6 Not fixed	17%	30%	28%	23%	23%

What types of fertilizer and pesticides do you use?

Table A.43: Fertilizer and pesticide use, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
2.7 Organic manure	98%	100%	100%	97%	98%
2.7 Bio-pesticides	2%	5%	13%	10%	9%
2.7 Chemical fertilizer	62%	89%	90%	87%	92%
2.7 Chemical Pesticides	79%	91%	95%	95%	97%

Table A.44: Fertilizer and pesticide use, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
2.7 Organic manure	99%	99%	99%	96%	100%
2.7 Bio-pesticides	9%	7%	7%	8%	6%
2.7 Chemical fertilizer	92%	84%	82%	84%	73%
2.7 Chemical Pesticides	95%	91%	91%	92%	85%

Table A.45: Fertilizer and pesticide use, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
2.7 Organic manure	100%	100%	98%	100%	78%
2.7 Bio-pesticides	0%	2%	12%	21%	11%
2.7 Chemical fertilizer	82%	84%	85%	89%	100%
2.7 Chemical Pesticides	87%	92%	91%	100%	89%

Table A.46: Fertilizer and pesticide use, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
2.7 Organic manure	98%	99%	96%	99%	99%
2.7 Bio-pesticides	10%	5%	6%	8%	7%
2.7 Chemical fertilizer	85%	85%	86%	85%	85%
2.7 Chemical Pesticides	91%	92%	98%	91%	92%

Have you noticed any changes in livestock?

Table A.47: Changes to livestock, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
2.8 No. of cattle increased	6%	11%	7%	8%	3%
2.8 No. of cattle decreased	68%	75%	80%	82%	86%
2.8 Breed improved	45%	31%	48%	44%	39%
2.8 Milk production increased	21%	30%	33%	38%	26%

Table A.48: Changes to livestock, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
2.8 No. of cattle increased	2%	11%	7%	16%	3%
2.8 No. of cattle decreased	78%	71%	82%	76%	88%
2.8 Breed improved	31%	55%	37%	40%	30%
2.8 Milk production increased	28%	38%	25%	28%	15%

Table A.49: Changes to livestock, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
2.8 No. of cattle increased	5%	8%	9%	7%	0%
2.8 No. of cattle decreased	95%	82%	66%	82%	67%
2.8 Breed improved	40%	33%	44%	50%	33%
2.8 Milk production increased	13%	30%	38%	25%	22%

Table A.50: Changes to livestock, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
2.8 No. of cattle increased	7%	7%	6%	7%	7%
2.8 No. of cattle decreased	76%	79%	78%	78%	78%
2.8 Breed improved	34%	46%	36%	41%	40%
2.8 Milk production increased	26%	32%	26%	30%	29%

3.1-3.2 Have you noticed any major change in the weather compared to that of previous years?

Table A.51: Major changes in weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
3.1 Major change in weather?	100%	100%	100%	100%	98%
3.2 Increased temperature	91%	97%	98%	95%	98%
3.2 Severe winter	2%	6%	0%	5%	9%
3.2 Mild winter	0%	0%	2%	0%	0%
3.2 Increased unpredictability of weather	72%	67%	58%	59%	68%
3.2 Increased length of winter season	4%	3%	2%	0%	3%
3.2 Reduced length of winter season	0%	2%	7%	13%	3%
3.2 Increased length of summer season	68%	83%	75%	85%	85%
3.2 Reduced length of summer season	2%	1%	0%	5%	3%
3.2 Reduced amount of rainfall	57%	58%	72%	54%	67%
3.2 Increased amount of rainfall	2%	5%	10%	8%	5%
3.2 Rains arrive later	62%	81%	70%	79%	89%
3.2 Land slides	9%	18%	25%	26%	15%

Table A.52: Major changes in weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
3.1 Major change in weather?	100%	100%	100%	100%	97%
3.2 Increased temperature	95%	98%	94%	100%	97%
3.2 Severe winter	1%	3%	4%	8%	15%
3.2 Mild winter	0%	0%	1%	0%	0%
3.2 Increased unpredictability of weather	65%	70%	70%	44%	64%
3.2 Increased length of winter season	2%	2%	3%	0%	6%
3.2 Reduced length of winter season	1%	4%	7%	4%	6%
3.2 Increased length of summer season	82%	84%	81%	80%	58%
3.2 Reduced length of summer season	1%	2%	0%	8%	3%
3.2 Reduced amount of rainfall	60%	62%	61%	84%	52%
3.2 Increased amount of rainfall	3%	11%	4%	0%	3%
3.2 Rains arrive later	84%	70%	85%	80%	61%
3.2 Land slides	18%	21%	21%	12%	9%

Table A.53: Major changes in weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
3.1 Major change in weather?	98%	100%	100%	100%	100%
3.2 Increased temperature	100%	98%	92%	96%	100%
3.2 Severe winter	3%	2%	5%	14%	0%
3.2 Mild winter	0%	0%	1%	0%	0%
3.2 Increased unpredictability of weather	77%	76%	54%	54%	67%
3.2 Increased length of winter season	0%	1%	6%	0%	0%
3.2 Reduced length of winter season	7%	2%	3%	7%	22%
3.2 Increased length of summer season	83%	84%	79%	64%	67%
3.2 Reduced length of summer season	3%	0%	3%	0%	0%
3.2 Reduced amount of rainfall	65%	56%	62%	64%	89%
3.2 Increased amount of rainfall	7%	5%	5%	7%	0%
3.2 Rains arrive later	78%	81%	74%	75%	89%
3.2 Land slides	17%	17%	18%	25%	22%

3.3 What have the impacts of these observed changes in weather been?

Table A.54: Impact of changes in weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
3.3 Change in start/end and/or length of growing season	68%	82%	87%	77%	89%
3.3 Decreased grain production	79%	83%	93%	82%	89%
3.3 Land use change	2%	5%	8%	3%	3%
3.3 Pests and diseases	72%	69%	70%	64%	59%
3.3 Soil degradation	13%	15%	7%	10%	12%
3.3 Yield decline	79%	86%	95%	97%	89%
3.3 Loss of species/varieties	19%	26%	23%	28%	36%
3.3 Others	0%	3%	0%	3%	2%

Table A.55: Impact of changes in weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
3.3 Change in start/end and/or length of growing season	80%	85%	85%	68%	79%
3.3 Decreased grain production	84%	84%	88%	88%	88%
3.3 Land use change	4%	6%	6%	0%	0%
3.3 Pests and diseases	70%	64%	76%	56%	58%
3.3 Soil degradation	10%	13%	13%	12%	9%
3.3 Yield decline	94%	90%	90%	80%	79%
3.3 Loss of species/varieties	28%	25%	30%	32%	18%
3.3 Others	1%	0%	1%	4%	6%

Table A.56: Impact of changes in weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
3.3 Change in start/end and/or length of growing season	85%	84%	78%	79%	89%
3.3 Decreased grain production	95%	90%	79%	82%	67%
3.3 Land use change	3%	0%	6%	14%	0%
3.3 Pests and diseases	70%	68%	67%	61%	67%
3.3 Soil degradation	3%	11%	13%	32%	0%
3.3 Yield decline	95%	90%	84%	89%	100%
3.3 Loss of species/varieties	30%	28%	25%	21%	33%
3.3 Others	2%	1%	1%	4%	11%

3.4 Observed changes in the availability of natural resources

Percentages of respondents stating that each resource increased, decreased, or remained the same in availability.

