WATER VARIABILITY, LIVELIHOODS, AND ADAPTATION: A CASE STUDY FROM THE ANGAT RIVER BASIN (PHILIPPINES)

by

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Abstract

In the Global South, agrarian households face stressors to smallholder agriculture – a primary livelihood for many. One stressor increasingly documented is the re-allocation of surface irrigation for domestic and industrial uses. This is concerning because the timely, adequate, and predictable provision of irrigation was designed to enhance crop production and protect smallholders from hydro-climatic variation. **Chapter 2** of this thesis examines a case from the Angat River Basin (Philippines) where a systematic set of rules have restructured reservoir governance to privilege domestic water use in Metro Manila over irrigation for regional rice-farming. A review of multiple secondary datasets and an analysis of household surveys (n = 124) and interviews (n = 70) in a rice-farming municipality (Bustos) reveals that restructured reservoir governance arrangements now interact with existing effects of climatic variation to undermine the intended benefits of irrigation. Based on the nature of irrigation service change, **Chapter 3** argues that on- and off-farm efficiency measures *alone* are insufficient to protect households from risks of irrigation insecurity. Moreover, access to water alternatives is limited and increasingly uncertain. This suggests complementary and alternative (CA) livelihood activities are increasingly important as risk mitigation measures given irrigation service change and broader social-ecological stressors. All too often however, standardized livelihood activities promoted by governments encounter resistance, rejection, or are rendered irrelevant. One reason why proposed activities fail is because they do not align or overlap with certain CA activities that households are able and willing to engage in (termed here as "decision spaces"). **Chapter 3** provides an integrative framework that allows policy-makers to better understand how contextual factors – from land-use regulations to cultural aspirations – constrain or widen household "decision spaces." The framework is applied to Bustos providing direction for adaptation policy to i) promote CA livelihood activities that are both relevant and palatable to households; and to ii) challenge certain constraints to enlarge the set of activities household could engage in. Overall, this thesis represents an analysis of irrigation re-allocation as one facet of social-ecological change in the Angat River Basin and provides measures for accommodating change effects through substantive recommendations for adaptation policy.

Preface

"I" (Sameer H. Shah) am the sole author of all four chapters. My contribution to all chapters includes conceptualization, fieldwork design, data collection, data analysis, and writing. Professor Leonora Angeles, the Principal Investigator of the SSHRC Partnership Development Grant #890-2011-0100 "Collaborative Governance of Urbanizing Watersheds: Integrated Research, Institution- and Capacity Building for Sustainability and Climate Risk Adaptation in Angat River Basin, Philippines" identified the region of study and allowed me to design the thesis research around this larger funded project. Professors Leonora Angeles, Leila Harris, and Hisham Zerriffi provided thoughtful comments, suggestions, and feedback on all four chapters. I received funding support from Professors Leonora Angeles and Leila Harris, via SSHRC Partnership Grant #890-2011-0100. I also received funding support from a Social Sciences and Humanities Research Council (SSHRC) Joseph-Armand Bombardier Canada Graduate Scholarship #766-2013-0104, from the University of British Columbia (Li Tze Fong Memorial Fellowship, Graduate Student International Research Mobility Award), and from the C.A.R.E. Society of Asia.

Chapters 2 and 3 of this thesis have been written as stand-alone manuscripts. Chapter 2 was submitted for publication to a peer-reviewed journal at the time of writing. The paper (not the Chapter) is co-authored, in order, by Sameer H. Shah and Hisham Zerriffi. I designed the majority of the experiment, collected and analyzed the data, and wrote the manuscript under the supervision of my supervisory committee. Professor Zerriffi contributed on an on-going basis to the conceptualization and refinement of the manuscript. Professor Leila Harris reviewed the paper along with many other individuals (see "Acknowledgements"). At the time of writing, I plan to submit Chapter 3 as a sole-authored manuscript for peer-reviewed publication.

This thesis was approved by UBC Research Ethics Board certificate #H14-00462.

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List of Abbreviations

AMRIS – Angat-Maasim River Irrigation System

BBWP – Bulacan Bulk Water Project

"CA" Livelihoods Activities – Complementary and Alternative Livelihood Activities

ENSO – El Niño Southern Oscillation

IPCC – Intergovernmental Panel on Climate Change

MLD – Million Litres per Day

MWSS – Metropolitan Waterworks and Sewerage System

NIA – National Irrigation Administration

NRW – Non-revenue Water

NWRB – National Water Resources Board

UATP - Umiray-Angat Transbasin Project

m^3 – Cubic Metres

Acknowledgements

This thesis would not have been possible without the continual assistance and support of many people. First, I want to extend sincere appreciation to the Social Sciences and Humanities Research Council (SSHRC), the Asia C.A.R.E. Society, and the University of British Columbia for their financial support and equally so for their confidence in the research presented here.

Maraming maraming salamat po sa lahat to all of the farmers in Bustos who unconditionally invited me into their homes and shared their knowledge and stories over *meryenda* and coffee. What I learned from them – certainly not least from an academic lens – I will forever remember. The Municipality of Bustos allowed me the opportunity to study and learn alongside their committed staff. I would especially like to recognize Mayor Arnell Mendoza, Secretary Fernan Tadeo, and Municipal Agricultural Officer Manolito V. Martin for supporting this research in all aspects and welcoming, quite literally, the hundreds of questions asked. I am also grateful to all of the *barangay* captains across Bustos for welcoming me and supporting our surveying and interviewing processes.

I am grateful for the supervision I received from my Supervisory Committee. To Leila and Hisham: thank you pushing me into new and uncomfortable ground, for your critical and constructive feedback on the (probably) hundreds of draft versions, and most of all for your *patience*. You allowed me great freedom and flexibility in my research, for which I am grateful. To Nora: The same applies, of course. Thank you for not only considering me as a suitable candidate to work in the Angat but most of all for believing in me.

It is safe to say that this research could *never* have been completed in its current form without the leadership and commitment of Julie Ramos and Gilbert Angeles. After 8-hour field days, I could not believe that you pushed me for *one* more interview, *one* more survey: "We can do it!" On top of this, you fed me, housed me, and gave me incredible laughs and inside jokes that will last forever. I could not have asked for anything more (except to have not tried *balut*!). I also want to especially extend personal thanks to Beth, Angel, and 'Tin' for lightening our moods everyday

and for taking care of us. To all of you, thank you for welcoming me into your home and allowing me the pleasure to learn from you. We are friends for life.

Many colleagues helped me along each step of the way. I benefited hugely from the support of the EDGES Research Collaborative and the Zerriffi Research Group. Thank you to many of my incredible colleagues who I have the pleasure of calling friends. Special thanks to Ale and Jason for morning and afternoon coffee breaks, uncountable laughs, and "hashtags". I must also acknowledge the lively and vibrant community that is Green College that so well captures the motto *Scholarship in Society* and even more so *Ideas in Friendship*.

While all of the above were immense contributors to my personal and professional development, Elli supported me in every single facet of this project, from listening to my muddled ideas for literally hours on end, to checking in on me every single day in the Philippines. Last, but not least, thank you to my family for supporting me unconditionally in all aspects of my life, including in supporting my decisions to venture down new paths that even I myself don't know where will end.

Dedication

To Priya Mundkur (Hattiangdi)

Lover of reading and writing, of family,

and of two ten-year olds and their turtle.

To Gopal Hattiangdi

Grandfather, scholar, master of Jumble.

Chapter 1: Introduction & Context

Over 1 billion people in the Global South depend on smallholder agricultural production as a central livelihood, or income-generating source (IFAD, 2013). Past efforts to support agrarian households lied partially in the "invigoration of farming", which sought to increase smallholder production and enhance household economic benefits (Rigg, 2006, p. 180). Central to this invigoration was the application of high-yielding crop variants, agro-chemical inputs, mechanized labour, and irrigation water (Pingali, 2012). These efforts were, one could argue, hegemonic to the agricultural development discourse in the Global South (cf. Sneddon, 2013).

Of particular importance was the extensive development of surface reservoir and canal irrigation, which were actively pushed in newly independent countries as a means of "development", but also as a process of establishing geopolitical alliances (Sneddon, 2015). In the immediate post-war era of the Philippines – the country of focus in this thesis – urgent efforts were made to increase palay (unhusked rice) production. These efforts were implemented to achieve self-sufficiency in the country's staple food and to support 70% of the population, who at the time were dependent on agriculture for livelihood generation (NIA, 1990). Manuel Roxas, the first President of the Republic of the Philippines, implemented measures to increase palay cultivation by 500,000 hectares over a five-year period (*ibid*). A key reason, however, for the inabilities to meet rice self-sufficiency was that "…a critical element was missing: **irrigation**" (*ibid*, bold original). From then on, irrigation in the Philippines has been viewed as a limiting resource, for without, agricultural (specifically rice) production would have been much less and cultivation would have been restricted to wetter seasons.

Shortly a decade after Roxas' plan, the National Irrigation Administration (NIA) of the Philippines was established under Republic Act (RA) No. 3601 in 1963. The Act gave a number of powers to NIA, one of which included investigating all possible water resources in the country for the purposes of irrigation in an effort "…to make the ten to twenty-year period following the approval of [the] Act [1963-1983] as the Irrigation Age of the Republic of the Philippines" (Gonzales, 1993; RA No 3601, 1963, Section 2(b)). The results were impressive: 223 national irrigation systems have been developed in the post-war era to reduce variation in water

availability (NIA, 1990; 2013). From this developed infrastructure, the government set sectoral water priorities giving rice cultivation "…a significant share of the water supply from major dams built during [this] period" to enhance volumetric production across multiple seasons (Rola et al., 2015, p. 5,7).

An abundance of literature debates the successes and deficiencies of state-driven surface irrigation, its management, and its net effects in the Philippines and elsewhere (see Araral, 2005; Bedore, 2011; Hayami & Kikuchi, 1999; Meinzen-Dick, 2007). Prior to infrastructure expansion, rice-farming households cultivated rain-fed palay, harvesting one crop per year. The 'secure' provision of irrigation water, defined in **Chapter 2**, brought two cropping seasons and enhanced seasonal production (Gonzales, 1993; Hayami & Kikuchi, 1999). Enhanced production standards and its coupled agricultural water demand established baseline requirements for "secure" irrigation service provision.

Increasingly, however, research reveals that multiple stressors, from water resource competition, to land-use change, and climatic variation threaten 'secure' irrigation service provision (see Birkenholtz, in review; Molle & Berkoff, 2006; Wagle, Warghade, & Sathe, 2012; Wang, Yang, Shi, Zhou, & Zhang, 2015). **Chapter 2** contributes to this expanding literature through analyzing a case from the Angat River Basin of systematic and long-term water re-allocations from irrigation to domestic use. This Chapter acknowledges shifts in irrigation services are *one* stressor amongst a set of multiple other climatic and non-climatic stressors that threaten crop production and value in the rural Global South. Other stressors include the erosion of profitability for smallholders (Bryceson, 2002; Eakin, 2005; Rigg, 2006), decreasing land-use sustainability (Pingali & Gerpacio, 1997; Rigg, 2006), climatic change and variation (Dasgupta et al., 2014), and transformative changes in social-ecological systems, such as urbanization and its associated shifts in resource allocation (Fresco & Angeles, 2012; Morton et al., 2014). Where research agrees to a "very high confidence" that major resource-related changes are occurring in the rural Global South, including in agricultural water access (Dasgupta et al., 2014), scholars have suggested that "new" or "revisionist" answers for supporting rural households and mitigating adverse change effects could lie in complementary and alternative (CA) livelihood activities to farming (Rigg, 2006). As I emphasize in **Chapter 3,** governmental and

intergovernmental strategies often promote standardized and generalist livelihood activities across variegated geographies. In many cases, these programs encounter resistance, rejection, or irrelevance, thus presenting an important problem for rural policy-makers in the context of social-ecological change. On the basis of significant shifts in water allocation – and broader social-ecological change – **Chapter 3** develops one policy approach to identify relevant and palatable CA livelihood activities while also addressing specific factors that constrain household participation in certain CA livelihood activities.

1.1 Conceptual Foundations

There are a number of concepts that are used extensively in this thesis. I provide an overview of common ones in the Sections below.

1.1.1 Livelihoods and Households

The concept of 'livelihood' is central to this research thesis. Following Ellis (2000a, p. 10), I define a livelihood to "comprise the assets (natural, physical, human, financial, and social capital), the activities, and the access to these (mediated by institutions and social relations)" that together contribute to household needs, both material and non-material (also Bebbington, 1999; Scoones, 1998). Coupled with the 'livelihood' concept is the concept of a 'household'. Again, following Ellis (2000a, p. 18), I define a household as "a site in which particularly intense social and economic interdependencies occur between a group of individuals." This definition is not founded only on the notion of co-residence but on broader spatial extensions that recognize socio-cultural relationships and networks across local and distant places (*ibid*). I have operationalized these defined concepts within the methodology of this thesis.

There is a clear relationship between these two concepts. Single or multiple livelihoods can often be found *within* a household and are responsible, in part, for meeting those household needs (i.e. a nested relationship). Livelihoods can also reflect the social composition of households. As stated above, to engage in particular livelihood activities, households use assets (endowments) and access new assets and resources (entitlements) through the exchange of owned things. Engagement in particular livelihoods are mediated through social (e.g. gender, race, ethnicity)

and institutional (e.g. social rules and customs, relationships of power) factors, all of which are grounded in household social differences (see Armitage, 2007; Ellis, 2000a; Scoones, 1998). We can therefore imagine livelihoods to be both situated within households and also reflective of household difference.

I selected 'households' versus individuals as a central unit of analysis for this research because decisions are often made as a household unit, or influenced *through* household dynamics. Household members advance adaptive strategies together rather than as independent beings because multiple contextual factors – from their relationships, to culture, to illnesses, and responsibilities – *condition* particular activities. Attempts to de-link individuals from households might suggest that household dynamics do not influence or inform livelihood decisions.

1.1.2 Adaptation and Adaptive Capacity

The concepts of adaptation and adaptive capacity are also important in this thesis. For the time being, it is helpful to conceptualize adaptive capacity as the abilities and willingness of a household to prepare for change in advance and adjust to potential damage effects in certain ways (Agard et al., 2014). I selected the intentionally broad definition proposed by Agard and colleagues because it accounts for multiple different 'types' of action, including 'coping' (remaining within the livelihood activity), complementary and alternative livelihood activities, or various combinations of these three types (cf. Moser & Ekstrom, 2010; Smit & Wandel, 2006; Walker et al., 2004). I refer to complementary livelihood activities as those on- or off-farm activities that are pursued in complement with rice-farming. Alternative livelihoods are transformative in nature, involving a complete shift from rice-farming towards a new livelihood state. In **Chapter 3**, I focus on developing substantive policy recommendations to promote relevant CA livelihood activities as one 'type' of action on the adaptation spectrum for rice-farming households facing irrigation stress and broader social-ecological change. It is there where I will introduce the related concept of "decision spaces" – as referenced in the **Abstract** – in *specific reference* to household capacities to engage in particular CA livelihood activities.

The concepts of adaptation and adaptive capacity have been explored and advanced through broader conceptual frameworks to understand environmental change. Two frameworks are

‘resilience’ and ‘vulnerability’ (Engle, 2011; Folke, 2006; Adger, 2006). Even within these literatures, the concept of adaptation has been applied in diverse fashions to different units of analysis, both human (individuals, households, institutions) and non-human (ecosystems). These literatures (‘vulnerability’ and ‘resilience’), in the context of environmental change research, are motivated primarily to understand: i) *why* certain units (individuals, households, and ecosystems) are susceptible to harm from particular hazards; and ii) *how* those particular units could persist through and respond to adverse change. While this thesis attempts to avoid confusion or conflation through the use of multiple interrelated concepts (adaptation, resilience, vulnerability), it nevertheless remains important to trace their conceptual histories in order to advance adaptation as a concept that reflects synthesis and comprehension. The review below begins with an overview of how adaptation is conceptualized in vulnerability and resilience literatures. It then provides three insights in **Section 1.1.5** that are important when building adaptation policy tailored to specific contexts. I will draw upon these three insights in **Chapter 3**.

1.1.3 A Short Overview of ‘Vulnerability’ and Adaptation

Scholarship theorizing why particular units are vulnerable (susceptible to harm) from exposures (social, political, biophysical) is central to ‘vulnerability’ studies. Historically, scholarship framed this question using a hazard-risk or a social constructivist model (Ribot, 2009).

Hazards scholarship suggests populations are vulnerable *to* hazards (e.g. floods, droughts) if its impact *and* probability of occurrence are high (Engle, 2011; Ribot, 2009). In other words, communities are vulnerable *to* hazards if adverse outcomes, such as famine and livelihood loss, are likely to occur (Ribot, 2009). For example, irrigation-dependent households facing increased periods of water insecurity likely to result in damage and loss could be thought of as *vulnerable*.

Human geographers argued this conceptualization was incomplete in that “vulnerability does not fall from the sky” (Ribot, 2009, p. 1). Rather, initial conditions of populations, such as status, gender, and access to support services – themselves *productions* of socio-political structures – condition impacts to biophysical hazards (Bohle, Downing, & Watts, 1994; Nightingale, 2015; Ribot, 2009; Watts & Bohle, 1993). It framed people as vulnerable *to* undesirable outcomes, thus locating vulnerability within socio-political structures that condition both hazard effects *and*

capacities to respond to impacts (Adger, 2006; Ribot, 2009). Sen (1981), for example, suggested famines occur because what people own (endowments) and have access to through the exchange of owned things (entitlements) is insufficient to gain access to food. Here, vulnerability is conditioned through the *capacities* of people to access food in the context of hazard events, such as drought.

These framings (hazards and social constructivist) have been bridged in vulnerability research (Adger, 2006; Blaikie, Cannon, Davis, & Wisner, 1994). Chambers (1989) suggested earlier that, "Vulnerability has thus two sides: an external side of risks, shocks, and stress to which an individual or household is subject; and an internal side which is defencelessness, meaning a lack of means to cope without damaging loss" (p. 1). Others, namely Blaikie et al., (1994), worked to develop the "Pressure and Release Model", positing disasters occur from the interaction between physical hazards *and* causal (socio-political) structures of vulnerability.

Where framings are remarkably different, all view adaptation as crucial for mediating vulnerability whether it involves mitigating hazards (hazard-risk model), adapting to outcomes of social-ecological change, or challenging the socio-political structures that condition hazard effects and response options (social constructivist model).

1.1.4 A Short Overview of 'Resilience' and Adaptation

In the early 1970s, Holling (1973) examined predation interactions in ecosystems. His research found that multi-stable states for ecosystems were possible, challenging the dominant paradigm that invoked single equilibria and return points (Holling, 1973). He developed 'resilience' to refer to the capacities of an ecosystem to remain in a particular state (or "basin of attraction") when faced with disturbance (i.e. not crossing thresholds that push ecosystems into alternative states). Over time, resilience scholars saw social and ecological systems as interconnected and interdependent, giving more emphasis to maintain human-nature (social-ecological) systems (Berkes & Folke, 1998; Berkes, Colding, & Folke, 2003; Engle, 2011).