Table A.57: Observed changes in the availability of natural resources

	Fuel lumber	Fodder grass	Pasture land	Spring water
Increased	8%	2%	2%	5%
Decreased	83%	87%	89%	74%
Remained the same	9%	11%	9%	21%
Total # of respondents	305	305	297	307

3.5 Observed changes in the role of women due to changing weather patterns

Respondents' perspectives on changes to women's roles that result from changing weather patterns; given as the total number of respondents for each response, percentage of each response given by women, and percentage of all respondents who gave each response.

Table A.58: Observed changes to the role of women due to changing weather patterns

	# of respondents	% of response given by women	% of all respondents
More time in the field	152	51%	50%
More time at home	94	50%	31%
Travel farther for water	115	44%	38%
Travel farther for wood	146	44%	48%
Travel farther for grass	150	41%	50%

3.6 Observed changes in the role of men due to changing weather patterns

Respondents' perspectives on changes to men's roles that result from changing weather patterns; given as the total number of respondents for each response, percentage of each response given by men, and percentage of all respondents who gave each response.

Table A.59: Observed changes to the role of men due to changing weather patterns

	# of respondents	% of response given by men	% of all respondents
More time in the field	187	52%	64%
More time at home	19	68%	6%
More time in the market	13	38%	4%
Paid labor	48	50%	16%
Other job	43	44%	15%

3.9 From where do you access the seed of crops that are resistant to adverse weather?

Table A.60: Access to adverse-weather-resistant seeds, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
3.9 Own saved seed	64%	75%	77%	72%	89%
3.9 Relative/friend	49%	50%	57%	51%	67%
3.9 University	0%	0%	0%	0%	0%
3.9 Government	2%	1%	0%	0%	2%
3.9 Community Seed Bank	0%	0%	0%	0%	2%
3.9 Market	53%	53%	55%	56%	65%
3.9 Do not know	15%	13%	12%	8%	3%

Table A.61: Access to adverse-weather-resistant seeds, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
3.9 Own saved seed	83%	73%	76%	64%	76%
3.9 Relative/friend	59%	53%	61%	52%	39%
3.9 University	0%	0%	0%	0%	0%
3.9 Government	1%	0%	1%	4%	0%
3.9 Community Seed Bank	0%	0%	0%	0%	3%
3.9 Market	56%	66%	51%	52%	48%
3.9 Do not know	3%	11%	15%	20%	9%

Table A.62: Access to adverse-weather-resistant seeds, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
3.9 Own saved seed	80%	84%	70%	68%	78%
3.9 Relative/friend	60%	62%	53%	36%	33%
3.9 University	0%	0%	0%	0%	0%
3.9 Government	2%	0%	1%	4%	0%
3.9 Community Seed Bank	0%	1%	0%	0%	0%
3.9 Market	55%	55%	57%	64%	56%
3.9 Do not know	17%	4%	11%	14%	0%

3.10 What are potential sources of seeds of crops that you no longer grow but would be resistant to adverse weather?

Table A.63: Access to adverse-weather-resistant crops no longer grown, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
3.10 Own saved seed	36%	50%	55%	69%	67%
3.10 Relative/friend	36%	49%	45%	51%	53%
3.10 University	0%	0%	0%	0%	0%
3.10 Government	4%	1%	2%	8%	2%
3.10 Community Seed Bank	0%	0%	2%	0%	0%
3.10 Market	28%	39%	38%	64%	50%
3.10 Do not know	42%	32%	33%	8%	20%

Table A.64: Access to adverse-weather-resistant crops no longer grown, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
3.10 Own saved seed	56%	49%	57%	48%	67%
3.10 Relative/friend	51%	45%	52%	44%	36%
3.10 University	0%	0%	0%	0%	0%
3.10 Government	1%	2%	1%	8%	6%
3.10 Community Seed Bank	0%	0%	1%	0%	0%
3.10 Market	40%	43%	43%	40%	52%
3.10 Do not know	28%	33%	27%	24%	21%

Table A.65: Access to adverse-weather-resistant crops no longer grown, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
3.10 Own saved seed	55%	69%	46%	43%	56%
3.10 Relative/friend	47%	52%	47%	36%	44%
3.10 University	0%	0%	0%	0%	0%
3.10 Government	2%	0%	3%	4%	22%
3.10 Community Seed Bank	0%	0%	0%	0%	11%
3.10 Market	48%	52%	34%	39%	33%
3.10 Do not know	32%	18%	32%	36%	22%

Table A.66: Access to adverse-weather-resistant crops no longer grown, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
3.10 Own saved seed	57%	52%	48%	56%	55%
3.10 Relative/friend	45%	49%	46%	47%	47%
3.10 University	0%	0%	0%	0%	0%
3.10 Government	4%	1%	2%	3%	3%
3.10 Community Seed Bank	1%	0%	0%	0%	0%
3.10 Market	41%	45%	42%	43%	43%
3.10 Do not know	25%	31%	34%	27%	28%

What type of assistance would be most helpful for supporting the continued cultivation of recently abandoned species and varieties of crops?

Table A.67: Preferred assistance for culivating abandoned crops, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
3.11 An award	15%	22%	17%	13%	29%
3.11 Improved access to irrigation	66%	69%	62%	72%	70%
3.11 Training to improve yield and value addition to increase income	62%	43%	52%	46%	56%
3.11 Assured access to seeds of landraces	64%	56%	55%	74%	64%
3.11 Access to value-addition infrastructure	9%	16%	18%	21%	24%
3.11 Access to credit/crop loan	0%	7%	8%	10%	9%
3.11 Higher market price	58%	59%	77%	72%	77%
3.11 Fixed sum cash payment for land race conservation	6%	3%	7%	5%	6%
3.11 Other (specify)	0%	2%	0%	3%	0%

Table A.68: Preferred assistance for culivating abandoned crops, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
3.11 An award	25%	24%	15%	12%	12%
3.11 Improved access to irrigation	68%	64%	64%	68%	82%
3.11 Training to improve yield and value addition to increase income	44%	47%	52%	56%	76%
3.11 Assured access to seeds of landraces	53%	65%	60%	64%	76%
3.11 Access to value-addition infrastructure	17%	13%	18%	28%	21%
3.11 Access to credit/crop loan	9%	8%	6%	4%	3%
3.11 Higher market price	75%	70%	76%	48%	42%
3.11 Fixed sum cash payment for land race conservation	5%	3%	6%	12%	3%
3.11 Other (specify)	0%	1%	1%	4%	0%

Table A.69: Preferred assistance for culivating abandoned crops, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	**Primary School**	**Secondary School**	**Intermediate**	**University Degree**
Total # of respondents	60	93	117	28	9
3.11 An award	18%	23%	21%	14%	11%
3.11 Improved access to irrigation	63%	75%	61%	75%	78%
3.11 Training to improve yield and value addition to increase income	67%	44%	46%	61%	56%
3.11 Assured access to seeds of landraces	58%	61%	63%	57%	67%
3.11 Access to value-addition infrastructure	10%	13%	21%	25%	44%
3.11 Access to credit/crop loan	2%	4%	9%	18%	11%
3.11 Higher market price	68%	77%	62%	68%	56%
3.11 Fixed sum cash payment for land race conservation	7%	3%	8%	0%	0%
3.11 Other (specify)	0%	0%	1%	4%	11%

4.1 What, if anything, have you done in response to changing weather patterns?

Table A.70: Implemented adaptations to weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	**10-19 nali**	**20-29 nali**	**30-39 nali**	**40 nali <**
Total # of respondents	53	88	60	39	66
4.1 Plant different varieties of existing crops	8%	19%	32%	13%	30%
4.1 Plant new crops altogether	53%	53%	55%	56%	70%
4.1 Increase frequency of exchange of seeds among farmers	30%	32%	48%	26%	32%
4.1 Changes in cropping systems	28%	34%	32%	38%	33%
4.1 Plant fast maturing varieties	9%	20%	38%	28%	26%
4.1 Plant disease resistant varieties	0%	3%	3%	0%	5%
4.1 Change planting locations of crops	68%	52%	63%	54%	56%
4.1 Change planting time	42%	41%	38%	36%	45%
4.1 Move across land	6%	8%	8%	10%	6%
4.1 Keep more livestock, instead of crops	4%	8%	0%	3%	6%
4.1 Plant trees	55%	49%	57%	59%	45%
4.1 Do more water harvesting	8%	10%	10%	10%	17%
4.1 Do more off-farm work, instead of farming	2%	0%	5%	5%	5%
4.1 Soil management	2%	2%	3%	10%	5%
4.1 Weather forecasts	0%	0%	0%	3%	0%
4.1 Risk instruments	0%	0%	0%	0%	0%
4.1 Livelihood diversification	8%	2%	10%	8%	8%
4.1 Land use	6%	2%	7%	3%	5%
4.1 Do nothing	6%	8%	3%	3%	5%
4.1 Others	0%	0%	0%	0%	0%
4.1 Do not know	2%	2%	2%	0%	2%

Table A.71: Implemented adaptations to weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
4.1 Plant different varieties of existing crops	17%	20%	34%	24%	6%
4.1 Plant new crops altogether	58%	60%	60%	56%	45%
4.1 Increase frequency of exchange of seeds among farmers	27%	40%	42%	40%	15%
4.1 Changes in cropping systems	37%	31%	30%	40%	27%
4.1 Plant fast maturing varieties	27%	30%	24%	16%	6%
4.1 Plant disease resistant varieties	1%	2%	4%	0%	6%
4.1 Change planting locations of crops	55%	55%	60%	72%	61%
4.1 Change planting time	29%	53%	39%	36%	48%
4.1 Move across land	6%	8%	6%	8%	12%
4.1 Keep more livestock, instead of crops	5%	0%	4%	0%	6%
4.1 Plant trees	54%	45%	49%	60%	64%
4.1 Do more water harvesting	10%	11%	7%	8%	24%
4.1 Do more off-farm work, instead of farming	3%	2%	6%	0%	0%
4.1 Soil management	2%	4%	1%	4%	12%
4.1 Weather forecasts	0%	1%	0%	0%	0%
4.1 Risk instruments	0%	0%	0%	0%	0%
4.1 Livelihood diversification	4%	8%	10%	4%	3%
4.1 Land use	4%	2%	3%	8%	9%
4.1 Do nothing	5%	2%	4%	16%	6%
4.1 Others	0%	0%	0%	0%	0%
4.1 Do not know	5%	0%	0%	0%	3%

Table A.72: Implemented adaptations to weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
4.1 Plant different varieties of existing crops	28%	24%	17%	18%	11%
4.1 Plant new crops altogether	50%	70%	50%	64%	44%
4.1 Increase frequency of exchange of seeds among farmers	58%	32%	28%	21%	0%
4.1 Changes in cropping systems	22%	38%	35%	32%	33%
4.1 Plant fast maturing varieties	22%	20%	25%	36%	33%
4.1 Plant disease resistant varieties	0%	3%	2%	7%	11%
4.1 Change planting locations of crops	58%	69%	53%	50%	33%
4.1 Change planting time	48%	33%	44%	39%	33%
4.1 Move across land	5%	2%	10%	14%	22%
4.1 Keep more livestock, instead of crops	3%	5%	0%	11%	11%
4.1 Plant trees	57%	44%	54%	61%	44%
4.1 Do more water harvesting	5%	6%	17%	18%	0%
4.1 Do more off-farm work, instead of farming	2%	0%	5%	4%	11%
4.1 Soil management	3%	2%	5%	4%	11%
4.1 Weather forecasts	2%	0%	0%	0%	0%
4.1 Risk instruments	0%	0%	0%	0%	0%
4.1 Livelihood diversification	3%	3%	9%	11%	11%
4.1 Land use	5%	2%	6%	4%	0%
4.1 Do nothing	5%	3%	7%	4%	11%
4.1 Others	0%	0%	0%	0%	0%
4.1 Do not know	3%	0%	3%	0%	11%

4.2 What are some challenges to responding to these changing weather patterns?

Table A.73: Challenges to adapting to weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
4.2 Lack of proper information	72%	67%	65%	69%	65%
4.2 Lack of seeds	77%	60%	67%	69%	67%
4.2 Extra burden on farm work	4%	6%	8%	3%	9%
4.2 Lack of money	81%	70%	70%	64%	71%
4.2 Lack of labor	19%	26%	30%	36%	30%
4.2 Do not know	4%	3%	2%	3%	5%

Table A.74: Challenges to adapting to weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
4.2 Lack of proper information	61%	72%	66%	56%	82%
4.2 Lack of seeds	65%	66%	70%	56%	76%
4.2 Extra burden on farm work	11%	4%	4%	8%	0%
4.2 Lack of money	70%	76%	69%	76%	64%
4.2 Lack of labor	29%	33%	21%	24%	27%
4.2 Do not know	8%	0%	4%	0%	3%

Table A.75: Challenges to adapting to weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
4.2 Lack of proper information	77%	65%	65%	71%	44%
4.2 Lack of seeds	73%	74%	64%	50%	33%
4.2 Extra burden on farm work	5%	4%	9%	4%	11%
4.2 Lack of money	68%	78%	68%	79%	44%
4.2 Lack of labor	12%	20%	39%	36%	33%
4.2 Do not know	5%	2%	3%	4%	11%

4.4-4.7 Do people within your community have the knowledge to cope with these changing weather patterns?

Table A.76: Community knowledge to cope with weather, by landholding category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	<10 nali	10-19 nali	20-29 nali	30-39 nali	40 nali <
Total # of respondents	53	88	60	39	66
4.4 Is knowledge to cope with climate change available to community?	9%	19%	22%	33%	12%
4.6 Is information received from any agency?	8%	10%	8%	10%	3%
4.7 Do you know of any program to assist farmers in dealing with climate change?	4%	7%	7%	8%	3%

Table A.77: Community knowledge to cope with weather, by age category; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Age <40	Age 40-49	Age 50-59	Age 60-69	Age >69
Total # of respondents	93	89	67	25	33
4.4 Is knowledge to cope with climate change available to community?	19%	15%	15%	40%	15%
4.6 Is information received from any agency?	10%	7%	6%	8%	9%
4.7 Do you know of any program to assist farmers in dealing with climate change?	6%	6%	7%	4%	0%

Table A.78: Community knowledge to cope with weather, by education level; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	No Formal Schooling	Primary School	Secondary School	Intermediate	University Degree
Total # of respondents	60	93	117	28	9
4.4 Is knowledge to cope with climate change available to community?	13%	8%	26%	29%	33%
4.6 Is information received from any agency?	7%	5%	10%	11%	0%
4.7 Do you know of any program to assist farmers in dealing with climate change?	3%	1%	8%	14%	11%

Table A.79: Community knowledge to cope with weather, by gender, social category, all surveyed; percentages of respondents in each category (column) who gave an affirmative response for or mentioned the crop or quality given in each row

	Men	Women	Scheduled Castes	General	All Surveyed
Total # of respondents	157	150	50	256	307
4.4 Is knowledge to cope with climate change available to community?	24%	13%	6%	21%	18%
4.6 Is information received from any agency?	9%	7%	2%	9%	8%
4.7 Do you know of any program to assist farmers in dealing with climate change?	6%	5%	0%	7%	6%