Walker et al., (2004) then expanded the concept towards "social-ecological resilience", or the capacities of a human-nature system to absorb disturbances and re-organize while experiencing

change to maintain a similar structure, function and identity. They presented three aspects of resilience: i) latitude (the 'width' of the basin, or the amount the system can be changed); ii) resistance (the ease or difficulty in changing the system); and iii) precariousness (how close the system is a 'threshold', or tipping point) (*ibid*). The state of each can be redefined through interactions with systems across multiple scales (i.e. "panarchy") (Gunderson & Holling, 2002; Holling et al., 2002b; Walker et al., 2004). Given cross-scalar interactions and broader dynamic conditions, adaptation evolved in resilience scholarship from persistence to shifting, shaping, and transforming in response to change (Folke, 2006). As a result, "adaptability" is now framed as the capacities of human actors in social-ecological systems to manage resilience in "desirable" manners, either through maintaining systems in status-quo, or by completely transforming them (Engle, 2011; Walker et al., 2004, Folke, 2006).

1.1.5 Insights for Enhancing Adaptive Capacity in Policy-making

All three vulnerability lenses (hazards, social constructivist, bridged approaches) view adaptation as important for reducing vulnerability. Similarly, adaptation is viewed as an important management process that can enhance resilience of social-ecological systems. Below, I identify three key insights that are important for creating adaptation policies committed to furthering CA livelihood activities that are relevant and palatable for households. These insights will be drawn upon in **Chapter 3**.

First, hazards scholarship lent insight into the positioning of humans within capacity-building initiatives. Adaptation policy initiatives, guided by this literature, stress mitigating and preventing adverse outcomes (e.g. livelihood loss) that are likely to occur *from* exposure events. It advertently focuses policy initiatives around the hazard itself, to some extent removing the focus on household and the broader socio-political structures that condition degrees of exposure *and* outcomes of such exposures. Bassett & Fogelman (2013) show a bias in the climate change adaptation literature, where published works often locate vulnerability within climatic impacts or hazards themselves; a much smaller percentage of research focuses on the role of political-economic change in conditioning vulnerability. Eriksen, Nightingale, and Eakin (in press) further suggest this, adding that research "…continues to suffer from an under-theorization of the political mechanisms that serve to reproduce vulnerability over time and space" (p. 3). While

water substitutes, hybrid crops, and infrastructure maintenance, have been used to mitigate potential adverse outcomes to households, these strategies represent *one* slice of policy response options to deal with a broad set of environmental changes. If these measures fail, and where initiatives designed to strengthen *household* capacities to respond to change are absent, adverse outcomes to households could result (Eakin, 2003). As a result, there must be a multi-tiered focus to enhancing adaptive capacities, which extend beyond controlling or mitigating hazard effects. This focus puts people and *their* capacities to adjust to change at the centre of adaptation policy initiatives.

The second insight emerges from the social-ecological resilience literature. The literature provides abundant detail on the "mechanics" of adaptation, including heuristical models that describe its cyclical process (see adaptive cycle, Gunderson & Holling, 2002). Yet, the reasons for adaptation occurring are largely overemphasized as environmental and its goals are often assumed to re-create specific human-nature interactions to meet material (economic) needs (Fabinyi, Evans, & Foale, 2014). Emerging research on farm adaptation decisions (see **Chapter 3)** now recognizes multiple factors, including risk perception, culture, historical and institutional contexts, and multiple axes of social difference, condition adaptation responses. In other words, multiple factors, aside environmental conditions, inform *when* adaptation occurs and *why* specific adaptation activities are selected. This realization is not specific to agricultural literatures but part of a larger critical perspective in resilience and vulnerability thinking (Brown, 2014; Cote & Nightingale, 2012; Curry et al., 2015; Fabinyi, Evans, & Foale, 2014; Fresque-Baxter & Armitage, 2012; Marshall et al., 2012; Nielsen & Reenberg, 2010; Wilson, 2013). The factors that influence household adaptation decisions could be incorporated, somehow, in policy to propose more relevant livelihood adaptation activities.

The last insight builds on the former in that these factors that shape adaptive capacities are not only multiple, but multi-scalar. In their literature review, Nalau et al., (2015) found a bias within adaptation science literature towards framing adaptation as a local process and responsibility. This is problematic because localized action can be constrained by other levels and actors at multiple scales (*ibid*). Similarly, research in social-ecological and social vulnerability literatures collectively suggests household adaptive capacities emerge (and are constrained) from socio-

political networks and relationships that interact across multiple scales (also Berkes et al., 2003; Gunderson & Holling, 2002). From critical institutional perspective, MacKinnon & Derickson (2013) problematized the global fervour of self-organization and adaptation within socio-political realities of authority, unequal power relations, and capitalism (also Porter & Davoudi, 2012). Ensor et al., (2015) advocates for a "rights-based" approach to adaptive capacity, wherein entitlements can be recognized through processes of contestation, or through appealing for accountable legal and administrative systems. The implications suggest that policies designed to enhance adaptive capacity cannot be concentrated at *one* geographical scale but must target multi-scalar factors that actively condition capacities.

Overall, these three insights – a focus on *household* capacities and on the multiple and multi-scalar factors that shape those adaptive capacities – provide a starting point or direction for policy to promote CA livelihood activities that are relevant to households, and to gain insight into factors that constrain household capacities to engage in particular CA activities. These insights are advanced in **Chapter 3**.

1.2 Research Questions and Objectives

Investigating a case of rice-farming and irrigation security in the Philippines, **I ask:** How have multiple interacting stressors affected irrigation service provision for rice-farming households? What contextual factors shape 'adaptive capacities' of agrarian households to engage in CA livelihood activities under the context shifting irrigation services? The following are key objectives of the research endeavour:

1. Assess how irrigation services in the Angat River Basin have shifted over time with respect to diverse interacting stressors across multiple scales.
2. Identify diverse and multi-scalar factors that condition household adaptive capacities to engage in CA livelihood activities in the context of irrigation service change.
3. Develop a conceptual framework that will better allow government and intergovernmental organizations to develop tailored and specific CA livelihood programs for smallholder agricultural households facing irrigation (and other social-ecological) change.

1.3 Methodology

This section describes the broader region of study, the field methods used to collect data sources, and the methods of data analysis used in this thesis.

1.3.1 Region of Study: The Angat River Basin (Bulacan, Philippines)

Central Luzon (Region III) on the Island of Luzon is often considered the "rice-basket" of the Philippines. Here, 21 national irrigation systems exist servicing 80,840 hectares, or about 10% of irrigated rice-land in the Philippines (NIA, 2013). As **Fig. 1.1** shows, irrigated palay production here has grown by 164% in the last three decades; last year, this region produced 16% of total irrigated palay in the Philippines. One important system is the Angat-Maasim River Irrigation System (AMRIS). Located in the Province of Bulacan (**Fig. 1.2**) and within the Angat River Basin, the AMRIS is capable of servicing 31,000 hectares and 22,000 farmer beneficiaries, the vast majority rice-farming households (Tabios & David, 2004). The system is fed by the Angat Reservoir, which serves the interests of multiple stakeholders, including Metro Manila where water allocations serve 97% of their domestic water need. Water allocations are complicated through inter-seasonal differences and inter-annual climatic variation, driven through seasonal change (dry-wet seasons) and El Niño Southern Oscillation (ENSO) events. These affect the reservoir's stock and thus its allocation to multiple stakeholders, namely irrigation as shown in **Chapter 2**. As this thesis is interested in examining how multiple stressors affect irrigation service provision for rice-farming households, the Angat Reservoir provides an unique case of two increasingly dominant drivers re-shaping irrigation provision in the Global South – increasing domestic water demand and climatic variation (see **Sections 2.2.1** and **2.2.2**). One municipality served by the Angat Reservoir and AMRIS is Bustos, where field methods were deployed to understand reported effects of irrigation service change. A more comprehensive overview of this municipality and the rationale for selection is provided in **Section 1.5**.

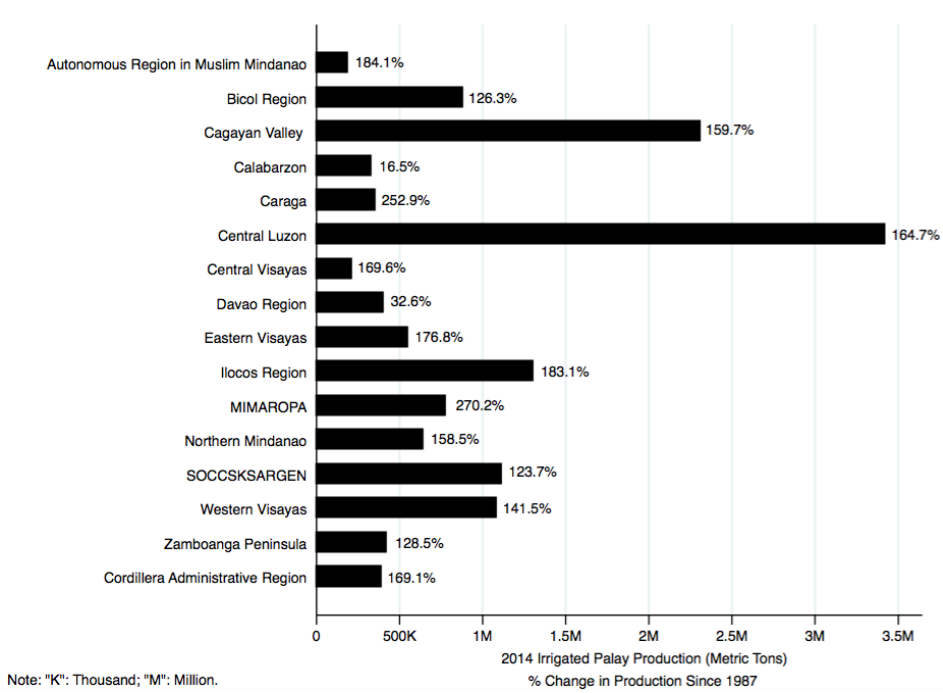

Figure 1.1: Irrigated palay production (2014) by region. Percent figures represent change in production since 1987. Source: Publically available data sourced from CountrySTAT (2014).

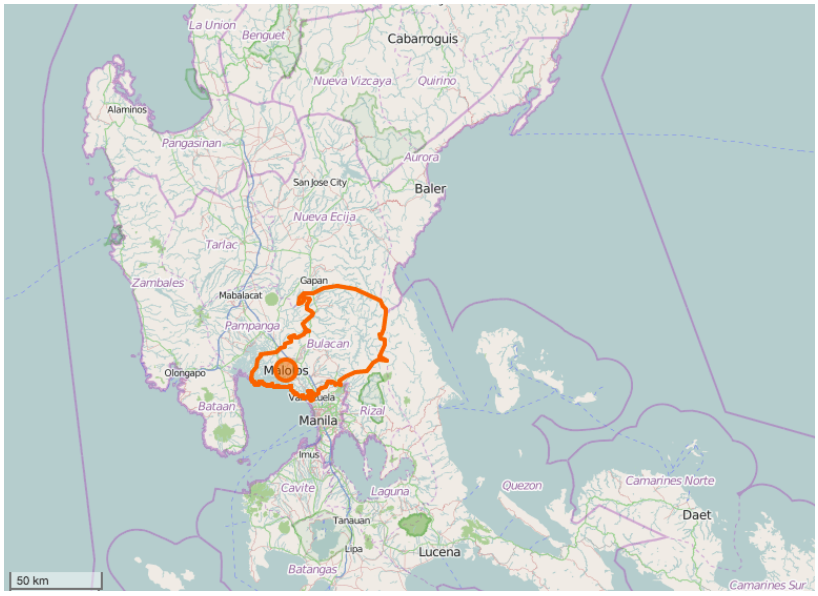

Figure 1.2: Map of Bulacan Province (orange) with the capital Malolos (circle). Source: Image created by author using OpenStreetMap (2015a).

1.3.2 Field Methods

1.3.2.1 Household Surveys and Interviews

Household surveys (n=124), semi-structured interviews (n=70), and focus group sessions (n=10) were completed with the help of three research assistants over a three month period (July-

September, 2014). Interviews expanded on components of the survey. Participation in the survey and interview were voluntary. Households were also free to end the survey at any point and were not required to answer all questions. The survey focused on two central themes: irrigation service changes and household responses to such changes (if change was reported as adverse).

The survey was divided into four parts and, on average, lasted between 45 minutes and 1 hour (**Appendix A**). Three research assistants conducted surveys in Tagalog. First, "we" (research assistants and myself) asked households for basic characteristics on family size, sex ratio, age, education level, occupational details, religion, savings, and held assets (e.g. vehicles, mechanized equipment, livestock). We also asked questions related to rice-farming (or other land-use activities), including distance from the head of Bustos dam (i.e. how far downstream is the household?), land-tenurial status, land-use patterns in an "average year", and the average irrigation water used for different uses (from rice, to other crop production, to domestic use) across wet- and dry-seasons. These questions provided basic knowledge and introduction to household characteristics and land-use patterns.

The second component of the survey was based on irrigation service related change. We began by asking the top five concerns that households faced with respect to farming during both seasons, with examples including but not limited to unpredictable irrigation amount and quality, drought, flooding, and storms, low market prices, and land tenure security. This was important to situate the extent to which irrigation is a seasonal concern for livelihood generation amongst a suite of social-ecological, political, and economic stressors in Bustos. Next, households were asked to compare the existing irrigation service conditions to 15 or more years ago with respect to three key water security parameters (amount, duration, and timing) for agricultural production. This time period will be clarified below. We then asked households to state whether *current* provision was "predictable" relative to past conditions. This was followed by one question on whether households anticipate *future* irrigation services – in terms of timing, amount, and duration – to be "predictable". These parameters of prediction, amount, duration, and timing are all related to the concept of water security and outlined in greater detail in **Chapter 2.** Interview questions investigated the nature of service change in greater qualitative depth.

The third component of the survey investigated household dependence on irrigation services to meet various on-farm livelihood needs (major crops, agricultural income, livestock, fishpond), and household access to alternative water sources to meet said needs. The last section investigated particular coping and adaptation (on- and off-farm) strategies households used, if negative changes in irrigation services had occurred. This included a sub-section on social relationships to various others within and outside household units and the sources of 'help' that could be mobilized when needed. We qualitatively investigated asked questions such as, "why" this strategy and not others to gain appreciation for particular reasons households engaged in one and not other activities. This was an important component of **Table 3.1** – highlighting key decision-making influences important in guiding household adaptation decisions.

Focus groups (n=10) were conducted often spontaneously at different farmer events in Bustos, including in "palay-checks", where experts showcased best management farm practices to local farmers in training and on-farm seminar training sessions; irrigation association meetings; and meetings between farmer leaders in communities at the municipal government hall. The questions asked followed the survey and interview themes outlined above, but varied from event to event and were thought of in spontaneous and organic fashion as the focus group meetings continued and new information arose.

1.3.2.2 Household Qualification and Sampling Strategy

To participate in the survey, three criteria were required. First, households themselves must have grown rice *in Bustos* before. I excluded day or seasonal labourers but not those who were *also* rice land tenants or owners. This is because the transient nature of labour cannot often account for the depth and richness of irrigation experience as compared to households stationed in particular locations over long periods of time. Second, households had to have used the AMRIS for rice-farming. While households could have grown rice in Bustos to meet the first qualification, it is possible a sub-set of these households could grow rainfed rice, such as in the barangays (village-level administration) of Catacte and Malawak where a combined 60 hectares and 96 farmers depend on precipitation alone (Municipality of Bustos, 2014). Last, households *could* have switched out of rice-farming due to declining service provision but were important to survey for this *exact* adaptation response. Therefore, households must have grown or harvested

rice in the last 15 or more years using AMRIS. This period reflects significant changes to water allocation guidelines in the Angat Reservoir (1997/1998) and will be discussed in depth in **Chapter 2.** Moreover, this latter criterion allowed for households to be surveyed over a wide time frame, capturing households that might have engaged in mixed or alternative land-use in the context of irrigation service change.

Two sampling strategies were used for household surveys and interviews. First, one or two barangays were selected at random each time surveys or interviews were conducted (i.e. at least once every two days). In rare instances, certain barangays were visited more than once in one week to complete previously scheduled surveys and interviews. We aimed to select households from *across* barangays (vs. clustered sampling) to participate in the survey and interview at the time or at later times. We randomly selected households in different geographic areas of the barangays. We also used snowball sampling where barangay officials or leaders were asked to randomly select households for surveying at a later time or date. We then would meet households at the barangay headquarters, or at their location. The latter sampling strategy was effective because it leveraged social connections of barangay councilors and community leaders.

1.3.2.3 Interviews with Government and Community Leaders

Interviews with community leaders and government officials were also conducted. Open-ended interviews with leaders, including barangay captains, academics, and historical experts were used to gain insight into specific challenges across barangays of Bustos, and gain contextual understanding of broader shifts in livelihood, water access, infrastructure, and agrarian life over a historical time period. Interviews with the Municipal Agricultural Office and the Municipal Livelihoods Office allowed for a strong appreciation of social-ecological drivers of change to agricultural livelihoods in Bustos. Furthermore, these two departments provided information on the types of programs available to support rice-farming households respond to shifts in irrigation and other social-ecological changes.

An essential benefit of working with local government was the establishment of a trusting partnership. This partnership is key because “endorsement” letters at one level of government (e.g. municipal) could be transferable, serving as a catalyst for trust-building across different

government levels (e.g. provincial, central) and their various departments. This facilitated the collection of multiple long-term datasets on agricultural production, hydrological flows into the Angat and Bustos Reservoirs, and water allocation across multiple stakeholders. Datasets will be drawn upon to triangulate shifts in water access occurring at the reservoir-level with self-reported experiences of irrigation service change at the household scale (see **Chapter 2**).

1.4 Data Analysis

As described above, we collected three major sources of data. These included surveys (household-level), interviews (household, government, community-leaders), and multiple secondary datasets (via municipal, provincial, and national government officials). All information, with the exception of secondary datasets, was translated from Tagalog to English.

Household surveys were entered into Microsoft Excel and descriptive and summary statistics were conducted for each survey question. For qualitative components of the survey, such as where households expanded upon the nature of irrigation service change, quotes were coded and summarized to infer broader trends (e.g. in **Fig. 2.8**). Interviews were often audio-recorded and translated into Microsoft Word. To gain a stronger appreciation for context, but also help answer the research questions above, I coded interview data – based on four main questions – that were *consistent* across surveys, interviews, and focus group sessions. These included (bold relates to overarching research questions, non-bold refers to other general contextual questions):

- What is rice-farming like today?
- **How have irrigation services changed in comparison to the past?**
- **What factors limit or enhance livelihood adaptation to irrigation service change?**
- What makes farmers better off when facing environmental change?

Three rounds of coding were performed using Saldaña's (2012) coding manual. The first round was "attribute" coding, where similar quotes from surveys, interviews, and focus groups were highlighted. These could include quotes such as water is "often less in volume", or "not enough". The second round of coding was "descriptive", where these quotes were grouped within

descriptive themes, such as "scarce water amount". The final group of coding synthesized these descriptive themes to gain an overall message or messages to the question at hand. These codes have been weaved into the findings of **Chapter 2**, with respect to shifts in irrigation services, and into **Chapter 3**, with respect to delineating particular factors that shape household adaptive capacities to engage in CA livelihood activities. Moreover, the codes have been used to gain contextual appreciation for the state of rice-farming that are used to substantiate the 'need' for livelihood adaptation (**Sections 1.5.3** and **1.5.4**).