Appendix B

Survey Forms

B.1 Hindi

जीन कैम्पेन :– परम्परागत फसलें, मौसम परिवर्तन और कृषि

सर्वेक्षण प्रपत्र

जीन कैम्पेन

भाग 1: सामान्य/किसान की रूप रेखा

1.1	सर्वे प्रपत्र संख्या	
1.2	साक्षात्कारकर्ता का नाम	
1.3	साक्षात्कार की तिथि	
1.4	गॉव का नाम	
1.5	विकासखण्ड का नाम	
1.6	जनपद का नाम	
1.7	किसान का नाम	
1.8	पिता/पति का नाम	
1.9	किसान का लिंग	□1. पुरुष □ 2. महिला
1.10	किसान का सामाजिक वर्ग (जाति समूह)	□ 1. अनुसूचित जनजाति □ 2. अनुसूचित जाति □ 3. अन्य पिछड़ा वर्ग □ 4. सामान्य जाति □ 5. अन्य (स्पष्ट करें) .....
1.11	किसान की उम्र	□ 1. 40 वर्ष से कम □ 2. 40 से 49 वर्ष तक □ 3. 50 से 59 वर्ष तक □ 4. 60 से 69 वर्ष तक □ 5. 69 वर्ष से अधिक
1.12	शिक्षा का स्तर	□ 1. निरक्षर (कोई विद्यालयी शिक्षा नहीं) □ 2. प्राथमिक शिक्षा/5वीं □ 3. माध्यमिक शिक्षा/10वीं □ 4. इण्टरमीडिएट/12वीं □ 5. विश्व विद्यालय डिग्री □ 6. अन्य (कृपया स्पष्ट करें) .....
1.13	परिवार के सदस्यों का विवरण	□ 1. 0 से 5 वर्ष के बच्चों की संख्या ..... □ 2. 6 से 12 वर्ष के बच्चों की संख्या ..... □ 3. 13 से 20 वर्ष के पुरुषों की संख्या ..... □ 4. 13 से 20 वर्ष की महिलाओं की संख्या ..... □ 5. 21 से 41 वर्ष के पुरुषों की संख्या ..... □ 6. 21 से 41 वर्ष की महिलाओं की संख्या ..... □ 7. 42 से 52 वर्ष के पुरुषों की संख्या ..... □ 8. 42 से 52 वर्ष की महिलाओं की संख्या ..... □ 9. 52 वर्ष से अधिक उम्र के पुरुषों की संख्या ..... □ 10. 52 वर्ष से अधिक उम्र की महिलाओं की संख्या ..... □ 11. परिवार में आय कमाने वाले कुल सदस्यों की संख्या .....

1.14	भूमि स्वामित्व (नाली में) ..... नाली	□ 1. वर्षा पर निर्भर भूमि ..... नाली □ 2. सिंचित भूमि ..... नाली
1.15	क्या आपके पास निजी वाहन है ?	□1. हॉ □2. नहीं यदि हॉ तो कौन सा वाहन है ? .....
1.16	क्या आपके पास पशुधन हैं ?	□1. हॉ □2. नहीं यदि हॉ तो क्या–क्या है ? .....
1.17	क्या आपके पास कृषि उपकरण हैं ?	□1. हॉ □2. नहीं यदि हॉ तो कौन सा उपकरण है ? .....
1.18	क्या आप अपने घर के बाहर से लोगों को दैनिक मजदूरी कार्य में बुलाते हैं ?	□1. हॉ □2. नहीं
1.19	क्या आपको कभी मौसम परिवर्तन तथा इससे होने वाली हानियों के सम्बन्ध में जानकारी प्राप्त हुई है ?	□1. हॉ □2. नहीं
1.20	आपको यह जानकारी कहॉ से प्राप्त हुई ?	□1. कृषि मंत्रालय / एम0ओ0ए0 □2. अनुसंधान केन्द्र (जैसेः ए0आर0सी0) □3. विश्व विद्यालय □4. गैर सरकारी संगठन (स्पष्ट करें) ..... □5. मित्र या रिश्तेदार □6. अन्य (स्पष्ट करें) .....
1.21	क्या आपके यहॉ कभी कृषि अधिकारियों द्वारा भ्रमण किया गया है ?	□1. हॉ □2. नहीं
1.22	आप मडुवा, कौणी, चीणा, इत्यादि के बीज कहॉ से प्राप्त करते हैं ?	□1. कृषि मंत्रालय / एम0ओ0ए0 □2. अनुसंधान केन्द्र (जैसेः ए0आर0सी0) □3. विश्व विद्यालय □4. गैर सरकारी संगठन (स्पष्ट करें) ..... □5. मित्र या रिश्तेदार □6. व्यक्तिगत बीज कम्पनी □7. स्वयं के द्वारा बचाया गया बीज □8. अन्य (स्पष्ट करें) .....

भाग 2: उगाई जाने वाली फसलें और मुख्य उपयोग

		फसलों की सूची	*प्रजातियों का नाम*	*मुख्य उपयोग*
2.1	पिछले दो वर्षों से आपने कौन–कौन सी फसलें उगाई हैं, और उनका क्या उपयोग किया है ?	गेहूँ		□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
		मडुवा		□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
		दालें		□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
		धान		□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
		मक्का		□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
	अन्य फसलें			□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
				□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों
				□1. स्वयं उपभोग हेतु □2. विक्री हेतु □3. दोनों

2.2	आप किस अनाज/फसल को सबसे ज्यादा पौष्टिक मानते हैं ?	1..... □ 2. नहीं जानते	
2.3	पिछले 5 वर्षों में कौन सी फसलें/प्रजातियों की खेती में गिरावट आई है और क्यों ? *(फसल/प्रजाति का नाम व कारण आगे स्पष्ट करें)*	फसल/प्रजाति 1	**सम्भावित कारणों पर सही का निशान लगायें:** □1. वैकल्पिक फसलों की उपलब्धता □2. कम उपज या प्रतिलाभ □3. बीज उपलब्ध होने में कठिनाई □4. ज्यादा लाभ देने वाली फसलों का विकल्प □5. मजदूरों का अभाव □6. प्रतिकूल मौसम □7. अन्य (स्पष्ट करें) .....
		फसल/प्रजाति 2	**सम्भावित कारणों पर सही का निशान लगायें:** □1. वैकल्पिक फसलों की उपलब्धता □2. कम उपज या प्रतिलाभ □3. बीज उपलब्ध होने में कठिनाई □4. ज्यादा लाभ देने वाली फसलों का विकल्प □5. मजदूरों का अभाव □6. प्रतिकूल मौसम □7. अन्य (स्पष्ट करें) .....
		फसल/प्रजाति 3	**सम्भावित कारणों पर सही का निशान लगायें:** □1. वैकल्पिक फसलों की उपलब्धता □2. कम उपज या प्रतिलाभ □3. बीज उपलब्ध होने में कठिनाई □4. ज्यादा लाभ देने वाली फसलों का विकल्प □5. मजदूरों का अभाव □6. प्रतिकूल मौसम □7. अन्य (स्पष्ट करें) .....
2.4	आपके अनुसार आने वाले समय में कौन सी फसलें सफलतापूर्वक उगाई जायेंगी। *(फसल/प्रजाति का नाम व कारण आगे स्पष्ट करें)*	फसल/प्रजाति 1	**सम्भावित कारणों पर सही का निशान लगायें:** □1. भोजन के रूप में महत्वपूर्ण □2. नगदी के लिए महत्वपूर्ण □3. चारे के लिए महत्वपूर्ण □4. भूमि की उर्वरकता बढ़ाने के लिए बेहतर □5. प्रतिकूल मौसम के लिए उपयोगी □6. अन्य (स्पष्ट करें) .....
		फसल/प्रजाति 2	**सम्भावित कारणों पर सही का निशान लगायें:** □1. भोजन के रूप में महत्वपूर्ण □2. नगदी के लिए महत्वपूर्ण □3. चारे के लिए महत्वपूर्ण □4. भूमि की उर्वरकता बढ़ाने के लिए बेहतर □5. प्रतिकूल मौसम के लिए उपयोगी □6. अन्य (स्पष्ट करें) .....
		फसल/प्रजाति 3	**सम्भावित कारणों पर सही का निशान लगायें:** □1. भोजन के रूप में महत्वपूर्ण □2. नगदी के लिए महत्वपूर्ण □3. चारे के लिए महत्वपूर्ण □4. भूमि की उर्वरकता बढ़ाने के लिए बेहतर □5. प्रतिकूल मौसम के लिए उपयोगी □6. अन्य (स्पष्ट करें) .....