Multiple secondary datasets were analyzed to identify long-term trends in irrigation service change. Other datasets were used to summarize agricultural production in Bustos. All data was analyzed using Microsoft Excel and STATA 13.0. All figures produced in this thesis were generated from STATA 13.0.

1.5 The Municipality of Bustos

The field methods outlined in **Section 1.4** were applied in the Municipality of Bustos.

1.5.1 Site Selection

This research occurred in the Municipality of Bustos, located 50 km north of Metro Manila in the Province of Bulacan. This particular location was chosen for three reasons. First, Bustos is one of two municipalities[1] situated at AMRIS's main canal-head. It thus provides a context of different levels of exposure across the site, from households situated at the canal-head, to those situated in more distant locations. Second, this municipality a diversity of social-ecological relationships, aside from rice-farming, across topographies and locations, from fishpond activities to vegetable farming. This diverse social-ecological context will be drawn upon in **Chapter 3** as it relates to cross-scalar effects on rice-farmer adaptive capacity. Third, this project is affiliated with a larger Social Sciences and Humanities Research (SSHRC) funded project[2] in the Angat River Basin. As a part of this project, other previous research has established strong relationships and working

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[1] The other Municipality is San Rafael, served by the North Main Canal.
[2] Entitled: "Collaborative Governance of Urbanizing Watersheds: Integrated Research, Institution and Capacity-Building of Angat River Basin, Philippines".

partnerships between researchers and the households, businesses, and government of Bustos (see Harding, Iwama, & Thomas, 2013; Thomas, 2014). These partnerships were critical for rapidly establishing a trusting relationship given the limited time frame of the field season.

1.5.2 An Overview of Farming in Bustos

Bustos is sub-divided into 14 barangays and has approximately 70,000 inhabitants comprising 14,000 households (Municipality of Bustos, 2013). Over 60% of households in Bustos are involved directly or indirectly in agricultural production or agribusiness (Harding et al., 2013). Of the households sampled, 50% of households were landowners (amortizing owners, owners non-cultivators, or owner-cultivators) and 50% were lease tenants. Households also engaged in agricultural labour work. Although this is a *sample*, it contrasts with other research that estimates 15-25% of households working on farms in Bustos are landowners (cf. Harding et al., 2013).

The agricultural land farmed in Bustos is mostly irrigated rice (82.6%) with the remaining percentage divided between rainfed rice, vegetable and mango production, and fishpond (aquaculture). The majority of sampled households exclusively farm rice. As I recall in later Chapters, 83% and 82% of sampled households dedicate the totality of their land to rice production in wet and dry seasons, respectively. Most of these households are connected to the AMRIS and 80% use irrigation *only* for rice production. Fishponds cultivating tilapia, catfish, or waterfowl were major secondary users of irrigation[3]. As a result of this coupling with irrigation, 89% of households were "strongly dependent" on irrigation for their major crop, and 82% were "strongly dependent" on irrigation for agricultural income in the dry season. During the wet season, households were less dependent on irrigation for rice production and income generation, but 91% and 87% reported dependency (strongly or sometimes[4]) on service provision.

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[3] Households use groundwater for livestock and vegetable production.
[4] These were self-interpreted terms, often taken as dependent on irrigation at all times of the rice life cycle ("strongly") or dependent some of the time, such as during periods of non-rain periods.

1.5.3 An Overview of Farmers in Bustos

Of the 124 households sampled, the average age of the household head was 59, though a considerable number of heads (40%) were under the age of 55. Many, especially those elder households, recalled that land redistribution, increasing costs attributed to intensive inputs and mechanization, and the withdrawal of certain state services, such as guaranteed pricing, have now established a "high-risk" context for farming. As one household recalled, "Farming is like gambling…Sometimes you have a clear view of your win only to find out that you'll lose in the end". The context of high-risk resonates with a broader literature outlined above in **Section 1** that traces diverse threats to crop production and value in the Global South.

This context has led, as households suggest, to a culture of individualism in farming ("kanya-kanya") in Bustos. For example, one household suggested that today people ask, "Will I gain anything from that? What's in it for me?...Today, you cannot find *bataresan* (favors given without return expectations), yesterday you could call a farmer a hero". Another suggested, "*bayanihan* (spirit of communal unity) became *bayarana* (work for money). Gone now are the days that everyone will help each other and work for the better without charging monetary value". Such a context is well aligned to other Philippine scholarship, including the work of Kerkvliet who suggested land reform and rising costs ensured that "[c]ash is required at nearly every step in the farming process…[and households] compete with each other and with the large proportion of farming families who need multiple sources of income" (Kerkvliet, 2002, p. 4). As a partial result of monetary needs for high-cost farming, networks such as informal lending and robust rental markets have emerged.

The context of high-risk and individualism in farming is problematic when considering that Bustos is experiencing important social-ecological change, from rural-to-urban land conversion, industrialization and resource appropriation, infrastructure degradation, and invasive species proliferation (**Fig. 1.3**). Other work highlights potential stressors, namely climatic, to resource-dependent livelihood in the Angat River Basin (Barisky, Carter, & Crego-Liz, 2014; Camargo, Lennon, & Shah, 2014; Greig, Leib-Milburn, Ngo, & Taylor, 2014; Harding, Iwama, & Thomas, 2013). These factors, in addition to growing urban water demand in Metro Manila, can interact to

affect household irrigation access (see **Chapter 2**). As a result of complexities associated with irrigation provision and access, 71% and 30% of sampled households ranked irrigation as their "top concern" in the dry and wet seasons, respectively. The potential for substantial investment loss in a particular cropping season is problematic considering 48% of households reported not having savings[5] to mitigate effects of loss and damage. Of these households, a considerable number of these rely on informal high-interest lending as a means of supporting agricultural production in the following seasons and years. I will return to this issue of informal credit, as it relates to adaptation to irrigation service change, in **Chapter 3**.

Figure 1.3: Social-ecological change in Bustos. A) Land conversion; B) Canal clogging; C) Industrialization; D) Invasive species proliferation (*igat,* or rice-eel). Source: Photographs taken by the author.

1.6 Thesis Outline

Chapter 2 examines how irrigation service provision has been reshaped through interacting stressors at multiple scales, namely water re-allocation to Metro Manila and climatic variation.

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[5] Approximately 10% chose not to answer this question.

The Chapter first provides an adapted definition of irrigation water security, which was widely recognized as a key pillar of 'development' for enhanced production in agrarian regions. Second, it highlights an emerging literature investigating potential impacts on agricultural water supply, namely from irrigation water re-allocation and climatic variation. Building on this scholarship, I show how a systematic set of rules and regulations restructured reservoir governance to privilege domestic urban water uses in Metro Manila. These shifts interact with existing periods of climatic variation to drive irrigation "water insecurity" for smallholder agriculturalists in Bustos, and elsewhere in the river basin. The Chapter concludes by suggesting the interaction between governance reform and climatic variation can compromise the intended benefit of irrigation infrastructure, that is, to enhance agricultural water security by providing predictable flows that protect users against climatic variation.

Based on the nature of irrigation service change, **Chapter 3** argues that on- and off-farm efficiency measures *alone* are insufficient to completely protect households from risks of irrigation insecurity. Moreover, access to water alternatives is limited and increasingly uncertain. It suggests CA livelihood activities are increasingly important as risk mitigation measures given irrigation service change and broader social-ecological stressors. Those households sampled in Bustos share this recognition. All too often however, standardized livelihood activities promoted by governments encounter resistance, rejection, or are rendered irrelevant. One reason why proposed activities fail is because they do not align or overlap with certain CA activities that households are able and willing to engage in ("decision spaces"). **Chapter 3** provides an integrative framework that allows policy-makers to better understand how contextual factors, which are multiple and multi-scalar in nature (**Section 1.1.5**) – from national land tenure laws to individual household *ways of life* – condition household capacities to engage in particular CA activities. Applying the framework in Bustos, the Chapter provides guidance as to how adaptation policy can i) promote CA livelihood activities that are both relevant and palatable to households; and ii) challenge constraints such to enlarge the set of activities households could engage in. Overall, this thesis represents an analysis of irrigation re-allocation as one facet of social-ecological change in the Angat River Basin and provides suggestions for accommodating change effects through substantive recommendations for adaptation policy.

Chapter 2: Water Governance, Climatic Variation, and Irrigation Water Insecurity: A Case from the Angat River Basin (Bulacan, Philippines)

2.1 Introduction

As mentioned in **Chapter 1**, smallholder poverty alleviation programs have often focused on enhancing agricultural production (Rigg, 2006). Within these programs were widespread investments in surface irrigation designed to enhance agricultural water security, namely by providing predictable, adequate, and timely flows of water to protect smallholders from hydro-climatic variation. From the beginning to the end of the 20th century, for instance, irrigation supply from reservoirs increased globally from 18 km^3 yr^{-1} to 460 km^3 yr^{-1} (Biemans et al., 2011). Empirical evidence has since demonstrated positive associations between irrigation service provision, agricultural production, poverty reduction, and asset accumulation[6] (Hussain and Hanjra, 2003; Lipton et al., 2003). However, the stabilization and control of water can facilitate the cultivation of water-intensive crops, establishing a tight coupling between agricultural livelihoods and the supporting infrastructure[7]. Such couplings have the potential for harm if the effectiveness of infrastructure and service provision diminishes or fails (Holling et al., 2002a; Moench, 2007; Young et al., 2009). Increasingly, research suggests multiple stressors, such as climatic variation and cross-sectoral water re-allocation, challenge the effective provision of irrigation services, disrupting feedbacks between stable provision, irrigated production, and household economic benefit (e.g. Liverman, 1990; Molle and Berkoff, 2006; Birkenholtz, in review). In this Chapter, I examine a case from the Angat Reservoir (Philippines) showing how reservoir water governance, re-structured to protect and prioritize domestic urban water use in Metro Manila, interacts with existing climatic variation to detract from a central goal of surface irrigation: enhancement of agricultural water security for smallholder use. This work is unique because it illustrates how aspects of governance reform (social) and climate variation

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[6] Infrastructure benefits can be uneven across categories of social difference (Harris, 2008) and can also compromise contributions to sustainability (Shah and Gibson, 2013).
[7] Scholarship has shown couplings with other stressors, like global market entrance, can enhance vulnerabilities associated with the cultivation of irrigated crops (Eakin, 2003).

(biophysical) *interact* to detract from irrigation water security, a central component of agrarian poverty alleviation initiatives.

First, I outline linkages between water governance, irrigation infrastructure, and water security. Second, I highlight literature examining how water re-allocation and climatic variation create irrigation service change. Third, I detail how Metro Manila was able to appropriate water, infrastructure, and allocation rules of the Angat Reservoir based on the need to mitigate and alleviate urban water scarcity. Following Celio et al. (2010), I adapt "appropriation" as the power to induce water transfers and also to subsume institutions, here as allocation processes, to secure a larger entitlement to water. Last, I show how appropriation interacts with climatic variation, in this case low precipitation periods often originating from El Niño events, to undermine irrigation water security for rice-farming households. The somewhat paradoxical outcome is that households can face irrigation water insecurity, defined below, in *both* wet and dry seasons thus increasing their reliance on variable precipitation patterns.

2.2 Irrigation Water Security

Adapting the works of Grey and Sadoff (2007), Cook and Bakker (2012) and Bakker (2012), I consider 'secure' irrigation services to: i) be adequate in the amount, duration, and timing of water supply that together satisfy agricultural needs; ii) protect against water-related hazards, such as low-precipitation events; and iii) be predictable in its delivery. I use the term irrigation water security to emphasize the above facets, whereas water security relates to a broader set of water alternatives needed to meet agricultural and household needs[8]. Reservoir governance occupies a central role in fulfilling irrigation water security apart from the physical infrastructure that facilitates the transfer of water. I refer to reservoir governance as the systematic set of frameworks (rules and regulations) that strategically *shape* water allocation decisions (goals and directions), and the processes by which trade-off effects are identified, mitigated, and resolved (adapted from Bakker, 2003). Reservoir management, on the other hand, refers to *how* the goals and directions set out in governance frameworks are accomplished and addressed (*ibid*). As it

[8]Commercial and industrial users of the Angat River Basin also require water security, but I stress its importance in the agricultural context here.

relates to the Angat context, I examine: i) how increased urban domestic demand and climatic variation have restructured water rights and allocation decisions for domestic and agricultural use; ii) its effects on irrigation water security; and iii) the mechanisms available for the accountable resolution of trade-offs in water use. I begin first with two stressors that affect service provision: its re-allocation and climatic variation.

2.2.1 Re-allocation of Irrigation Water

The re-allocation and re-prioritization of water allocated irrigation to alternative uses directly threatens irrigation water security. A growing literature highlights increasingly common rural to urban transfers, occurring through various mechanisms, particularly in developing countries (Loeve et al., 2004; Molle and Berkoff, 2006; Levine et al., 2007; Meinzen-Dick and Ringler, 2008; Celio et al., 2010; Bao and Fang, 2011; Wagle et al., 2012; Wang et al., 2015; Birkenholtz, in review). Transfers emerge to support growing urban needs, often thought to emerge from a lack of available water, even in plentiful areas, rather than inadequacies in urban water capture and management (Molle and Berkoff, 2006). The lack of urban water is often blamed on irrigation for having high water inefficiencies and using the dominant share (*ibid*). Re-allocation for urban demand can serve both domestic and industrial or commercial use. Wagle et al. (2012), for instance, highlighted how Special Economic Zones in Maharashtra (India), designed to attract private and foreign investment, have increased industrial demand for land-water resources. Maharashtrian water policy now reflects a broader urban water bias, prioritizing industrial uses above irrigation uses, with powerful political interests driving water distribution (*ibid*). Rola et al. (2015) suggest policies guiding water allocation in the Philippines are now "…seen to be biased for the urban centres" (p. 10). Transfers are also being facilitated under broader discourses of "good governance", such as the access to safe drinking water (Birkenholtz, in review). Here, Birkenholtz's (in review) work in Rajasthan (India) suggests transfers should be seen as a solution to meet demands for GDP growth rather than solely an exercise to meet growing urban domestic needs. While it is widely recognized that "good" governance is central to ensuring and meeting multiple human and non-human needs (World Water Council, 2000, 2003, 2015), agricultural water shifts must be situated within larger processes of growing urban demand, political priorities, and international discourse.

2.2.2 Climate Variation and Surface Irrigation

Irrigation will be the "water sector" most influenced by climatic change and variation (Döll, 2002). Following the Intergovernmental Panel on Climate Change (IPCC), climatic change is a change in the state of the climate that is identifiable using statistical tests and persists for extended periods of time (Agard et al., 2014). A growing literature suggests climate change will affect global irrigation water availability (Immerzeel et al., 2010; Elliott et al., 2014) and irrigation demand requirements (Döll, 2002; Rodríguez Díaz et al., 2007; Fischer et al., 2007; García-Garizábal et al., 2014; Chavez-Jimenez et al., 2014; Islam and Gan, 2015). Climatic variation, the focus here and linked to climatic change processes, refers to variability in the mean state of the climate across space-time scales that extend beyond individual weather events (Agard et al., 2014). Climatic variation challenges the ability of irrigation services to protect households from water-related hazards, including low-precipitation events (Young et al., 2009). Liverman (1990) working in Mexico, showed that prolonged multi-year drought reduced reservoir inflow and stock over time compromising long-term agricultural investments in certain irrigated service areas. As a result, financial losses in irrigated areas can be greater than drought losses in rain-fed areas, including where irrigation expanded or intensified agricultural production (*ibid*). In Chile, Vicuna et al. (2014) showed how a strong reliance on irrigation infrastructure allowed households to become exposed to climatic variation when prolonged drought cycles compromised services. Here, households implemented efficient drip irrigation structures, allowing them to increase the acreage of permanent crops (*ibid*). This acreage increase, combined with reduced opportunities for increasing water efficiencies, created a new social-ecological context where irrigation-dependent households became increasingly exposed to the impacts of prolonged drought (*ibid*). While the effects of climatic variation are partly determined by how irrigation water is used and allocated, scholarship consistently suggests low-precipitation events can compromise household protection from water hazards.

2.2.3 Interactions of Re-allocation and Climate Variation

Scholarship examining how rural to urban water transfer and climatic variation affect the allocation of irrigation services view them as interacting rather than independent factors (e.g. Molle and Berkoff, 2006; Celio et al., 2010; Komakech et al., 2012; Birkenholtz, in review).

Research argues that irrigation performance must improve given the projected impacts of global climatic change and increased competition from productive economic sectors (Turral et al., 2010). Where scholarship examines impacts to irrigation at this intersection, its focus often lies in examining processes of re-allocation and effects on irrigation users during short-term periods of water stress, such as individual low rainfall and river flow periods. Cases where interactions are not contingent but systematic are less well understood, as is the case of the Angat Reservoir. Here, systematic and increasing re-allocation of water for domestic use in Metro Manila was accompanied by reservoir rules that protected and prioritized this volume, per the National Water Code (1976), during periods of water stress. My efforts here examine the interaction of climatic variation and water re-allocation as a longer-term process linked to institutionalized rural to urban water re-allocation from the Angat Reservoir, showing how its interaction drives irrigation water insecurity for smallholder agriculturalists in the basin.

Providing a systematic case of interaction, I emphasize that this Chapter is not a single case of the Philippines. As shown above, a growing literature emphasizes impacts to irrigation from climatic variation *and* shifts in water governance processes. In other words, biophysical processes *and* socio-political processes, global and regional in nature, shape water distribution, provision, and access through a coupled hydrosocial cycle (Swyngedouw, 2004). Bridging these two variables is crucial, particularly because the impacts projected under climatic models depends on governance arrangements that specify *who* receives *how much* under *which* conditions. As irrigation often receives over 70% of allocated water budgets in the Global South, bridging is critical to understand specific and nuanced regional impacts to irrigation and agriculture. Byway of understanding interactive outcomes, policy-makers can develop specific measures to prevent impacts of water re-allocation under particular climatic contexts.

2.3 Study Site and Methods

The Angat River Basin is an important rice producing area in Bulacan (Philippines). The formalization of water institutions in the Philippines allowed the government to allocate a significant share of water from major dams constructed in the post-war era to rice-cultivation (Rola et al., 2015). The multipurpose Angat Reservoir (865 million m^3 capacity) provides water

for regional irrigation (National Irrigation Administration; NIA), domestic use in Metro Manila (Metropolitan Waterworks and Sewerage System; MWSS), hydroelectricity generation, and environmental flows (Jose and Cruz, 1999). Water is released from the reservoir, generating hydroelectricity, flowing downstream to the Ipo Dam. From there water for domestic use is diverted to Metro Manila. Water is also released downstream to the lower Bustos Dam, and then through the Angat-Maasim River Irrigation System (AMRIS) to 22,000 farmer beneficiaries (Tabios and David, 2004). The ability to meet multiple needs, primarily for NIA and MWSS, is largely contingent on inflows and water level of the reservoir. As shown in **Fig. 2.1**, however, the inflows into Angat Reservoir are characterized by strong intra- and inter-annual inflow variation, posing challenges to continuous provision of water for all users (Brown et al., 2009). A key climatic variable for this system is precipitation, which partially determines runoff and inflows into the Angat Reservoir (Jose et al., 1996). An important cause of variation in precipitation (and inflow) is the El Niño Southern Oscillation[9] (ENSO) (Yumul et al., 2009; Yumul et al., 2013). Under 'normal' years the summer-wet season, associated with the southwest monsoon (*Habagat*), occurs from June to September and accounts for 30% of the annual inflows into the reservoir (Brown et al., 2009). Similarly, the winter rain reason, associated with the northeast monsoon (*Amihan*) occurs from October to February, contributing 55% of annual reservoir inflow (*ibid*). El Niño events, often peaking between the last quarter of their occurring year (Oct-Dec) and the first quarter of the next year (Jan-Mar), can weaken the northeast monsoon, which is critical for Angat's inflows (Chao et al., 1996; Weng et al., 2009). I return to its implications in the context of water governance in **Section 2.4.4**.