2.5	क्या आपने फलों के बगीचे में परिवर्तन महसूस किया है ? □1. हॉ □2. नहीं	सेब	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. उत्पादन बढ़ा है □2. उत्पादन घटा है □3. पूर्ववत
		पुलम	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. उत्पादन बढ़ा है □2. उत्पादन घटा है □3. पूर्ववत
		नाशपाती	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. उत्पादन बढ़ा है □2. उत्पादन घटा है □3. पूर्ववत
		आड़ू	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. उत्पादन बढ़ा है □2. उत्पादन घटा है □3. पूर्ववत
		खुमानी	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. उत्पादन बढ़ा है □2. उत्पादन घटा है □3. पूर्ववत
		अन्य (स्पष्ट करें)	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. उत्पादन बढ़ा है □2. उत्पादन घटा है □3. पूर्ववत
2.6	क्या आपने कृषि फसलों में लगने वाले रोगों एवं हानिकारक कीटों में बदलाव पाया है ? □1. हॉ □2. नहीं	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. ज्यादा प्रभावी □2. कम प्रभावी □3. देर से आते हैं □4. जल्दी आते हैं □5. कोई निश्चित नहीं	
2.7	आप कृषि में कौन से उर्वरकों व कीटनाशकों का उपयोग करते हैं ?	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. जैविक खाद □2. जैव कीटनाशक □3. रसायनिक खाद □4. रसायनिक कीटनाशक □5. दोनों	
2.8	क्या आपने पशुपालन में कोई बदलाव पाया है ? □1. हॉ □2. नहीं	**कृपया सम्भावित उत्तर में सही का निशान लगायें:** □1. जानवरों की संख्या में वृद्धि हुई है □2. जानवरों की संख्या में कमी हुई है □3. पशुओं की नस्ल में सुधार हुआ है □4. दुग्ध उत्पादन में वृद्धि हुई है □5. अन्य परिवर्तन (स्पष्ट करें)	

भाग 3: मौसम अभिज्ञता (मौसम पर अनुभव)

3.1	क्या आपने पिछले वर्षों से मौसम में कोई बड़ा परिवर्तन पाया है ? (तापमान या वर्षा के आधार पर)	□ 1. हॉ □ 2. नहीं □ 3. नहीं जानते
3.2	आपने मौसम में क्या बदलाव पाया है ? *(कई उत्तर सम्भव हो सकते हैं, सभी को चुना जाए)*	□ 1. तापमान में वृद्धि □ 2. अधिक ठंड □ 3. हल्की ठंड (शीत) □ 4. कोई निश्चित मौसम नहीं है □ 5. सर्दी के मौसम का बढ़ना □ 6. सर्दी के मौसम का घटना □ 7. गर्मी के मौसम का बढ़ना □ 8. गर्मी के मौसम का घटना □ 9. वर्षा की मात्रा में कमी □ 10. वर्षा की मात्रा में वृद्धि □ 11. वर्षा का देर से होना □ 12 मलवा आना □ 13. अन्य (स्पष्ट करें) .....
3.3	इसका क्या प्रभाव पड़ा है ? *(कई उत्तर सम्भव हो सकते हैं, सभी को चुना जाए)*	□ 1. फसलों की बुवाई व कटाई के समय में बदलाव □ 2. खाद्यान्न के उत्पादन में कमी □ 3. भूमि के उपयोग में बदलाव □ 4. रोग व बीमारियॉ □ 5. भूमि का बंजर होना □ 6. पैदावार में कमी □ 7. प्रजातियों का लुप्त होना □ 8. अन्य (स्पष्ट करें) ..... □ 9. नहीं जानते

3.4	क्या आपके अनुसार प्राकृतिक संसाधनों में बदलाव आया है ? □1. हॉ □2. नहीं	ईंधन की लकड़ी की उपलब्धता	□1. वृद्धि □2. कमी □3. पहले के ही बराबर □4. अलग प्रकार की उपलब्ध है (कृपया स्पष्ट करें) .....
		चारा घास की उपलब्धता	□1. वृद्धि □2. कमी □3. पहले के ही बराबर □4. अलग प्रकार की उपलब्ध है (कृपया स्पष्ट करें) .....
		चारागाह की उपलब्धता	□1. वृद्धि □2. कमी □3. पहले के ही बराबर □4. अलग प्रकार की उपलब्ध है (कृपया स्पष्ट करें) .....
		पानी के प्राकृतिक स्रोतों की उपलब्धता	□1. वृद्धि □2. कमी □3. पहले के ही बराबर □4. अलग प्रकार की उपलब्ध है (कृपया स्पष्ट करें) .....

3.5	क्या आप सोंचते हैं कि मौसम में परिवर्तन के कारण महिलाओं की भूमिका में परिवर्तन हुआ हैं ? □1. हॉं □2. नहीं	**यदि हॉं तो कैसे :–** □ 1. खेत में अधिक समय देती हैं □ 2. घर में अधिक समय बिताती हैं □ 3. पानी के लिए दूर जाना पड़ता है □ 4. ईंधन की लकड़ी हेतु दूर जाना पड़ता है □ 5. चारा/घास हेतु दूर जाना पड़ता है □ 6. अन्य (स्पष्ट करें) ..... □ 7. नहीं जानते
3.6	क्या आप सोंचते हैं कि मौसम में परिवर्तन के कारण पुरुषों की भूमिका में परिवर्तन हुआ हैं ? □1. हॉं □2. नहीं	**यदि हॉं तो कैसे :–** □ 1. खेत में अधिक समय देते हैं □ 2. घर में अधिक समय बिताते हैं □ 3. बाजार में अधिक समय बिताते हैं □ 4. अन्य (स्पष्ट करें) ..... □ 5. नहीं जानते
3.7	वे कौन सी फसलें/प्रजातियॉं हैं, जो बदलते मौसम के कारण बहुत जल्दी प्रभावित हो जाती हैं ? यदि सम्भव हो तो 5 नाम दीजिए।	□ 1. फसलों/प्रजातियों की सूची: .... □ 2. नहीं जानते
3.8	वे कौन सी फसलें/प्रजातियॉं हैं, जिनमें बदलते मौसम का कोई प्रभाव नहीं पड़ता ? यदि सम्भव हो तो 5 नाम दीजिए।	□ 1. फसलों/प्रजातियों की सूची: .... □ 2. नहीं जानते
3.9	ऐसी फसलों के बीज कहॉं से प्राप्त करते हैं, जिनमें मौसम परिवर्तन का कोई प्रभाव नहीं पड़ता है ? (कई उत्तर सम्भव हो सकते हैं, सभी को चुना जाए)	□ 1. स्वयं द्वारा बचाया गया बीज □ 2. रिश्तेदार/मित्र □ 3. विश्वविद्यालय □ 4. सरकार □ 5. सामुदायिक बीज बैंक □ 6. बाज़ार □ 7. नहीं जानते □ 8. अन्य (स्पष्ट करें) .....
3.10	क्या आप ऐसी प्रजातियों को जानते हैं, जो काफी लम्बे समय से नहीं उगाई जा रही हैं, किन्तु वे आजकल मौसम परिवर्तन का सामना करने के लिए उपयोगी हो सकती थी ? और क्या आप जानते हैं कि उनके बीज कहॉं से प्राप्त किये जा सकते है ?	□1. हॉं **प्रजातियों की सूची:** ..... □2. नहीं □3. नहीं जानते □4. अन्य (स्पष्ट करें) ..... **सम्भावित स्रोतों पर निशान लगायें:** □ 5. स्वयं द्वारा बचाया गया बीज □ 6. रिश्तेदार/मित्र □ 7. विश्वविद्यालय □ 8. सरकार □ 9. सामुदायिक बीज बैंक □ 10. बाजार □ 11. नहीं जानते □ 12. अन्य (स्पष्ट करें) .....

3.11	जिन फसलों को उगाना बंद कर दिया है, उनको उगाने के लिए आपको किस प्रकार की सहायता चाहिए ?	□ 1. एक पुरस्कार (परम्परागत प्रजातियों के संरक्षण के तौर पर ईनाम और पहचान) □ 2. उत्पादकता बढ़ाने हेतु कृषि सम्बन्धी तकनीकी जानकारी □ 3. अच्छी पैदावार व अच्छी आमदनी के लिए मूल्यवर्धन पर प्रशिक्षण □ 4. परम्परागत प्रजातियों के बीजों की उपलब्धता □ 5. कम लागत पर उत्पादों के मूल्यवर्धन की जानकारी □ 6. उधार एवं फसली ऋण तक आसान पहुँच □ 7. अधिक बाजार मूल्य □ 8. परम्परागत प्रजातियों के संरक्षण के लिए निश्चित धन की अदायगी □ 9. अन्य (स्पष्ट करें) .....

भाग 4: कार्यप्रणाली और प्रोत्साहन

4.1	क्या आपने मौसम परिवर्तन का सामना करने के लिए कुछ उपाय किये हैं ? (कई उत्तर सम्भव हो सकते हैं, सभी को चुना जाए)	□1. वर्तमान में उगाई जा रही फसलों की अलग–अलग प्रजातियों को उगाना □2. नई फसलों को मिला कर लगाना □3. किसानों के मध्य बीजों के आदान–प्रदान में बढ़ोत्तरी □4. फसल प्रणाली में बदलाव □5. जल्दी तैयार होने वाली प्रजातियों को उगाना □6. बीमारी प्रतिरोधक प्रजातियों को उगाना □7. फसल लगाने के स्थान में परिवर्तन □8. फसल लगाने के समय में बदलाव □9. जमीन की ढलान के विपरीत खेती करना □10. फसलों के बजाय पशुधन अधिक □11. वृक्षारोपण □12. अधिक जल संग्रहण करना □13. कृषि के बजाय गैर कृषि पर आधारित गतिविधियॉं अधिक □14. भूमि प्रबन्धन □15. मौसम का पूर्वानुमान □16. विपदा उपकरण □17. अन्य आजीविका गतिविधि करना □18. भूमि का उपयोग □19. कुछ नहीं करते □20. अन्य (स्पष्ट करें) ..... □21. नहीं जानते
4.2	इन नये उपायों को लागू करने के लिए कौन सी कठिनाईयॉं आयी ?	□ 1. उचित जानकारी का अभाव □ 2. बीजों का अभाव □ 3. कृषि कार्य पर अतिरिक्त बोझ □ 4. धन की कमी □ 5. मजदूरों का अभाव □ 6. नहीं जानते □ 7. अन्य (स्पष्ट करें) .....
4.3	फसल का चुनाव करने के बारे में कौन निर्णय लेता है ?	□ 1. पुरुष □ 2. महिला □ 3. अन्य (स्पष्ट करें) .....
4.4	क्या समुदाय को मौसम परिवर्तन का सामना करने की जानकारी उपलब्ध है ?	□ 1. हॉं □ 2. नहीं □ 3. अन्य (स्पष्ट करें) .....
4.5	यह जानकारी किसके पास उपलब्ध है ?	□ 1. पुरुष □ 2. महिला □ 3. दोनों के पास

4.6	क्या आप यह जानकारी किसी संस्था के माध्यम से प्राप्त करते हैं ?	☐ 1. नहीं ☐ 2. हॉ ☐ 3. यदि हॉ, कौन सी संस्थायें ये जानकारी देती हैं ? .....
4.7	क्या आप किसी ऐसे कार्यक्रम के विषय में जानते हैं, जिससे मौसम परिवर्तन का सामना करने में सहायता प्राप्त होती है ?	☐ 1. नहीं ☐ 2. हॉ ☐ 3. यदि हॉ, स्पष्ट करें .....

किसान के हस्ताक्षर

साक्षात्कारकर्ता / सर्वेक्षक के हस्ताक्षर

संस्था का नाम .....

B.2 English translation

GENE CAMPAIGN:- TRADITIONAL CROPS, CLIMATE CHANGE & FARMING

SURVEY QUESTIONNAIRE

SECTION 1: GENERAL/ FARMER PROFILE

1.1	Questionnaire number	
1.2	Interviewer name	
1.3	Date of interview	
1.4	Village name	
1.5	Block name	
1.6	District name	
1.7	Farmer's name	
1.8	Father or husband's name	
1.9	Farmer's gender	□1. Male □ 2. Female
1.10	Social category of farmer (caste group)	□ 1. ST □ 2. SC □ 3. OBC □ 4. General □ 5. Others (specify) …….
1.11	Farmer's age	□ 1. < 40 □ 2. 40 - 49 □ 3. 50 - 59 □ 4. 60 - 69 □ 5. >69
1.12	Level of education	□ 1. No formal schooling □ 2. Primary school □ 3. Secondary school □ 4. Intermediate □ 5. University degree □ 6. Other (Please specify) ……..
1.13	Household members	□ 1. Number of children from 0-5 ……. □ 2. Number of children from 6-12 ……. □ 3. Number of males from 13-20 ……. □ 4. Number of females from 13-20 ……. □ 5. Number of males from 21-41 ……. □ 6. Number of females from 21-41 ……. □ 7. Number of males from 42-52 ……. □ 8. Number of females from 42-52 ……. □ 9. Number of males older than 52 ……. □ 10.Number of females older than 52 ……. □ 11.**Number of members who earn income** …..…….
1.14	Total landholding (*nali*) …… *nali*	□ 1. Rainfed land amount …… □ 2. Irrigated land amount ……

1.15	Do you own a vehicle (motorbike/car)?	□1. Yes □2. No If yes, please specify ……..
1.16	Do you own livestock?	□1. Yes □2. No If yes, please specify ……..
1.17	Do you own tractors/ agricultural machinery?	□1. Yes □2. No If yes, please specify ……..
1.18	Do you hire labour from outside the household?	□1. Yes □2. No
1.19	Have you ever been provided with information on climate change and its risks?	□1. Yes □2. No
1.20	From where did you get the information?	□1. Ministry of Agriculture/MOA □2. Research (e.g. ARC) □3. University □4. NGO (specify……) □5. Friend or relative □6. Others (specify……..)
1.21	Have you ever received visits from agriculture extension officers?	□1. Yes □2. No
1.22	How do you get NUS seeds? NUS: millets, *kauni*, *chiina*, etc…	□1. Ministry of Agriculture/MOA □2. Research (e.g. ARC) □3. University □4. NGO (specify……) □5. Friend or relative □6. Private seed Company □7. Own seed □8. Other (specify…….……)