A primary recipient of irrigation water within Bulacan, and the location of this study, is the Municipality of Bustos (**Section 1.5**) (**Fig. 2.2**). Agricultural land area in Bustos is composed mostly of irrigated palay (82.6%) (Municipality of Bustos, 2014). In 2012, irrigated palay totaled 10,786 Mt and 9,488 Mt in the dry and wet seasons, respectively, comprising almost 7% of provincial production (CountrySTAT, 2014; Municipality of Bustos, 2014). Given Bustos is 2% and 2.5% of provincial population and land area, respectively, I consider it an important rice producing area.

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[9] Refers to both El Niño and La Niña events. I focus on El Niño events in this Chapter.

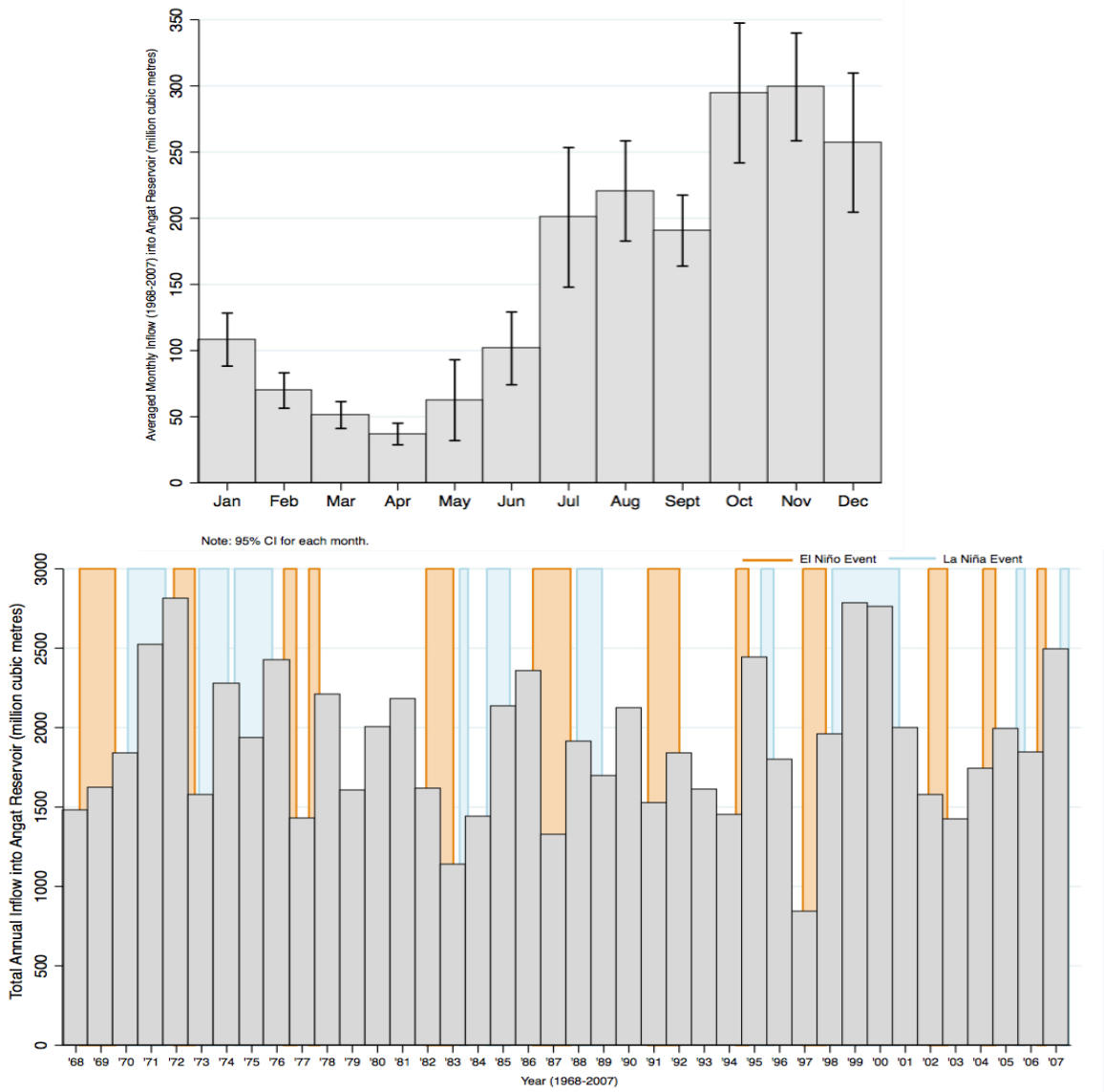

Figure 2.1: Historical average inflows per month into the Angat Reservoir (top). Historical average annual inflows into the Angat Reservoir (bottom). Source: Data used with permission from the International Research Institute for Climate and Society (IRI, 2010). Publically available data sourced from National Oceanic and Atmospheric Administration (NOAA, 2015).

Bustos[10] does not receive the benefits of the northeast monsoon and thus has both a wet (May-Oct) and a dry (Nov-Apr) palay cropping season. Irrigation is needed in the dry season given the lack of accessible water substitutions and in the wet season to provide predictable and certain volume of water that allows for planting to protect against delayed or variable rainfall patterns. The dry season, overlaps with the peak inflow period (Oct-Feb) into the Angat Reservoir. As shown in **Fig. 2.3** this means that water levels in the reservoir, to be allocated for multiple uses, often peak during the Bustos *dry* cropping season. The lowest inflow rates (Jan-Jul) correspond

[10] Bustos is situated in Zone I (distinct dry-wet seasons).

with reservoir draw down to and below 180 m during certain wet season years. This means that the water levels in the reservoir are at the lowest level *during* the wet cropping season (May-Oct). If the water level is at or below this minimum operating level (180 m), as described later, water is diverted to MWSS. It is important to note that almost all domestic water in Bulacan is sourced from groundwater (Bedore, 2011; Fresco and Angeles, 2012).

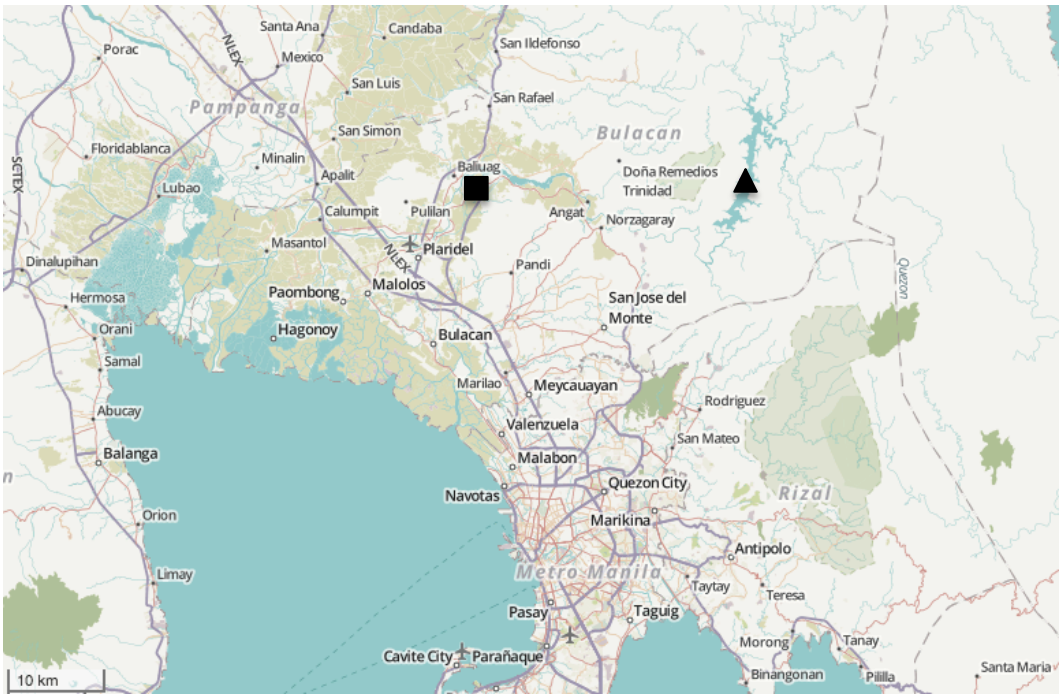

Figure 2.2: Map of Municipality of Bustos (square) and the Angat Reservoir (triangle). Source: Image created by author using OpenStreetMap (2015b).

I conducted a systematic analysis of multiple secondary datasets and policy regulations to examine how reservoir governance shifts and climatic variation interact to affect irrigation water security. I supplemented this analysis with 124 surveys of rice-farming households in Bustos (one survey per household). Surveys documented self-reported experiences with irrigation services, framed using the security criteria above, as compared to 15 or more years ago, a time frame that captures a key shift in reservoir governance (discussed further below). We (research assistants and myself) sampled households using random and snowball sampling techniques (see **Section 1.4**). STATA 13.0 was used to create figures.

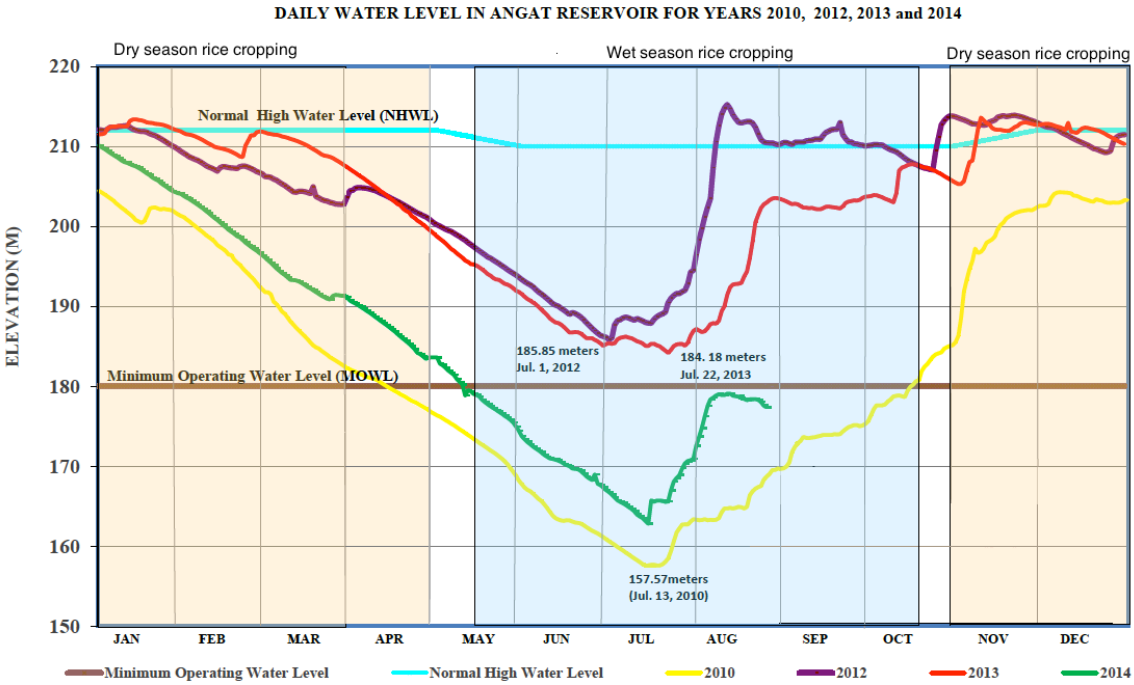

Figure 2.3: Water level in the Angat Dam (2010-2014). Orange shading represents dry cropping and blue shading represents the wet cropping. If water falls below 180 m ('Minimum Operating Water Level') irrigation will not receive water. Source: Image used with the permission from the National Irrigation Administration (NIA, 2014a).

2.4 Results

I now focus on how restructured water governance of the reservoir, increasingly favouring urban water use in Metro Manila over regional irrigation use, interacts with existing climatic variation to produce irrigation water insecurity. To do this, I first present an overview of legal and regulatory frameworks that facilitated an increase in Manila's water rights (**Section 2.4.1**). This includes historical changes in water rights for irrigators in Bulacan and domestic water users in Metro Manila. Next, I focus on the actual allocations to MWSS in light of these frameworks (**Section 2.4.2**) and on the processes of water allocation (**Section 2.4.3**). I then highlight implications of the above governance reforms and their implementation on irrigation water security during periods of climatic variation (**Section 2.4.4**).

2.4.1 Metro Manila's Accumulation of Water Rights

When the Angat Reservoir became operational in 1968, NIA held the dominant share of water rights[11] (40 m^3/s or est. 66% of reservoir inflows) with MWSS granted 9.5 m^3/s (est. 16%) (IRI, 2010; World Bank, 2012). The minimum downstream inflow requirement was 2 m^3/s (Tabios and David, 2004). Water rights, based on the rural and urban water needs at the time, were granted by the government to allow stakeholders to "appropriate and use water" (National Water Code, 1976). Water allocations are the actual provisions of water that might or might not align with granted rights based on prevailing hydrological conditions and adherence to the rules governing water rights. Here, right-holders could be allocated a lower or greater share of water. From 1968 to early 2000s, a series of systematic resolutions by the National Water Resources Board[12] (NWRB) increased the water rights to MWSS (World Bank, 2012). It also included, in 1988, Resolution No. 03-0188, allowing MWSS to use up to an additional 15 m^3/s of NIA's water right provided this right was unutilized by NIA (Tabios and David, 2004; Pascua, 2007; World Bank, 2012). Based on MWSS's non-conditional water right at the time (22 m^3/s) this Resolution allowed for a maximum withdrawal of 37 m^3/s (*ibid*). Much to the ire of irrigators downstream, regardless of whether NIA used its allotment or not, MWSS often staked claim to this conditional amount due to their strong reliance on the reservoir (World Bank, 2012). When conflicts occurred MWSS used the legal provisioning in the National Water Code of the Philippines (1976), which allowed domestic needs to be prioritized over irrigation needs during "times of emergency", thus overruling the First-in-Time First-in-Right clause that supported NIA's original water rights (National Water Code, 1976, Article 22; Molle and Berkoff, 2006; World Bank, 2012). Here, the concept of 'emergency' invoked an insufficient reservoir volume to meet domestic water use needs. In greater efforts to increase domestic supply and reduce tension, the Umiray-Angat Transbasin Project (UATP), in 1998, allowed for an additional diversion of 9 m^3/s into the Angat Reservoir for use by MWSS, raising their non-conditional

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[11] Estimates for NIA and MWSS vary. Tabios and David (2004, p. 111) state NIA's original right was 40 m^3/s and that MWSS's original water right was 22 m^3/s. This amount still means NIA held the 'lion's share' of water rights.

[12] The NWRB is the central government water agency in the Philippines. It is charged with allocation of water rights to the multiple competing water needs in the Angat Reservoir Basin.

right to 31 m^3/s (Fresco and Angeles, 2012). After UATP construction, the average annual inflow into the reservoir for use was 69 m^3/s (cf. World Bank, 2012)[13].

Overall, these three decades saw MWSS increase its water right to 31 m^3/s *and* accumulate conditional rights (15 m^3/s). As rights and demand increased, MWSS drew on the 'emergency' clause in the National Water Code to affect greater appropriation during periods of water stress. On the other hand, NIA saw a permanent reduction by 4 m^3/s, placing the two main users roughly equal in water rights under non-emergency conditions (Tabios and David, 2004; Fresco and Angeles, 2012). The totality of revised water rights for MWSS (31 m^3/s), NIA (36 m^3/s), and downstream flows (2 m^3/s) matched the average inflow rate (69 m^3/s). At the same time, using slightly higher allocation estimates, Dumol (2000) suggested that of the 3000 million liters/day (MLD), or 34.72 m^3/s to MWSS from Angat in 1994, about 56% was classified as non-revenue water (NRW)[14]. Moreover, water services only extended to two-thirds of the coverage population for an average duration of 16-hours per day (*ibid*). Despite the fact that MWSS was receiving a higher allocation to meet rising demand, the political discourse of an urban 'water crisis' emerged. The 'crisis' was, in large part, an institutional product of clientelistic water delivery where MWSS was treated as a component of the political apparatus, leading to a state of huge financial burdens and poor service deliveries (see Chng, 2013). Privatization, furthered through the influence of multilateral financial organizations and global neoliberal discourse in water circles, was viewed as the solution to simultaneously 'depoliticize' water distribution, absorb the massive debt, reduce NRW, and account for water demand growth (Dublin Principles, 1992; Dumol, 2000; Tabios and David, 2004; Chng, 2013). This should come as no surprise considering international discourses around water have strongly shaped the Filipino water governance contexts (Rola et al., 2015). As shown below, this had major implications for water rights, allocation, and irrigation water security.

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[13] World Bank (2012) estimates the annual average reservoir inflow, including the Umiray project, was 70.8 m^3/s.
[14] Non-revenue water is the unbilled water that is lost through pilferage and leakages before reaching the consumer.

2.4.2 Shifting the 'Lion's Share' of Water

Where the prior section discussed shifts in water rights here I focus on the shift in actual water allocations, which reflects the shifting water rights amongst the stakeholders. In 1997, contracts for urban water distribution in Metro Manila were given to two private concessionaires[15] who committed to absorbing debt accumulation, expanding the range of supply, and increasing the duration of service (see Dumol, 2000). The contracts, in effect, treated both the 31 m^3/s allocated to MWSS and the conditional 15 m^3/s that could be taken from NIA in emergencies as a firm water right of 46 m^3/s for the concessionaires (Brown et al., 2009; Someshwar et al., 2009; MWSS, 2015). This amount of 4000 MLD (46 m^3/s) amounts to 95.5% of the water used in the MWSS service area (World Bank, 2012). Moreover, MWSS was forced to compensate the concessionaires if 46 m^3/s was not delivered, thus fostering a negotiation process where MWSS was "…typically unwilling to accept reductions of more than 10 per cent below this amount, even though there is no written rule to this effect…" (Brown et al., 2009, p. 254; also Someshwar et al., 2009). This granting of 'additional' water allocation for inter-basin transfer, is again, not surprising given that the private concessionaires acquired immense power as 'solvers' of Metro Manila's water 'crisis.' As shown in **Fig. 2.4**, MWSS has since received the 'lion's share' of water, providing an indication that distribution is not independent of social and political relationships nested within the dominant and powerful discourse of an urban water crisis in Metro Manila (also see Swyngedouw, 2004). Their accumulation created a scenario where the effective water rights for all stakeholders exceeded the actual average inflows into the reservoir (see World Bank, 2012). Here, MWSS was allocated 46 m^3/s, where NIA and downstream needs were provisioned (on paper) 36 m^3/s and 2 m^3/s, respectively, indicating allocations exceeded the average annual inflow (69 m^3/s) (World Bank, 2012). During periods of shortage, the National Water Code prioritizes the right for human consumption over water for livelihood use (National Water Code, 1976, Article 10).

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[15] Manila Water Corporation Inc., serving the East Zone and Maynilad Water Services Inc., for the West Zone.

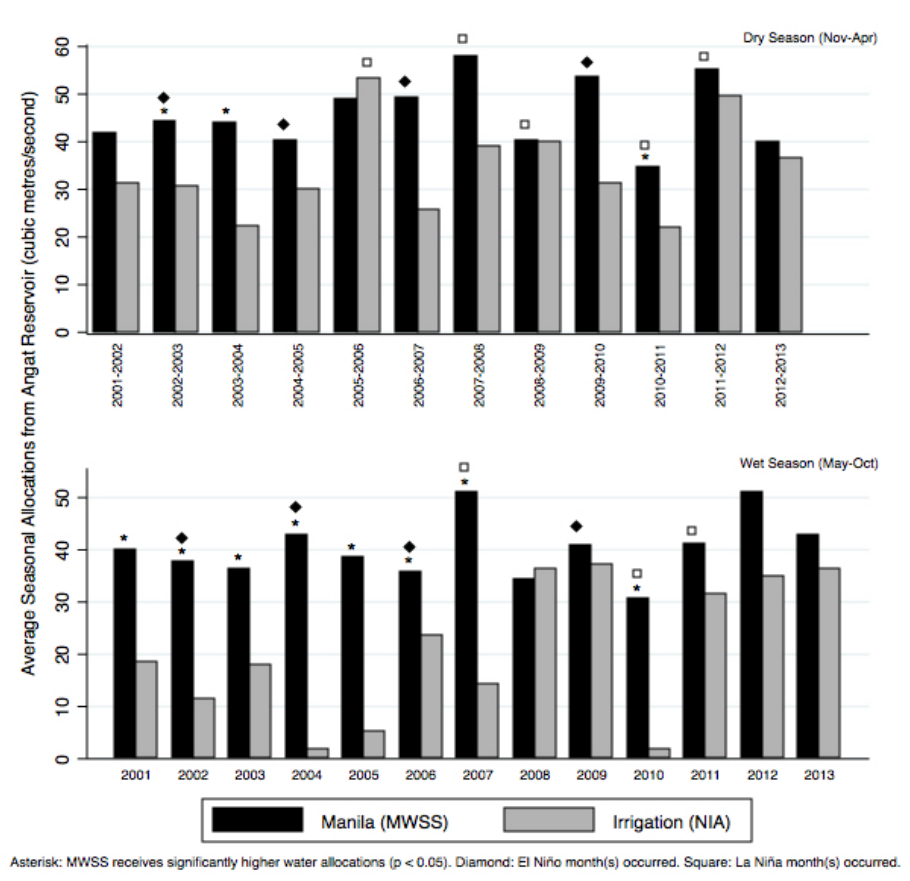

Figure 2.4: Actual water allocations for MWSS and NIA from Angat Reservoir (2001-2013). Source: Data used with the permission of the National Water Resources Board (NWRB, 2014). Publically available data sourced from NOAA (2015).

The re-allocation of water *away* from NIA – through forces of political power and urban demand – cast their rights as "…neither clearly recognized nor sustainable, as they are not strong, well defined, or secure" (Bedore, 2011, p. 119). As it stands, NIA now receives much less water (Rola and Elazegui, 2008; MWSS, 2015). From the coding exercise described in **Section 1.4**, a key theme that emerged was a reduction in the amount of water now available for irrigation and the notion of domestic water being "worth more" than irrigation water for livelihood purposes. Using empirical data, Dawe et al. (2009) show a consistent decline in the total water diversion into the AMRIS main canal during dry seasons from 1968-2005. My analysis found a declining trend in flows released for irrigation from the Angat Reservoir as proportion of reservoir

inflows[16]. Such a decline, shown in **Fig. 2.5**, can be particularly problematic during the dry season given heightened irrigation demand.

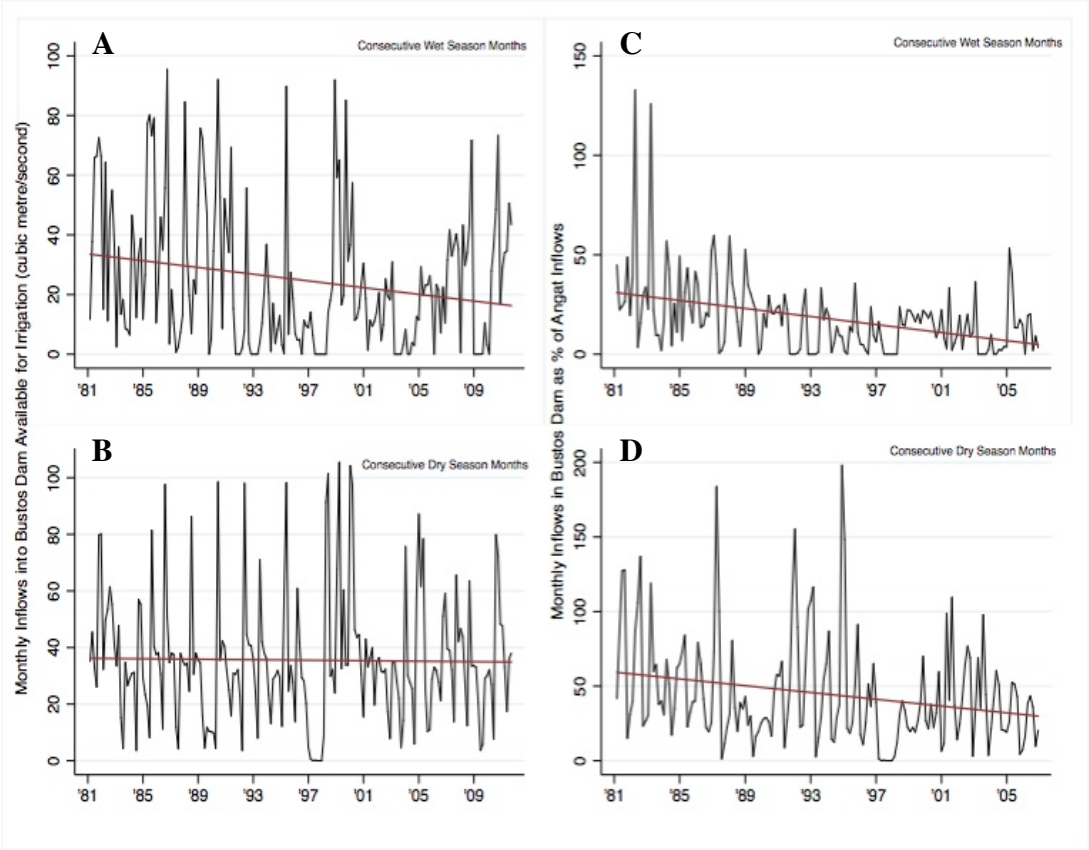

Figure 2.5: Monthly inflows into the Bustos Dam available for irrigation during wet (A) and dry (B) seasons. Monthly Inflows into Bustos Dam as a percentage of Angat Reservoir inflows during wet (C) and dry (D) seasons. Line of best fit indicates a declining trend in both seasons as a percentage of Angat Reservoir inflows. Source: Data used with the permission from the National Irrigation Administration (NIA, 2014b)

2.4.3 Shifting Allocation Timings

Irrigation water security is a function of both the amount of water available and the timing of the releases (as well as the predictability of both). As shown above, Metro Manila now uses the 'lion's share', or dominant portion of reservoir water as a result of *de facto* and *de jure* changes

[16] Inflow was used because it reflects the diversion of a stock of water to multiple users over time. Outflow from Angat to the Bustos Dam was not used because there is additional variability captured in this figure from the inflows of the Bayabas tributary.

in water rights, in part reflective of political water-use interests. This prioritization of water allocations for Metro Manila is further protected through changes in the rules that stipulate *when* water is allocated for irrigation purposes.

In 1999, the Reservoir 'rule curve' guideline was implemented following privatization of MWSS's water distribution services (Brown et al., 2009). The rule curve guideline is a decision-making instrument indicating the total reservoir water volume that should be maintained to both meet demand and avoid low reservoir water levels (Sankarasubramanian et al., 2009). The guidelines provide an upper and lower curve that shift over the year (NWRB, 2009 Res. No. 003-1209). As **Fig. 2.6** shows, 180 m in water elevation is the minimum operating level in the wet season; the lower curve is higher during the dry season. Where reservoir's water elevation exceeds the upper curve, all needs for MWSS, NIA, hydropower, and downstream flow requirements are met (Tabios and David, 2004). When the elevation is between the curves, MWSS and NIA needs are met but hydroelectricity generation is limited to times when releases to meet domestic and irrigation needs occur (*ibid*). When elevation is below the lower curve, MWSS is prioritized and the implications for NIA are uncertain (*ibid*).

Brown et al. (2009) suggest that if the lower rule curve is breached, domestic needs are serviced first and that irrigation releases "…*may* be allowed only when the resulting water level will not fall below the minimum operating level of 180 metres" (p. 259, my italics). If the lower curve is breached during the Bustos dry season (Nov-Apr), irrigation releases are uncertain, subject to the discretion of NWRB officials with the goal of ensuring adequate amount of water remains for the rest of the year. During the early wet season, however, if the 180 m elevation is breached, irrigation will not be allocated water. The guideline, also aligned with priority provisions in the National Water Code, is designed to protect and prioritize MWSS from strong inter-annual and inter-seasonal inflow and stock variation (Brown et al., 2009; Someshwar et al., 2009). Unlike MWSS's protected allocation, irrigation water users face a great deal of uncertainty when reservoir levels drop below the specified lower rule curve. One result of the highly specified rule curve guidelines is an *increase* in the possibility that irrigation users may not receive water during *both* seasons in the event of inflow shortages. Ortega (2011) highlights this for numerous years, including in 1998, 2004, and 2010, where water levels were below the rule curve mark for

both seasons. Historically, Rola and Elazegui (2008) note that prior to the rule curve (early 1980s-90s) farmers recalled the entire AMRIS area could be irrigated even if the water level was at 180 m. In my case, households suggested the rule curve reduced their abilities to receive water during critical periods, notably during the beginning of the wet season, with one recalling "When we need it most, it can't reach us. The irrigation water is *tagu-taguan* (playing hide-and-seek)."

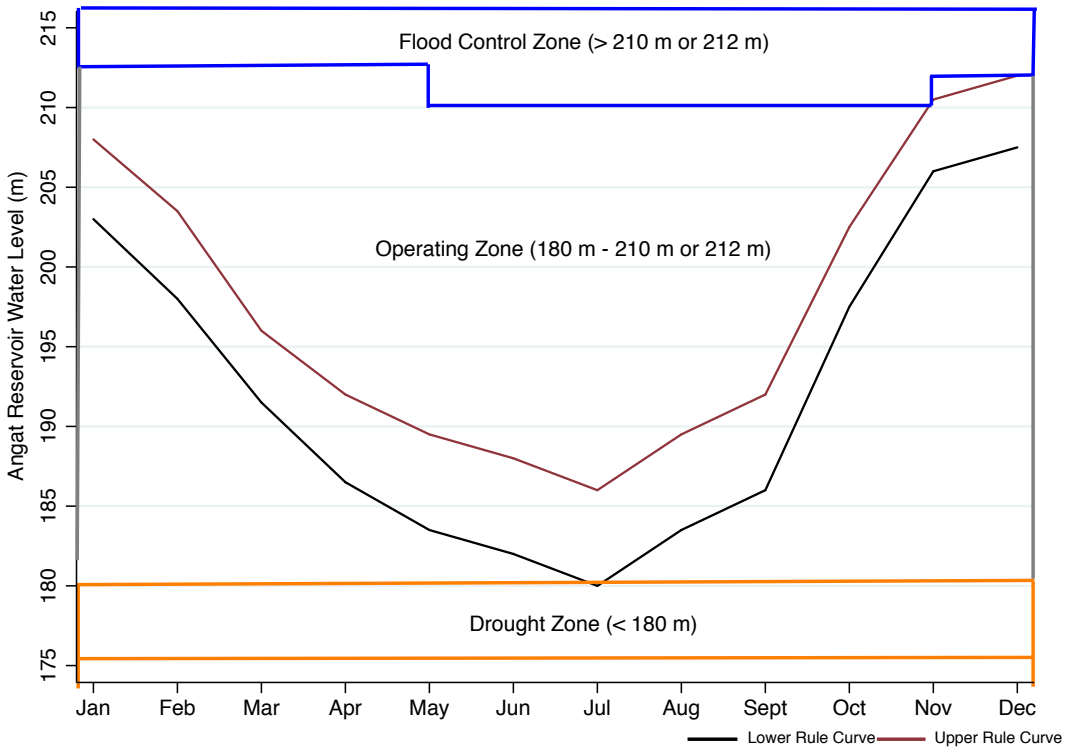

Figure 2.6: Rule curve guidelines for the Angat Reservoir. Source: Adapted from NWRB (2009) and Torio (2015 *pers. comm.*).

2.4.4 The Interaction of Reformed Governance and Climate Variation

I showed how Metro Manila was able to subsume water, infrastructure, and allocation rules for its beneficial use, which has had adverse effects on the effective provision of irrigation services. The prioritization of Metro Manila during periods of low reservoir levels due to low-precipitation can adversely affect irrigation water security for farming households during and following these periods. Because restructured reservoir governance interacts with and amplifies the effects of climatic variation, it is the intensity of low-precipitation events that determine the degree of impact on irrigation provision. Low-precipitation effects, when strong enough, can as explained above, lead to the re-direction of water away from NIA to Metro Manila. Where

research highlights how *prolonged* low-precipitation inflows can compromise surface irrigation over time (Liverman, 1990; Vicuna et al., 2014), this case suggests, elaborated below, that even *single* events of climate variation can have negative effects on the irrigation water security for users due to restructured reservoir governance (Rola and Elazegui, 2008). This contrasts with the 1970-80s, prior to substantial governance shifts, wherein El Niño events were reported to have "…*little effect* on rice area irrigated within AMRIS" (Dawe et al., 2009, p. 294, my italics).

The strong[17] event of 1997-1998 compromised inflows during the summer monsoon period (Jun – Sept) and the winter northeast monsoon (Oct – Feb) by an estimated 42% and 70%, respectively as compared to historical average inflow periods during the same months (1968-2007). This led the NWRB to cancel irrigation services for *both* wet and dry cropping seasons, resulting in an estimated loss of 968M ₱ in palay production for smallholder agriculturalists (Pascua, 2007; Rola and Elazegui, 2008). For the dry season, losses can be particularly acute given a higher water demand (i.e. evapotranspiration) and a lack of, and reliance on alternative water substitutes (e.g. precipitation). Only one-third of the sampled households reported having access to alternative water source for palay production. Tensions between NIA and MWSS escalated because the legal mechanisms to enforce compensation to NIA and to farming households in the event of rights appropriation have different interpretations (Tabios and David, 2004). Moreover, there is a lack of affordable and available crop loss insurance to act as a social safety net[18]. NIA and farming households have claimed that administrative reallocation of water should have compensation attachments for irrigation service fees and loss of palay production loss (cf. National Water Code, 1976, Article 30); MWSS argues that compensation is unnecessary because reallocation emerges from a force majeure[19] (cf. National Water Code, 1976, Article 27; Pascua, 2007). The latest sources on this matter report NIA has not received

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[17] Strong events are those where the Oceanic Niño Index (ONI), or the running mean sea-surface temperature (SST) anomaly, is equal to or greater than 1.5°C. Weak events (< 1°C SST anomaly) and moderate (1-1.5°C SST anomaly) also occur.

[18] Farmers reported a dismal state of securing insurance from formal lenders, most require large collateral (Bedore, 2011) and often package, to the dismay of farmers, loans with insurance packages. Households also reported the minimum coverage for crop loss paid through government avenues is not enough to cover investment costs.

[19] A *force majeure* is an unforeseeable event.

compensation (Pascua, 2007), indicating existing governance processes encounter difficulties in resolving trade-offs in water re-allocation. This is a critical issue for mitigating agricultural risk, heightened because climatic variation could increase in the future, with some predicting anthropogenic climate change will increase the frequency of El Niño events, including those extreme events (Timmermann et al., 1999; Cai et al., 2014).

Weaker climatic variations can still have negative impacts. In 2009-2010, a moderate El Niño event emerged in the late wet season and peaked year-end 2009, compromising inflows into the reservoir from the important winter monsoon period. This led to a rapid drawdown of the reservoir below 180 m at the onset of the wet season (**Fig. 2.6**). As a result, irrigation water was not released during the wet season (2010) based on the rule curve guidelines. It is clear that low-precipitation events resulting from El Niño and climatic variation periods can lead to the delay of irrigation releases *during* the wet season (**Fig. 2.6; 2.7**). This has adverse consequences for rice-farming households, with one recounting:

> "Before, we planted in June. Now we plant in July, with a one-month delay. Sometimes there is supply, sometimes none…Right now, we are just relying on rain. Since the water that we're expecting hasn't arrived yet…our expenses are doubled".

While these delays of irrigation could have occurred prior to the rule curve by Metro Manila exercising its 'better' right to water under the Water Code, the rule curve *explicitly* stipulated allocation guidelines for times of emergency that prioritized Metro Manila. However, the fact that reservoir levels reach their minima and that irrigation water availability is compromised into the wet season might suggest that reliance on rainwater, or other water alternatives, could buffer the effects of irrigation variability. Indeed, households are reliant on precipitation but respondents also reported changes in the predictability and reliability of rainfall. One household, for instance stated, "We gave up on the rain's availability because of changing [conditions]. If it is there, we welcome it. But we do not depend on it". Experiences resonate with broader research indicating shifts in precipitation of the southwest monsoon (Jun to Sept). For example, Cruz et al. (2013) report a significant decreasing trend (0.026%-0.075%) per decade in total southwest monsoon rainfall over the past 50 years. Moreover, the authors suggest an increasing trend in the

number of "no rain" days, concluding a climatic shift towards a decreasing trend in rainfall and drier period during the southwest monsoon (*ibid*). In my case, last year (2014), irrigation services during the wet season were delayed once again, and from May-July there were 45 "no rain" days[20] (and another 20 days with 0-5mm rainfall) (PDRRMC, 2015). Seasonal variations in climate can be rapid and unpredictable (Yumul et al., 2009). In 2007, for example, the wet season commenced but was suddenly stopped in June, bringing restrictions for irrigation water provision (*ibid*). The increasing abnormalities of climatic change in the Philippines led Yumul et al. (2013) to suggest that "one can make a case that global warming may already be affecting the country" (p. 724). Together, delayed irrigation services and unreliable precipitation periods mean that households plant at later dates, incurring disadvantages including susceptibility to pests and winds that could compromise palay at the flowering stage (Rola and Elazegui, 2008).