SECTION 2: CROPS GROWN AND RELEVANCE

2.1	Which are all the food crops grown in your farm over the last 2 years?	*List of Crops*	*Name of varieties*	*Major use*		
		Wheat		□1. Self consumption	□2. Market sale	□3. Both
		Millets		□1. Self consumption	□2. Market sale	□3. Both
		Legumes		□1. Self consumption	□2. Market sale	□3. Both
		Rice		□1. Self consumption	□2. Market sale	□3. Both
		Maize		□1. Self consumption	□2. Market sale	□3. Both
	Others:			□1. Self consumption	□2. Market sale	□3. Both
				□1. Self consumption	□2. Market sale	□3. Both
				□1. Self consumption	□2. Market sale	□3. Both

2.2	Which grain/crop do you consider most nutritious?	1…… □ 2. Do not know □ 3. No response	
2.3	Which crops/varieties have **declined** over the last 5 years and why? *(Please specify the name of crop/variety)*	Crop/ var 1 …… ……	**Tick possible reasons:** □1. alternative crop availability □2. low yields or returns □3 difficulty in obtaining seed □4. more profitable crop option □5. lack of labor □6. unfavorable weather; □7 other (specify) …….
		Crop/ var 2 …… ……	**Tick possible reasons:** □1. alternative crop availability □2. low yields or returns □3 difficulty in obtaining seed □4. more profitable crop option □5. lack of labor □6. unfavorable weather; □7 other (specify) …….
		Crop/var 3 …… ……	**Tick possible reasons:** □1. alternative crop availability □2. low yields or returns □3 difficulty in obtaining seed □4. more profitable crop option □5. lack of labor □6. unfavorable weather; □7 other (specify) …….
2.4	Crops/varieties will increase/ or remain stable in the future and why? *(Please specify the name of crop/variety)*	Crop/ var 1 …… ……	**Tick possible reasons:** □1. Important as food □2. Important for cash income □3. Important as fodder □4. Better for sustaining soil fertility □5. Good for difficult weather □6. Others (specify)…….
		Crop/ var 2 …… ……	**Tick possible reasons:** □1. Important as food □2. Important for cash income □3. Important as fodder □4. Better for sustaining soil fertility □5. Good for difficult weather □6. Others (specify)…….
		Crop/ var 3 …… ……	**Tick possible reasons:** □1. Important as food □2. Important for cash income □3. Important as fodder □4. Better for sustaining soil fertility □5. Good for difficult weather □6. Others (specify)…….

2.5	Have you noticed any changes in your fruit orchard? □1. Yes □2. No	Apples	**Please tick possible answer:** □1. Increased □2. Decreased □3. Same
		Plums	**Please tick possible answer:** □1. Increased □2. Decreased □3. Same
		Pears	**Please tick possible answer:** □1. Increased □2. Decreased □3. Same
		Peaches	**Please tick possible answer:** □1. Increased □2. Decreased □3. Same
		Apricot	**Please tick possible answer:** □1. Increased □2. Decreased □3. Same
		Other *(Specify)* …….	**Please tick possible answer:** □1. Increased □2. Decreased □3. Same
2.6	Have you noticed any changes in crop disease and harmful insects in farming? □1. Yes □2. No	**Please tick possible answer:** □1. More effective □2. Less effective □3. Come later □4. Come earlier □5. Not fixed	
2.7	Which fertilizers and insecticides do you use in farming?	**Please tick possible answer:** □1. Organic Manure □2. Bio-pesticides □3. Chemical fertilizer □4. Chemical Pesticides □3. Both	
2.8	Have you noticed any changes in livestock? □1. Yes □2. No	**Please tick possible answer:** □1. No. of cattle increased □2. No. of cattle decreased □3. Breed improved □4. Milk production increased □5. Other changes (Specify…….) …….	

SECTION 3: CLIMATE PERCEPTION

3.1	Have you noticed any major change in the weather compared to previous years? (in terms of major change in temperature or rainfall)	□ 1. Yes □ 2. No □ 3. Do not know
3.2	What is the change? (*multiple responses possible - to record all responses*)	□ 1. Increased temperature □ 2. Severe winter □ 3. Mild winter □ 4. Increased unpredictability of weather □ 5. Increased length of winter season □ 6. Reduced length of winter season □ 7. Increased length of summer season □ 8. Reduced length of summer season □ 9. Reduced amount of rainfall □ 10. Increased amount of rainfall □ 11. Rains arrive later □ 12. Land sliding □ 13. Others (specify……..…)
3.3	What has the impact been? (*multiple responses possible - to record all responses*)	□ 1. Change in start/end and/or length of growing season □ 2. Decreased grain production □ 3. Land use change □ 4. Pests and diseases □ 5. Soil degradation □ 6. Yield decline □ 7. Loss of species/varieties (specify……..…) □ 8.Others (specify……..…) □ 9.Do not know

3.4	Have you noticed changes in natural resources? □1. Yes □2. No	Availability of fuel wood	□1. Increased □2. Decreased □3. Same □4. Different type is available (Please specify)……
		Availability of fodder grass	□1. Increased □2. Decreased □3. Same □4. Different type is available (Please specify)……
		Availability of pasture land	□1. Increased □2. Decreased □3. Same □4. Different type is available (Please specify)……
		Availability of spring water	□1. Increased □2. Decreased □3. Same □4. Different type is available (Please specify)……

3.5	Do you think that the **role of women** has changed as a consequence of climate change? And if so, how? □ 1. Yes □2. No	If Yes, how? □ 1. Spend more time in the field □ 2. Spend more time at home □ 3. Go far away for water □ 4. Go far away for fuel wood □ 5. Go far away for grass/ fodder □ 6. Others (specify……..…) □ 7. Do not know
3.6	Do you think that the **role of men** has changed has a consequence of climate change? And if so, how? □ 1. Yes □2. No	If Yes, how? □ 1. Spend more time in the field □ 2. Spend more time at home □ 3. Spend more time in the market □ 4. Others (specify……..…) □ 5. Do not know
3.7	Which are the crops / varieties more **susceptible** to climate change? (list 5 if possible)	□ 1. List crop/varieties …….. …….. □2. Do not know
3.8	Which are the crops / varieties more **resistant** to climate change? (list 5 if possible)	□ 1. List crop/varieties …….. □2. Do not know
3.9	From where do you get the seed of resistant varieties? (multiple all responses)	□ 1. Own saved seed □ 2. Relative/friend □ 3. University □ 4. Government □ 5. Community Seed Bank □ 6. Market □ 7. Do not know □ 8. Others (specify……..…)
3.10	Do you know of varieties no longer grown that would be useful today to cope with climate change? And would you know how to get access to them?	□1. Yes **List varieties** ……. □2. No □3. Do not know □4. Other (Specify) …… **Tick possible sources of seed** □ 5. Own saved seed □ 6. Relative/friend □ 7. University □ 8. Government □ 9. Community Seed Bank □ 10. Market □ 11. Do not know □ 12. Others (specify……..……..…)

3.11	Which type of assistance would be most helpful for supporting the continued cultivation of recently abandoned species/varieties?	□ 1. An award (Reward & recognition as a custodian of landraces); □ 2. Improved access to agricultural extension advice for increasing productivity; □ 3. Training to improve yield and value addition to increase income; □ 4. Assured access to seeds of land races; □ 5. Access to value addition infrastructure at a reduced cost; □ 6. Access to credit/ crop loan; □ 7. Higher market price; □ 8. Fixed sum cash payment for land race conservation; □ 9. Other (specify……..….)