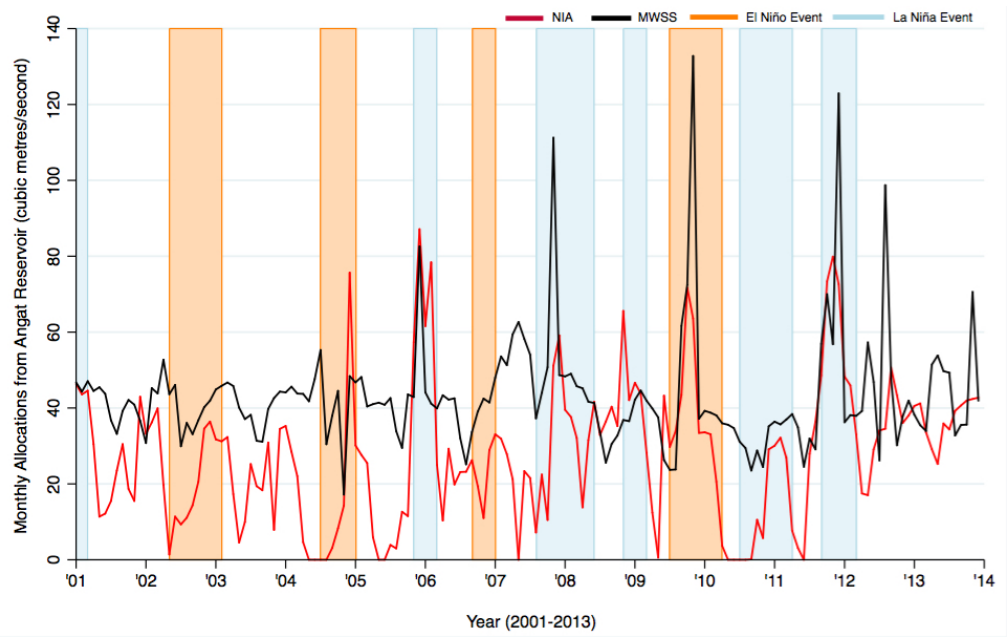

Figure 2.7: Decadal allocation for NIA (red) and MWSS (black). Orange shading represents El Niño events. Blue shading represents La Niña events. Source: Data used with the permission from the NWRB (2014). Publically available data sourced from NOAA (2015).

[20] This data is collected from Malolos City, 13-15 km from the border of Bustos.

2.5 Additional Converging Stressors on Irrigation Water Security

While the shifts in reservoir governance are one prominent stressor, other key stressors impact effective irrigation service provision. These include infrastructure deterioration and failure, water hoarding, and urbanization. Reflecting on the totality of converging stressors, including governance shifts described above, households reported changes in the timing (75%), duration (57%), and amount (65%) of irrigation services over the last 15 or more years, of which the dominant changes recorded were negative (see **Fig. 2.8**). This of course suggests that not all sampled households self-reported negative changes across these facets of irrigation service provision, particularly those closer to the canal head or those at lower elevations who do not rely on centralized pumps, which are subject to frequent breakdowns.

Looking to the future, one factor that could catalyse further substantial change for irrigation services is increasing urbanization. The construction of the bypass road in Bustos, built in part to form stronger linkages between rural and urban centres, has intensified land conversion from agricultural to urban (Fresco and Angeles, 2012). If irrigation demand for agricultural water drops, it could result in further reallocation for domestic use in Metro Manila. At the same time however, Bulacan's domestic water services have over-extracted groundwater to a point where communities now experience land subsidence and salt-water intrusion (Bedore, 2011). The Bulacan Bulk Water Project (BBWP) is intended to provide 230 million litres/day (2.7 m^3/s) of water through securing "…permanent water rights from Angat's already overextended supply" (*ibid*, p. 118). Although demand reduction in irrigation is anticipated, these multiple factors cast greater uncertainties onto the future effective provision of irrigation water. This, and the factors above, has generated a sense of uncertainty for most of the sampled households concerning the future of irrigation service provision. Approximately 60% of sampled households project irrigation to be either "unpredictable" or "very unpredictable" in the future.

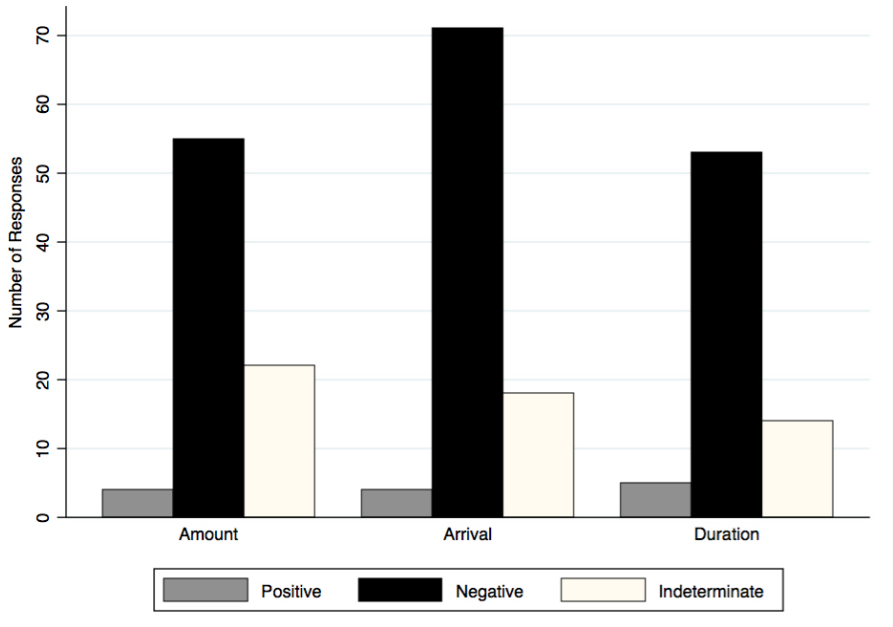

Figure 2.8: Household experience with irrigation as compared to 15 + years ago. Responses are for households that reported a 'change' in irrigation services. Source: Data collected using household surveys by the author. Coding of values completed by the author.

2.6 Conclusions

Research highlights on-going change in agrarian communities from multiple factors (Dasgupta et al., 2014). Shifts in surface irrigation, an important component of agricultural water security, has and will continue to be one component of change (Biswas, 1994). In this Chapter, I highlighted how urban 'appropriation' of water, both through re-allocation and re-prioritization, interacts with climatic variation to undermine irrigation water security of irrigators in the Angat River Basin. Although scarce irrigation releases can occur during both seasons, the interaction of these two factors can ensure scarce releases or delays even during the wet season. I suggest that it is the interaction between reformed reservoir governance and climatic variation, effecting infrastructure use, flows of water, and allocation rules, that detracts from the abilities of irrigation infrastructure to enhance agricultural water security as conceptualized above. This Chapter hopes to provide a basis for designing strong trade-off rules in water use in key legal frameworks, such as the National Water Code (1976), in cases where limited water supply must serve multiple stakeholder uses. It also begins to present a case for the need for CA livelihood activities to mitigate risks to households from irrigation insecurity, which is elaborated in **Chapter 3.**

Chapter 3: From Identifying to Operationalizing Context in Livelihood Adaptation Policies: A Case of Rice Farming and Irrigation in the Angat River Basin (Bulacan, Philippines)

3.1 Introduction

As I alluded to in **Chapter 1**, development theory and practice saw surface irrigation as capable of increasing smallholder production and by extension delivering household economic benefits. Systematic efforts to control hydrological variation with large irrigation systems also occurred in the Philippines (Gonzales, 1993; NIA, 2013; Rola et al., 2015). In **Chapter 2**, I showed how diverse stressors at multiple scales undermine secure irrigation service provision in the Angat River Basin. This is not a single phenomena occurring in the Philippines nor is it the only stressor to agrarian livelihoods here and elsewhere in the Global South (Birkenholtz, in review; Dasgupta et al., 2014; Molle & Berkoff, 2006; Pingali & Gerpacio, 1997; Rigg, 2006; Wang, Yang, Shi, Zhou, & Zhang, 2015). **Chapter 3**, using key insights from **Section 1.1.5** attempts to strengthen the capabilities of rural policy to enhance household adaptive capacities to deal with irrigation and other social-ecological stressors.

'Adaptive capacity' is a concept used to understand, measure, and enhance household capabilities to adjust to negative effects (e.g. climatic change, shifts in water access) on rural livelihoods (Darnhofer, 2014; Dasgupta et al., 2014; Engle, 2011; Smit & Wandel, 2006). I refer to adaptive capacity, following **Chapter 1**, as the abilities and willingness of households to "…adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (Agard et al., 2014, p. 1758). 'Adjusting', and 'responding' invoke several strategies, one of which includes increasing household engagement in complementary or alternative (CA) livelihoods activities (farm- and off-farm) (Chambers & Conway, 1992; Scoones, 1998). Empirical evidence suggests livelihood diversification, flexibility, and redundancy – all associated with CA livelihoods – can reduce negative effects to households that might otherwise have particular livelihood activities compromised or threatened (Efstratoglou-Todoulou, 1990; Ellis, 1998; Ellis & Freeman, 2004). For example, Ellis (1998) highlights that the capacity to "…diversify income sources signifies an improvement in the livelihood security

and income-increasing capabilities of the rural household." (p. 29). Eakin (2006) argued policies should expand further than identifying optimal strategies in a particular time window and towards "…providing society with greater flexibility and an increasing diversity of choice…" (p. 40). Hussein & Nelson (1998) suggests few have argued against the idea "…that 'keeping options open' is inevitably important in the context of risk and uncertainty" (p. 12). Based on this and other research, scholarship has emphasized, even directed rural policy to promote CA livelihoods for households facing social-ecological stress, including substantial changes in water access (Rigg, 2006). These insights have been adopted by organizations such as the Food and Agriculture Organization (FAO) who state that "[t]he development of alternative livelihoods – both local off-farm employment and exit from agriculture – will be an important component of poverty reduction programmes" including in contexts of environmental change (Dixon, Gulliver, & Gibbon, 2001, p. 10).

While CA livelihood activities are likely important to deal with social-ecological stress, the manner in which programs or activities are often promoted by government or intergovernmental organizations requires re-examination. To understand why, I first outline some important concepts relating to conventional policy approaches. The "solution space" represents all of the theoretical CA livelihood options to adjust to change, as defined by outside agents. Of all the theoretical options in the solution space, only a subset of these activities is *possible* for households; this subset is the "decision space" (also Klein, Pfaff, & Drury, 2009; Wise et al., 2014; Vervoort et al., 2014). The extent to which a particular livelihood activity is *possible* depends on household abilities *and* willingness to engage in that activity. While the notion of abilities is digestible, willingness is much more difficult to conceptualize. As I show below in select examples, willingness *can* shape decision spaces, or limit the set of theoretical options to a plausible subset (see e.g. in Nielsen & Reenberg, 2010; Patt & Schröter, 2008 below). Household willingness also guides the actual choices made within decision spaces if multiple possible options are available. The concept of decision spaces represents the *specific application* and operationalization "adaptive capacity" for CA livelihood engagement, as stated in **Chapter 1**.

Government and intergovernmental organizations, however, often promote general and standardized CA livelihood activities across variegated geographies (Klein et al., 2014). These

activities are pre-determined off-site, calculated as technically viable and economically optimal, and assumed to be both applicable and palatable to a homogenous set of households. Despite the deficiencies of standardized activities abstracted from context (see Ferguson & Lohmann, 1994; Ostrom, 2007; Scott, 1998; Smucker et al., 2015), households are encouraged to follow these strategies to achieve the most optimal 'benefits' or reduce 'risks' of environmental change to their lives. Calling attention to the extensive use of "policy panaceas" (universalized solutions), Ostrom (2007) argued strongly for policy-makers to "…match governance arrangements to specific problems embedded in a social–ecological context" (p. 15181). Although "panaceas" or standardized activities fall within the "solution space", they may or may not fall within the decision space of households or a household. For example, all households might be encouraged to shift land-use patterns in response to irrigation service change, but for a subset this falls outside their decision space due to factors like ecological restrictions, strict land-use rules, debt obligations in the form of specific crop types, or disagreements over rationale for the solution. In essence, without distinguishing between prescribed activities in the solution space and those possible in the decision space, standardized activities could be irrelevant, contested, or rejected. This is illustrated in Patt & Schröter (2008) who show how a "risk-reducing" plan to resettle households away from floodplains in Mozambique failed because fertile deposits re-attracted resettled villagers. Other examples are highlighted later in this Chapter.

Moving forward, this Chapter proposes that policy-makers should focus *not* on designing generalizable activities for how households *should* be responding as much as understanding what CA activities could be *possible* for households. Here, literature suggests that farm adaptation decisions are "a heterogeneous process influenced by more than economic and technological development", the criteria dominant in crafting standardized solutions (Nielsen & Reenberg, 2010, p. 142; Ghazouani, Molle, Swelam, Rap, & Abdo, 2014; Harmer & Rahman, 2014; Opiyo et al., 2015). This points to a need for descriptive models to identify criteria important in shaping human decisions (Cote & Nightingale, 2012; Levine, Chan, & Satterfield, 2015). But there continues to be a need to *integrate* these contexts into developing *alternative models* to standardized approaches that propose relevant and palatable adaptive programs for households. This is supported by Klein et al. (2014), who suggest "… significant work remains in understanding such context-specific determinants of vulnerability and adaptive capacity and in

effectively using the knowledge gained from available case studies *to facilitate adaptation more broadly*" (p. 908, my italics; also Biesbroek, Klostermann, Termeer, & Kabat, 2013; Engle, 2011). What the authors refer to is the need to identify contextual factors that 'matter' *and* to more effectively operationalize contextual insights into substantive policy recommendations to facilitate adaptation more broadly.

Using a case of rice-farming and irrigation from the Philippines, this Chapter has two contributions for understanding and operationalizing context to better inform adaptive policies. The first contribution (**Table 3.1**) provides an introduction for identifying contextual factors relevant in shaping decision spaces for households. Its main purpose is to set up the second and more substantive contribution of the Chapter. Recognizing that these important contextual factors are *not* uni-dimensional but work in nuanced ways, the second contribution (**Table 3.2)** is an integrative 'push-pull' framework. Decision-makers can use **Table 3.2** to understand how different factors 'work' in multi-dimensional ways to *condition* (constrain or widen) differently the decision spaces for individual households or groups of households. In other words, it helps decision-makers navigate *where* the decision spaces lies for different households. It then allows them to then target contextual factors that constrain decision spaces, thus opening up potential opportunities (i.e. widening decision spaces in informed ways). Here, policies need not fit activities *solely* within decision spaces, but can work to actively expand them through challenging constraining factors that exist at multiple scales. It can also be used to identify activities considered suitable to households *within* their existing decision spaces, such as CA livelihoods they have training in, or are already familiar with (e.g. livestock). I begin this Chapter by outlining the case from the Philippines, and presenting the case for why CA livelihood activities are important in the context of irrigation water insecurity (**Section 3.3**). I then explain and illustrate how both contributions can improve conventional approaches to encourage CA livelihood activities (**Section 3.4** and **3.5**).

3.2 Methods

Research was undertaken in Bustos (Bulacan, Philippines), a municipality in the Angat River Basin, over a three-month period (Jul-Sept 2014). Agriculture is the primary source of livelihood

in Bustos; over 60% of the population engages in agriculture or agri-business related employment (Harding, Iwama, & Thomas, 2013). Sampled households are dependent on irrigation for rice production as over 80% dedicate their entire land to palay in both seasons (**Fig. 3.1**). Irrigation serves as crucial to these livelihoods and the wider community, serving 97% of rice fields in the municipality (Harding, Iwama, & Thomas, 2013). **Chapter 2** provided detail on irrigation infrastructure and local hydro-climatology.

Surveys (n = 124), interviews (n = 70), and focus groups (n = 10) were conducted with rice-farming households to document the extent of irrigation service change and adaptation responses. As described in **Chapter 1**, the survey identified adopted household adaptation (on- and off-farm) strategies if negative changes irrigation service provision had occurred. The survey and interview then qualitatively investigated and coded answers to "why" certain strategies were used as compared to others in the wider community to understand decision-making factors. I defined a "rice-farming" household as one engaged in rice-farming in the last 15 to 20 years, a period reflecting major shifts in how irrigation was to be allocated given the rising domestic needs in Metro Manila (see **Chapter 2**). The definition allowed for an inclusive characterization of households that may have diversified or switched livelihood activities as a result of irrigation change or other determinants. Interviews were also conducted with barangay, municipal, and provincial government officials on similar topics of service change and institutional support for particular household responses.

Reflecting on the contributions to be developed in **Sections 3.4** and **3.5**, I have used Ostrom's (2007; 2009) framework for analyzing social-ecological systems as an organizing principle of avoiding panaceas for adaptation policy. I do this two ways. First, I use it in a way to group particular contextual factors that *could* be important in shaping household decision spaces. Ostrom's framework is useful in that it identifies different multi-scalar components of social-ecological systems (resource systems, units, users, governance). In **Section 3.4** (**Table 3.1**), I grouped multiple contextual factors from the adaptation literature that could be important in shaping decision spaces within Ostrom's framework. These factors are also multi-scalar as illustrated through their grouping.

Second, I use the framework to suggest how individual factors can interact with households to condition decision spaces in different ways. Factors – if relevant to particular studied systems – can be broken down and understood through the push-pull framework (**Table 3.2**). As I elaborate in **Section 3.5**, there is no single way in which contextual factors 'work' or interact with households, but a variegated set (see **Section 3.6** for examples). Through focusing on particular interactions, policy is much better positioned to leverage this knowledge to expand the range of possible options for households, or tailor adaptation policies to existing household capacities. Overall, in **Sections 3.4** and **3.5** I use Ostrom's framework as a starting point towards building a path *away* from panaceas and towards more contextually sensitive and intelligible policy design.

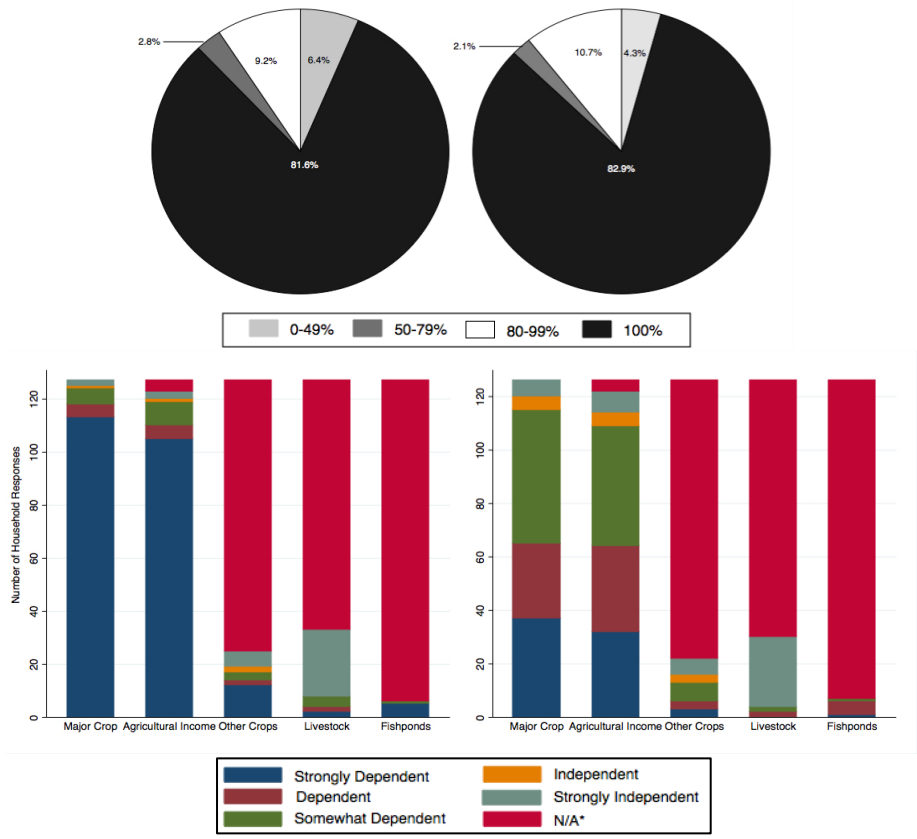

Figure 3.1: Top: Household land area dedicated towards palay production in dry and wet seasons. **Bottom:** Household dependence on water for farm-related needs. Note: N/A indicates water is not used for a particular need, or the answer is unknown. Source: Data collected using household surveys by the author.

3.3 The Rationale for Adaptation in Bustos

I suggested above that rural policies increasingly consider CA livelihood activities as critical for risk mitigation. A review of global scholarship, however, reveals the conventional method of dealing with agricultural water stress is through increasing efficiencies both on- (water application techniques, *more crop per drop*) and off-farms (infrastructure maintenance), and enhancing access to water substitutes. These strategies view the *crop* as the unit vulnerable to inadequate water access (Eakin, 2003). As a result, storage, infrastructure upgrades, and tolerant crops are held as the solution to water stress (Lankford & Beale, 2007). Common approaches for smallholders in the Global South include supply-side management (e.g. deepening wells, farm reservoirs) (Molle, Venot, Lannerstad, & Hoogesteger, 2009; Pradhan, Sijapati, & Bajracharya, 2015; Roost, Cai, Turral, Molden, & Cui, 2008); demand-side management (e.g. less water-intensive crops, land preparation) (Bouman, Lampayan, & Toung, 2007; Ghazouani et al., 2014; Pereira, Oweis, & Zairi, 2002; Tabbal, Bouman, Bhuiyan, Sibayan, & Sattar, 2002); and re-allocating assets (selling land, reducing acreage) (Vicuna, Alvarez, Melo, Dale, & Meza, 2014).

In **Chapter 2**, I showed that stressors from distant (urban water demand growth, governance transformation, climatic variation) and local scales (infrastructure deterioration, excessive water hoarding, and regional land urbanization) have systematically undermined secure irrigation provision and household water access. The inability to control such substantial change is *not* an indication of underdeveloped water management, or a process that control can fix, but rather the outcome of multiple interacting systems driving and perpetuating change. Fundamental shifts in water provision cannot be mitigated *only* through on- and off-farm efficiency measures. For example, water stress tolerant crops, cementing and cleaning of canals, and more efficient water application techniques cannot be expected to relieve the effects of service delays that increase crop susceptibility to pest outbreaks (Rola & Elazegui, 2008); mitigate the effects of immediate water cutoffs within a moments notice based on new management guidelines to accommodate unpredictable weather (Yumul, Cruz, Dimalanta, Servando, & Hilario, 2009); or protect households completely in cases where no irrigation is delivered whatsoever (Pascua, 2007).

Moreover, while accessing water substitutes ranked amongst the top coping strategies of households, the potential for alternatives – surface, sub-surface, and precipitation – to benefit the entire service area is limited. For example, small-farm reservoirs have been developed to supplement water supply in Bustos. However, these reservoirs are sparsely located and mainly used in *rain-fed* barangays of Catacte and Malawak. The Bayabas Reservoir, a proposed dam on a tributary to add additional water to the Bustos Dam for AMRIS has been deemed, by NIA, to provide *too little* water to 31,000 hectares to justify its cost (3 m^3/s, or 8% of existing maximum volume delivered to NIA at a given period). Regarding groundwater, only 22.5% of sampled households reported having access for irrigated rice production. Moreover, as mentioned in **Section 2.5**, Bulacan's groundwater is experiencing massive over-extraction. This has led to "salt-water intrusion to many of [Bulacan's] groundwater sources and many more at "critical" risk of intrusion" (Bedore, 2011: 118). The decline in groundwater quantity and quality led to plans to formulate the BBWP. As a result, it does not appear as though groundwater could be a viable long-term source for agriculture across this large service area. Last, I reported in **Section 2.4.4** that precipitation, particularly during the wet season, is experiencing a significant decreasing trend (see Cruz et al., 2013). Moreover, there is an increase in precipitation variation due largely to the increase in "no rain days" (*ibid*). This analysis of water alternatives is in line with Bedore's (2011) claim that sufficient irrigation water:

> "…will depend on the domestic water suppliers of Metro Manila and Bulacan finding alternative water sources, as NIA has been seemingly unable to protect their water rights in Angat from such powerful forces. NIA has been unable to find any viable alternative bodies of water to help meet their current and future demands" (p. 119).

Despite this complex reality in Bustos, efficiency strategies and water substitutes continue to dominate policy options for mitigating water stress for farm households. Although farmers recognize these strategies as important they also widely recognize CA livelihoods represent a critical risk mitigation strategy. For example, one household stated that, "Water is not enough...If you don't have extra income or source of living, it will be very hard." This need for CA livelihood activities *must* also be situated within the wider context of "high-risk" farming detailed in **Section 1.5.3**.

One government program that appears promising is the Municipal Livelihoods Program, designed to support local residents in gaining access to income-generation opportunities. The program, however, targets individuals who are unemployed (i.e. not farm households). Moreover, it promotes standardized activities driven from the national-scale, such as hairdressing, beauty care, and massage therapy, which from discussions with rice-farming households, are completely irrelevant to their interests. The focus on unemployed (i.e. not farm workers/household) and the promotion of standardized activities fails to support capacity-building activities for rice-farming livelihoods, despite it being a dominant form of income-generation in the municipality. These limitations do not preclude the program from designing and developing adaptation policies that promote CA livelihood activities in the future. I now begin to identify steps towards filling the gaps in adaptation science and practice outlined in **Section 3.1** with the hope of producing substantive frameworks and directions for potential future adaptation policy initiatives in Bustos.

3.4 Contextual Factors Shape Adaptive Capacity

Household decision spaces are made up of multiple activities that could *possibly* be engaged in. As I cite above, the concept emerged from decision theory (Klein et al., 2009). The adaptation literature has defined decision space similarly but in the context of adaptation "pathways" for climate change decision-makers (Wise et al., 2014). The concept, with its roots in decision theory and expert decision-making scenarios, has not been applied to the household scale to understand adaptive decision-making.

Before understanding how contextual factors condition differently individual household decision spaces, it is important to first identify factors that are actually relevant to households. To do this, two steps can be taken. First, decision-makers can identify what household actions are possible in the context of social-ecological change. One example includes having in-depth dialogue and at-length exposure to household planning decisions. In Bustos, 70 interviews and 124 household surveys indicated multiple activities occurred, including agricultural labour, shifting land-use, planting new crops, engaging in construction and industrial work (textiles, bag-making), food vending, fishing, seasonal and international migration, and so forth. Other diverse participatory approaches exist for discussing possible future changes and identifying possible response options

(Wise et al., 2014). Examples include in scenario planning and visioning (Enfors, Gordon, Peterson, & Bossio, 2008), and soft conceptual mapping, such as causal loop diagrams (Butler et al., 2014; Olabisi, 2010).

Second, with the identification of activities across households, researchers can begin to understand *why* these activities were identified as possible through broader social, historical, cultural, and ecological lenses. These are factors that have relevance and influence on the lives of households, and extend beyond technical and economic factors that configure generalizable strategies. As Cote and Nightingale (2012) suggest, such reflective and investigative research allows one to "…illuminate the processes through which individuals and groups come to understand their scope of response options and to act in relation to socio-ecological change" (p. 484). Such factors, drawing again from the insights in **Section 1.1.5**, will likely be:

- **Multiple**: Cultural, legal, biophysical, and types of factors and;
- **Multi-scalar:** Emerging from local to global scales. Identification across multiple scales avoids conflating 'contextual' with local jurisdictional boundaries instead emphasizing that context and conditioning factors are *produced* through multiple scalar relationships that have local manifestations (Massey, 2005)

Table 3.1 presents a set of multiple scalar factors that are relevant to informing decision spaces. The factors identified are specific to the Bustos case, but have been found important elsewhere. The use of Ostrom's (2007) framework helps illuminate how multiple influencing factors spanning different scales – from resource systems to governance models to resource user characteristics –can inform or be relevant to decision spaces.

Table 3.1: Factors relevant and important in shaping household decision spaces. Examples are for Bustos. Citations represent scholarship identifying these factors as relevant in farm household decision-making. See Ostrom (2007; 2009) for more detail on the framework.

SES sub-systems	Factors ("Is this factor important?")
Resource systems (RS) are larger	**Agro-ecological conditions:** Whether agro-ecological conditions influence household decisions (Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009).

SES sub-systems	Factors ("Is this factor important?")
environmental systems (e.g. agricultural areas, fisheries, forests).	**Social-ecological change:** Whether households experience changes in the RS (e.g. agriculture, fisheries) (Barnett & O'Neill, 2010; Ostrom, 2007). **Infrastructure**: Whether infrastructure capable of facilitating or reducing access to RUs exist (Armitage & Johnson, 2006; Harris, 2008; van Koppen, 1998). **Connections to land**: Whether the RS has agency over households (Dwiartama & Rosin, 2014).
Resource units (RU) are resources within RS.	**RU mobility:** Whether variation in RUs exist (e.g. irrigation, fish, rainfall). **Economic diversification:** Whether the presence of alternative livelihoods around different RUs exist.
Governance systems are organizations, rules and customs, and their processes of development within RS.	**Land-use control:** Whether land-use laws bind and control options for households. **Institutional support:** Whether institutions promote certain livelihood opportunities (e.g. through land-use planning, zoning, state interest) (Harris, 2006; Mehta, 2001; Turhan, Zografos, & Kallis, 2015). **Customary institutions and social networks**: Whether customary institutions and reciprocal social relationships exist (Deressa et al., 2009; Goldman & Riosmena, 2013).
Users: are human actors at multiple scales (e.g. individual, household, communal).	**Capital and assets:** Whether households have capital and are willing to use it (Armitage, 2007; Bebbington, 1999; Chambers & Conway, 1992; Scoones, 1998; Sen, 1981). **Access to affordable credit:** Whether accessibility affordable credit influences household decisions (Deressa et al., 2009; Ellis, 2000b; Wood, Jina, Jain, Kristjanson, & DeFries, 2014). **Worldview:** Whether household decisions are influenced by worldviews. **Cultural values, subjectivities, and identities:** Whether values and identities guides household decisions (Adger, Barnett, Brown, Marshall, & O'Brien, 2012; Frank, Eakin, & López-Carr, 2011; Marshall, Park, Adger, Brown, & Howden, 2012; Nielsen & Reenberg, 2010; O'Brien & Wolf, 2010; Galt, 2012) . **Social difference:** Whether social differences (age, health, dependents, gender, caste, class) are institutionalized to confer different possibilities (Agarwal, 1990; Carr, 2008; Ensor, Park, Hoddy, & Ratner, 2015; Jones & Boyd, 2011; MacKinnon & Derickson, 2013). **Cognition and psychology:** Whether psychological factors, including efficacy beliefs and environmental risk perceptions, influence household decisions (Grothmann & Patt, 2005; Truelove, Carrico, & Thabrew, 2015). **Lived experiences:** Whether distinct lived experiences inform household decisions.

3.5 Push-pull Framework

Above, I highlighted that multiple contextual factors at different scales are important in conditioning household adaptation decisions in Bustos and elsewhere as informed through broader adaptation literature (per **Section 1.1.5**). The challenge now is to "use" these contextual factors to develop substantive policy recommendations that promote and advance suitable and relevant CA livelihood options for households as an alternative to the blind application of standardized adaptation proposals. Where **Table 3.1** operationalized Ostrom's (2007) framework to suggest multiple factors could be important to household decision spaces, **Table 3.2** provides an integrative 'push-pull' framework to understand how these factors interact (push and/or pull) differently with households to condition decision spaces (outcomes). **Table 3.2**, as I have described above, provides a tool capable of operationalizing 'context' to design adaptation policy that targets specific household constraints and opportunities for CA livelihood activities.

3.5.1 How "Push" and "Pull" Factors Condition Decision Spaces

The ideas of "push" and "pull" originate from Lee's (1966) work on human migration theory. In the context of migration – one form of household adaptation – push factors *force* individuals from existing places (e.g. water stress, high costs, landlessness) and pull factors act as magnetic forces to *attract* individuals to places (e.g. for job opportunities, higher wages, sense of place) (Ellis, 2000b; Efstratoglou-Todoulou, 1990; McLeman & Smit, 2006; Reddy & Olsen, 2012). Those factors that force or attract individuals, driving migration *towards* places, are diverse and are no longer viewed as only being economic in nature (cf. Ravenstein, 1889, p. 286 cited in Lee, 1966). More recently, particularly in climate change literature, research identifies factors that constrain or limit human adaptive capacities to social-ecological change (Adger et al., 2008; Biesbroek et al., 2013; Klein et al., 2014). This is an attempt to identify and later resolve factors – financial, physical, technical, and biophysical – that push households *back* into existing livelihoods or reduce capacities to engage in certain CA livelihood activities. For example, Eakin (2006) finds "landholding size", or resource endowment size in a Mexican town can "inhibit [household] capacity to manage risk through economic diversification" (p. 81). Most recently, a now rapidly growing literature focuses on personalized factors that pull households *back* into existing livelihood activities, reducing (willingly) their potential engagement in certain CA

livelihood activities. Examples include culture (way of life), sense of place, identity and belonging, value sets and preferences, and connections to human and non-human actors (Adger et al., 2012; Dwiartama & Rosin, 2014; Fabinyi, Evans, & Foale, 2014; Frank et al., 2011; Fresque-Baxter & Armitage, 2012; Marshall et al., 2012; Nielsen & Reenberg, 2010; O'Brien & Wolf, 2010). For instance, Nielsen & Reenberg (2010) highlight how for the *Fulbe*, an ethic group in Northern Burkina Faso, preferences for bush living, occupational specializations, notions of personal freedom and integrity, and group identity are challenges for embracing "successful" livelihood strategies implemented elsewhere (e.g. migration, development projects, gardening, and gendered activities). In Papua New Guinea, Curry et al. (2015) found that significant lifestyle changes and the intensive farming methods to control a pest to cocoa were incompatible with existing farming systems, values, and livelihoods. As a result, the initial response of smallholders was to abandon cocoa production and expand the production of *alternative* food crops (*ibid*).

Yet, the extent to which "economic motivations", "land-use limitations", "culture", or other factors influence households are differentiated. In the case above, Eakin (2006) notes that landholding size can also enhance agricultural adaptation strategies, *pulling* households towards planting different adapted crop variants. Similarly, Nielsen & Reenberg (2010) contrast the *Fulbe's* case with a neighbouring ethnic group (*Rimaiibe*) who have continuously responded to social-ecological stress by diversifying livelihoods through those same "successful" strategies. These examples reveal that there is no single way in which contextual factors, such as "culture", or "economic motivations" affect all households. Rather, they work in *different* ways to 'push' and 'pull' households in **multiple directions**, towards and away from certain CA activities and thus, actively shaping decision spaces. I provide examples from the Bustos case in **Section 3.6**.

Table 3.2: Integrative push-pull table. Placement of contextual factors within this table might be difficult because factors can work in different ways under particular household contexts.

Pushed 'back': Households 'held back' from pursuing certain CA activities, although willing.	**Pulled 'back':** Households 'motivated', perhaps intrinsically, to remain in rice farming
Pushed 'towards': Households 'coerced' to pursue certain CA activities, but less willing.	**Pulled 'towards':** Households 'motivated' or 'incentivized' to pursue certain CA activities.

The goal now is to use **Table 3.2** to understand how different contextual factors 'work' in various ways so that decision-makers are better equipped to either target those factors that constrain decision spaces or to encourage livelihood activities that already exist within decision spaces. In order for this to be possible, the detailed identification of how these factors work in multi-dimensional ways is required. This is provided in **Section 3.6** where I highlight how *unique* factors from Bustos 'work' in different ways to condition household decision spaces. These unique factors emerged from household surveys, interviews, and focus groups described in **Section 3.2**. For each example, I suggest policy options to enhance household adaptive capacity.

3.6 Operationalizing Context in Adaptive Policies: Examples from Bustos

3.6.1 Self-identity

3.6.1.1 Self-identity as Pulling Households Back

A strong agrarian identity informs household decision spaces in Bustos. This can constrain (willingly) the decision space for certain households through pulling them 'back' into rice-farming, even under the context of irrigation insecurity. Here, rigid and independent containers of 'work' and 'personal' are replaced with an identity and sense-of-self. Farming can be considered a "social-ecological symbol" (Tidball, 2014) or a "structure of signification" (Westley, Carpenter, Brock, Holling, & Gunderson, 2002); it provides meaning and other tangible and intangible benefits to households, representing a critical organizing principle of decision-making. As one household candidly stated, "The farm will give you food, shelter, and love: income is one of the by-products of working on the farm". Another recalled their self-fulfillment even in the context of irrigation insecurity, "…I love what I am doing. I don't think I will feel content if I stop. I even talk to my crops. There is a certain happiness I get from farming so I will definitely continue…". These sentiments resonate with Bebbington's (1999) argument that livelihood assets are not mere instruments through which material gains are had, but that assets "…also give meaning to the persons world" (p. 2021).

Rice is also an active agent that shapes relationships between humans and their livelihood decisions (Dwiartama & Rosin, 2014). Rice land is produced and understood through cultural upbringings, historical narratives, and familial obligations; such productions of the landscape

cast back a sense of identity upon its farmers. Herein, the power of interrelationships between households, rice, and farming are important determinants (constraints) of a household's willingness to engage in off-farm CA livelihoods. Westley et al., (2002, p. 108) suggests such structures of signification can reduce the potential for social-ecological transformation, or in this case alternative livelihoods. These sorts of efforts contribute to an increasing recognition that profit maximization and environmental change might not serve as central a role as often assumed in adaptive decisions (Ghazouani et al., 2014). It reflects a growing literature recognizing how adaptive capacities are mediated through the lens of 'structures' (e.g. memories, values, sense of place, and culture) (Adger et al., 2012; Cote & Nightingale, 2012; Marshall et al., 2012).

3.6.1.2 Policy Options

Recognizing that this factor can pull households back into rice-farming, capacity-building initiatives could promote specific support packages or activities around the central node of rice-farm to reduce risks from irrigation. Examples could include promoting familiar activities that might be culturally compatible with intangible facets of everyday life **(Section 3.6.6)** or through supporting alternative income sources through social networks **(Section 3.6.5**), both of which were found to be applicable in Bustos. Other examples could include promoting local tourism around rice production, which could be viable given the Angat River Basin is becoming a bedroom community for the National Capital Region (Fresco and Angeles, 2012).