SECTION 4: PRACTICES & SUPPORT

4.1	Have you done anything to deal with climate changes? (*multiple responses possible- to record all responses*)	□1. Plant different varieties of existing crops □2. Plant new crops altogether □3. Increase frequency of exchange of seeds among farmers □4. Changes in cropping systems □5. Plant fast maturing varieties □6. Plant disease resistant varieties □7. Change planting locations of crops □8. Change planting time □9. Move across land □10. Keep more livestock, instead of crops □11. Plant trees □12. Do more water harvesting □13. Do more off-farm work, instead of farming □14. Soil management □15. Weather forecasts □16. Risk instruments □17. Livelihood diversification □18. Land use □19. Do nothing □20. Others (specify……) □21. Do not know
4.2	What are the difficulties in implementing these new practices?	□1. Lack of proper information □2. Lack of seeds □3. Extra burden to on farm work □4. Lack of money □ 5. Lack of labor □ 6. Do not know □ 7. Others (specify……)
4.3	Who decides to grow different crops or to change cropping patterns?	□ 1. Men □ 2. Women □ 3. Other (specify) …….
4.4	Is the knowledge to cope with climate change available in the community?	□ 1. Yes □ 2. No □ 3. Other (specify) …….
4.5	Who has this information?	□ 1. Men □ 2. Women □ 3. Equal access

4.6	Do you get any information on this from any Agency?	□ 1. No □ 2. Yes □ 3. if Yes, which agencies give this information? …….
4.7	Do you know of any program to assist farmers in dealing with climate change?	□ 1. No □ 2. Yes □ 3. If yes, specify……..

Signature of the Farmer **Signature of interviewer/ Surveyor**

Organization ……..

Appendix C

Fitting the Univariate Logistic Model

A more detailed treatment of the use of the univariate logistic regression that follows can be found in Hosmer and Lemeshow (2000).

I fit the following function $\pi(x_i)$ in Equation (C.1) to y_i as a function of x_i:

$$\pi(x_{1i}) = \frac{e^{g(x_{1i})}}{1 + e^{g(x_{1i})}}, \tag{C.1}$$

where $g(x_i)$ is a linear function,

$$\begin{aligned} g(x_{1i}) &= \ln\left(\frac{\pi(x_{1i})}{1 - \pi(x_{1i})}\right) && \text{(C.2)} \\ &= \beta_0 + \beta_1 x_{1i}. && \text{(C.3)} \end{aligned}$$

Here, $i = 1, 2, 3...n$ for n observations. The univariate $g(x_{1i})$ can be generalized to a multivariate function $g(x_i) = \beta_0 + \boldsymbol{\beta} \cdot \boldsymbol{x}$, in which $\boldsymbol{x}$ represents p independent

variables, $(x_1, x_2, ...x_p)$, and $\boldsymbol{\beta}$ is the vector of their respective estimated coefficients, $(\beta_1, \beta_2, \beta_3...\beta_p)$.

The likelihood of outcome $(\boldsymbol{x}_i, y_i)$ occurring is given by $\pi(\boldsymbol{x}_i)^{y_i} [1 - \pi(\boldsymbol{x}_i)]^{1-y_i}$, so assuming all observations to be independent, the likelihood of a set of n observations occurring is given by

$$l(\boldsymbol{\beta}) = \prod_{i=1}^{n} \pi(\boldsymbol{x}_i)^{y_i} [1 - \pi(\boldsymbol{x}_i)]^{1-y_i} . \tag{C.4}$$

The coefficients $\boldsymbol{\beta}$ are estimated by maximizing the log-likelihood function with respect to $\boldsymbol{\beta}$,

$$\begin{aligned} L(\boldsymbol{\beta}) &= \ln [l(\boldsymbol{\beta})] & \text{(C.5)} \\ &= \sum_{i=1}^{n} \{y_i \ln [\pi(\boldsymbol{x}_i)] + (1 - y_i) \ln [1 - \pi(\boldsymbol{x}_i)]\} . & \text{(C.6)} \end{aligned}$$

Differentiating the log-likelihood function with respect to β_j yields the *likelihood equations*,

$$\begin{aligned} \sum [y_i - \pi(\boldsymbol{x}_i)] &= 0 & \text{(C.7)} \\ \sum \boldsymbol{x}_i [y_i - \pi(\boldsymbol{x}_i)] &= 0, & \text{(C.8)} \end{aligned}$$

which are solved numerically in MATLAB for $\boldsymbol{\beta}$. The estimated variance of β_j is the second derivative of the log-likelihood function with respect to the β_j. (The covariance of β_j and β_k is found by taking the partial derivative of the log-likelihood function with

respect to β_j and then β_k.)

$$\begin{aligned} \mathrm{Var}(\beta_j) &= -\frac{\delta^2 L(\beta)}{\delta \beta_j^2} && \text{(C.9)} \\ \mathrm{Covar}(\beta_j, \beta_k) &= -\frac{\delta^2 L(\beta)}{\delta \beta_j \delta \beta_k} && \text{(C.10)} \\ SE_{\beta_j} &= \sqrt{\mathrm{Var}(\beta_j)} && \text{(C.11)} \end{aligned}$$

The analog for sum of squared error that is used to determine fit in linear regressions is a quantity termed the *deviance*, D:

$$D = -2 \ln \left[\frac{\text{likelihood of the fitted model}}{\text{likelihood of the saturated model}} \right]. \qquad \text{(C.12)}$$

In order to test whether the univariate model performs statistically significantly better than the constant-only model, where $g(x_i) = \beta_0$, we take the difference in *deviances* between the two models,

$$G = D(\text{constant-only model}) - D(\text{univariate model}), \qquad \text{(C.13)}$$

The test statistic G follows a χ^2 distribution with 1 degree of freedom (difference in number of parameters between the two models).

The p-values, noted as p_m, listed in the tables for the univariate logistic regressions refer to this χ^2 test. $1 - p_m$ tells us the confidence with which we can reject the null hypothesis that the particular univariate model does not predict the dependent variable any better than the constant-only model.

The Wald test is used to test the statistical significance of β_1 against the null hypothesis that $\beta_1 = 0$. The test statistic, W, follows a normal distribution with unit variance.

$$\hat{W} = \frac{\hat{\beta}_1}{\mathbf{SE}_{\beta_1}}, \quad \sim N(0,1) \tag{C.14}$$

The odds ratio, **OR**, gives the ratio of A to B, where A is the odds of $y_i = 1$ given that $x_{1i} = 1$ to $y_i = 0$ given that $x_{1i} = 1$ and B is the odds of $y_i = 1$ given that $x_{1i} = 0$ to $y_i = 0$ given that $x_{1i} = 0$; it can be shown to be equal to the following for the univariate logistic regression:

$$\mathbf{OR} = e^{\hat{\beta}_1} \tag{C.15}$$

The $100(1-\alpha)\%$ confidence interval for **OR** is given by $e^{\hat{\beta}_{1_j} \pm z_{1-\alpha/2} \cdot \mathbf{SE}_{\hat{\beta}_1}}$. The right-most columns in the tables below provide the upper and lower bounds of the 95% confidence interval of $\mathbf{OR}_{\beta_1}$, $(\mathbf{OR}_-, \mathbf{OR}_+)$, as well as the calculated **OR**.

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