3.6.2 Access to Unaffordable Credit

3.6.2.1 Unaffordable Credit as Pulling Households 'Towards'

Household access to affordable credit is an important influencing factor shaping (constraining or broadening) decision spaces in Bustos. This appears to be the case in the wider rural studies literature (Deressa et al., 2009; Ellis, 2000b; Wood et al., 2014). In Bustos, households that are more financially secure and hold collateral conform to formal (affordable) lending requirements. Such households can view this access as an *opportunity* to engage in possible CA livelihood activities. Lower rates can serve as a factor 'pulling' households towards investing in new livelihood opportunities, such as fishpond or *itik* (duck) farming, which exist within their decision spaces given access to affordable credit.

3.6.2.2 Unaffordable Credit as Pushing Households 'Back'

Those households that cannot access formal credit rely on informal (high-interest) loans. Lenders specifically target households that are *kapit sa patalim* (in dire circumstances; very poor) or *sige-sige lang*[21] (unsuspecting). A 500₱ ($10.68 USD[22]) can command 1 *cavan* (52 kg) of palay (600-1200₱; $12.82-$25.63 USD). Acquiring informal loans is also tied to irrigation shortages; those that are financially secure might not view obtaining loans as a necessity during periods of financial loss. One household explained, "When the supply of water is low, we are not able to plant. Some do not have capital and when they get smaller quantity of crops, they are forced to borrow money". By using palay as an un-concealable unit of currency, high interest rates combined with huge farming expenses leave less palay available for households to accumulate, sell, and re-invest into farming. The lack of accumulated capital constrains household abilities to invest their little capital into CA activities under irrigation insecurity. Loans are often renewed, pushing households back in rice-farming and constraining the decision space for CA activities.

3.6.2.3 Policy Options

Seeing informal lending as a push back factor (constraining decision spaces), and formalized loans as key opportunities for broadening decision spaces, capacity-building initiatives can establish low-interest systems (e.g. co-operatives), which could help expand decision spaces, particularly for lower-income households in the context of social-ecological change.

3.6.3 Land Tenure

3.6.3.1 Land Tenure as Pushing Households 'Back'

Land-use laws are an important influencing factor shaping (constraining or broadening) decision spaces for rice-farming households (see also Eakin, 2006). Two main (non-exclusive) land tenure relationships exist in Bustos: owners and tenants. Landowners are owner-non-cultivators or owner-cultivators; the former often hosts rice-farming tenants. For these owners, their distant

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[21] *kapit sa patalim* or *sige-sige lang* interpreted respectively as, those in dire circumstances that will even grasp the blade of a knife to meet their needs, and those that act in impulsive manners without analysing the situation first.
[22] Rate as of 24 Aug 2015.

relationship to land is one characterized as an investment or additional non-central source of income. Yet, they retain managerial rights and control over land-use decisions where tenant households farm their lands. These benefits crossover to owner-cultivators, who can make independent decisions as to how the land, often a central source of income, will be used to meet household needs. Lease tenants can be held to rigid specifications of land-use contracts, constraining their decision spaces. Under agricultural reform law, the lessor (landlord) of rice lands has the right to "propose a change in the use of the landholding"; lessee's do not have this right (RA No. 3844, 1963). Tenant households often expressed desire to alter land-use patterns, with one stating:

> "We are hoping for our landlord [has] a change of heart toward us…[our] farmland neighbours [are] doing fishpond…the landowner will never let us farm other agricultural produce. They want rice only. We want to try other crops and fishponds if given the chance".

As a result, this factor can constrain tenants from engaging in certain land-use activities.

3.6.3.2 Land Tenure as Pulling Households 'Back'

Even where tenant households can engage in alternative land-use activities, it could yield negative effects. The reason behind this is that tenant households have increasingly been afforded 'more equitable' contracts for rice-lands (e.g. fixed rents, rights on lease termination and land dispossession) (RA No. 3844, 1963). Contracts for land conversion to, for example tree growth or aquaculture, are regulated under different legislation (RA No. 1199, 1954) which can confer *less favourable* tenant benefits, depending on contract structure of households. As a result, tenant households could be pulled back (motivated/incentivized) to remain in rice-farming.

3.6.3.3 Policy Options

The former (land-use restrictions) and latter (possibilities for unfavourable contracts) show how this contextual factor can push and pull, respectively, tenant households back largely into rice-farming, and can constrain their decision space. Other scholars, like Eakin (2006), find flexibility in crop choice is crucial for mitigating a wide range of stressors, from market price fluctuations to climatic variation. Such "agricultural flexibility", Eakin writes, offers not simply a survival

strategy but a means to of "increasing stability and security" (*ibid,* p. 192). Herein, capacity-building initiatives need not be 'localized' or situated 'within' the household (see Nalau, Preston, & Maloney, 2015) but could target more equitable relationships that are suppressed through scalar laws governing land-tenant relationships.

3.6.4 Social-ecological Change (Aquaculture Activities)

3.6.4.1 Aquaculture as Pushing Households 'Towards'

Social-ecological change across landscapes is diverse and continuous and can carry different impacts for households. In Bustos, and elsewhere in the Angat River Basin (e.g. Hagonoy), rice-farmers are converting to aquaculture (fishpond) to avoid flooding in lowland areas, and reduce risks of inadequate water for farming in highland areas. The cross-scalar effects of fishpond development constrain decision spaces through pushing households towards narrower livelihood activities. Namely, the leakage of eutrophic (high-nutrient) water into neighbouring rice fields increases soil richness, damaging soil quality and the rice crop. One household accepted, "We are bound to produce less rice because of the fishpond's water leak[age] into our farm…". The deterioration of soil quality, one Municipal Agricultural Officer stated, *forces households to fish* on that specific piece of land (*napipilitan na mangisda*). This suggests households are *forced into*, or pushed towards, narrow livelihood adaptation activities, which could confer financial risk if inexperienced with fishpond ownership. If land-use change too is constrained, described in **Section 3.6.2**, these damaging effects could persist.

3.6.4.2 Aquaculture as Pushing Households 'Back'

Fishponds can constrain decision spaces through pushing households back into rice-farming. This occurs through the proliferation of *igat* (rice eels; *Monopterus albus*), which emerge from fishponds. Eels can spread to the dikes of flooded rice fields, boring holes and feeding on frogs and snails. Boring holes causes irrigation leakages, which can compromise the crop if the water is not replenished. Households reported that if this occurs, a disproportionately large amount of time must be spent on mitigating eel entry, or remedying the damage caused by *igat,* which could constrain the decision space through reducing the household investment (time) in off-farm CA

livelihoods. As a potentially harmful and recurrent event, it works to push households back into rice-farming even during periods of different social-ecological change.

3.6.4.3 Policy Options

Through mapping the different effects of this factor, interventions could reduce forced adaptation through establishing drainage patterns to reduce fishpond leakage, or encourage buffer or capture systems between rice-fish farming systems. Where these measures fail, initiatives could develop social safety nets to reduce risks to households that are forced into engaging in to unfamiliar fishpond activities. Options to reduce constraints on investigating activities include cultivating new industries around *igat* to capitalize on new resource in both lowland and highland areas.

3.6.5 Customary Institutions and Social Networks (Remittance Transfers)

3.6.5.1 Remittance Funds as Pulling Households Back

In Bustos, customary institutions and reciprocal social relationships exist and shape household decision spaces. Rice-farming households rely on their children for future remittance transfer through the cultural concept of *utang na loob*, or gratitude and a sense of indebtedness (Quito, 1994). This cultural discourse, itself a structure of signification, produces a shared sense of 'knowing' that the household organization and responsibilities will invert over time, with children acting as caregivers. It serves as a crucial form of 'help' during periods of social-ecological change, including irrigation insecurity. For instance, other scholars have found remittance funds can act to relieve the inabilities of rural households to obtain formal (low-interest) credit (Hussein & Nelson, 1998). In **Fig. 3.2**, I unpacked a dense network of household connections (n = 424) between other people (e.g. children, neighbours, uncles, aunts etc.) and institutions (e.g. government) that are mobilized when 'help' was needed. As can be seen, households relied extensively on children for remittance transfers. These transfers can be used in multi-dimensional ways, linking into continuing debates as to how remittance funds are used in rural economies (Hussein & Nelson, 1998). It could function to pull households back into rice-farming. Remittance flows can be viewed as a retirement fund, wherein there is a reduced need to engage in CA livelihood activities in the context of social-ecological change. The knowingness that children will care for parents, even during critical periods of change, informs

an epistemological orientation that households can anticipate future stability and security. Instead, remittance flows can be invested back into rice-farming, including during periods of irrigation service insecurity. Herein, 24% and 36% of households that engaged in coping strategies around irrigation insecurity used remittances to continue farming in the dry and wet seasons, respectively.

3.6.5.2 Remittance Funds as Pulling Households Towards

Remittance transfers could also pull households towards certain CA livelihood activities through enhancing their abilities to experiment with capital. As one household stated, "Capital can be a strong foundation for *malakas ang loob* (internal strength) and [allow one to be] brave enough to try new things and create experiences." Here, for those that engaged in adaptation strategies, approximately 45% used remittance funds in both seasons. The rationale for different uses is highly household specific, but could include themes of comfort (financial), age, and curiosity. Needless to state, remittance funds serve a critical, even system-wide, role in social-ecological persistence and change.

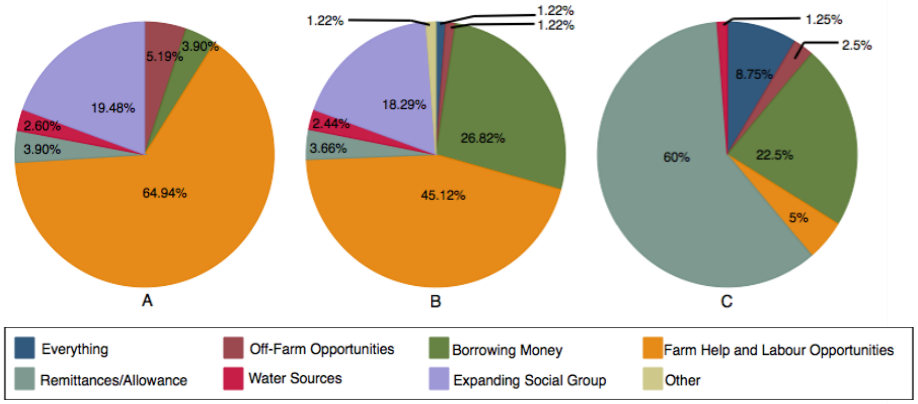

Figure 3.2: Unpacked connections (n = 424) for 124 rice-farming households based on the three most common sources of help: **A)** Government; **B)** Other farmers; **C)** Children. Source: Data collected using household surveys by the author.

3.6.5.3 Policy Options

While households adamantly stated that "a child who is able to finish their studies is a farmer's wealth", receiving future remittances depends on the abilities of households to afford education for their children. **Fig. 3.3** shows that for households investing in education, it ranked as their top priority for allocating their savings. However, the effects of inadequate irrigation can compromise this source of future help. One household reported, "…water is not enough. This affects even the children's education. If you don't have extra income or source of living, it will be very hard [to support it]." This multi-dimensional factor constrains and expands decision spaces. Capacity-building programs strengthening programs that support child education could facilitate household adaptation in the future, or in general provide a means of security. In other words, reflecting on culture reveals that an investment in *children* could be an investment in *parents*.

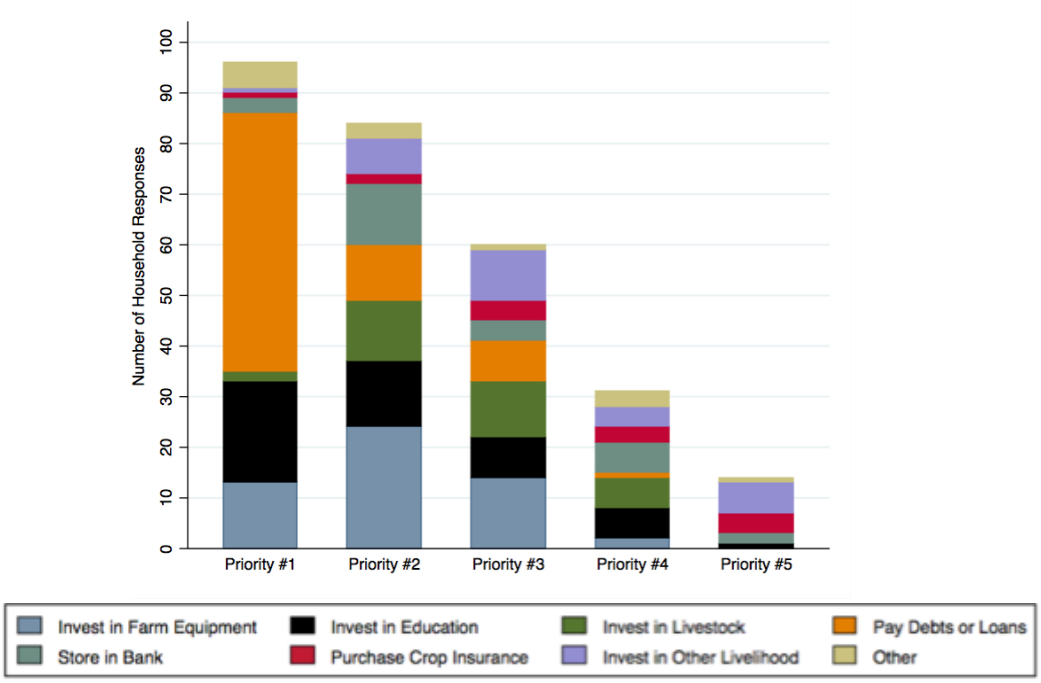

Figure 3.3: Spending priorities for households with savings. Source: Data collected using household surveys by the author.

3.6.6 Lived Experiences

3.6.6.1 Lived Experiences as Pulling Households Towards

Distinct lived experiences of rice-farming households shape decision spaces. In certain contexts, familiarities can broaden decision spaces by 'pulling' households towards certain activities. One key reason is because the transaction cost is lower given the accumulation of human capital ('know-how') and comfort (Ostrom, 2000). One household said, "I had cattle before and I am very familiar with it. For me, it's not new because I worked in a ranch before so I really know how to take care of cows". Other examples exist for piggeries and *itik* (black duck) raising, with households often referencing the influence of their social relations in teaching production skills.

3.6.6.2 Lived Experiences as Pulling Households Back

Experiences and memories from previous livelihood experimentation also produced a sense of risk and fear for some, effectively pulling them back into familiar activities, namely rice-farming. For example, one household stated their lack of experience and knowledge with appropriately caring for juvenile fish left them deep in debt. The household switched back into rice-farming and stated they would not engage in aquaculture activities again. This example suggests lived experiences condition decision spaces differently, which might or might not be successful in dealing with potential social-ecological change.

6.6.3 Policy Options

The implications for intervention include evaluating, with households, how successful familiar activities are in the context of social-ecological change and increasing their potential for success through training sessions and knowledge sharing and dissemination. It might also involve measures that seek to expand decision spaces, and where needed, mitigate risk of new and untested activities through support packages. This has occurred in the past through government support networks that provided training seminars on high-value crops and animals and made

farm households aware of changing consumer preferences (e.g. introduction of dragon fruit, organic vegetables).

3.7 Conclusions

The major contribution of this Chapter is an integrative 'push-pull' framework that can allow researchers to better understand how contextual factors work in different ways to shape household decision spaces. The Bustos case illustrates this in a fashion that is conducive to policy responses. Accordingly, this work hopes to have communicated both a method of identifying contexts shape decision spaces and illustrations of how policy can operationalize context using the push-pull framework. This central contribution speaks to the need for policies to take seriously the role of multi-scalar and multi-directional factors in shaping household decision-making concerning adaptive possibilities. I have shown how these factors clearly extend beyond technical and economic rationalities and into diverse and multi-scalar domains, ranging from self-identity and culture to accessing formal credit. The contributions here are not specific to irrigation in any sense, or rural environments. Rather, it hopes to be a step towards operationalizing nuance and diversity to facilitate adaptation more broadly.

Chapter 4: Conclusions

4.1 Thesis Conclusions

Agrarian livelihoods in the Global South will continue to face increasing degrees of stress (Dasgupta et al., 2014). Emerging from this recognition are two important directions for research. The first involves more thorough scholarship that examines how local social-ecological stress emerges from drivers at multiple scales. Through more comprehensive understandings of how local change emerges, policy-makers are better positioned to target those key drivers through processes of contestation, mitigation, or adaptation. In the Global South, adaptation continues to be stressed in rural policies, likely a partial product of scholarship that shows its favourable benefits under environmental change. I recognize that mitigation of adverse effects appears to be difficult especially against the backdrop of multiple and powerful competing interests that drive resource re-allocation and the resolution of trade-offs. If scholars and policies continue to view adaptation as an "imperative" (Smucker et al., 2015), more comprehensive approaches ask questions of *who* decides adaptation, to *what*, and *how* are plans and policies enacted to meet adaptation goals. This thesis, using a case from of irrigated rice-farming households in the Angat River Basin, focused on responding to these two research directions.

Chapter 2 suggested that multiple interacting stressors challenge the effective provision of irrigation services for smallholder use. Examining the case from the Angat Reservoir, I showed how reservoir governance, re-structured to protect and prioritize domestic water use in Metro Manila, interacts with existing climatic variation to drive irrigation water insecurity for irrigation-dependent households. The findings suggested the interaction between governance and climatic variation can compromise the intended benefit of irrigation infrastructure, that is, to enhance agricultural water security by providing predictable flows that protect users against climatic variation.

The Chapter added to a literature showing increasing trends towards the re-direction of agricultural water for livelihood towards urban centres for domestic and other related uses (see Molle & Berkoff, 2006). Where research showing these re-allocation trends often highlight examples based on conditional water re-allocation (i.e. during periods of drought emergency), I

showed how the Angat case is part of a much longer systematic direction to re-allocate and re-prioritize water for urban domestic uses. The Chapter also advocated for more research to examine interactive effects of social (governance) and biophysical variables to understand nuanced place-specific impacts of change on water security. This can allow for more targeted approaches to resolve potential trade-offs in water re-allocation and re-prioritization. The Chapter hopes to be used in the future as one piece of evidence-based research to support a strong trade-off resolution framework in the National Water Code (1976) of the Philippines. Such measures could allow for agrarian households to be protected from future water re-allocations from the Angat Reservoir owing to increasing urban water demand and expected increases in the frequencies of extreme climatic variation events (see **Chapter 2**).

Chapter 3 recognized that the effects of both distant and local stressors pose fundamental challenges in irrigation water provision and access that cannot be mitigated *only* through on-farm and off-farm efficiency measures. It also highlighted that access to water alternatives is limited and increasingly uncertain. Given this, and the broader set of stressors to agricultural production in Bustos, it turned its attention to the three-plus decades of research that show complementary and alternative (CA) livelihoods can reduce negative effects of environmental change to households that might otherwise have particular livelihood activities compromised. Yet, those strategies promoted by government or intergovernmental organizations are often standardized and generalized, sometimes failing. I argued that a critical reason why some strategies fail is because they exist outside household "decision spaces", or the subset of *possible* CA livelihood activities a household is able and willing to engage in. This Chapter was an effort to understand how rural adaptation policies can promote or advance livelihood strategies that are meaningful, do-able, and palatable to local households. In doing so, I recognized that what households are able and willing to do to adapt is shaped by different contextual factors. The major contribution was a framework for understanding how contextual factors work in multi-dimensional ways to condition (constrain or widen) decision spaces for households or groups of households. Using examples from Bustos, I show how policies can either target contextual factors constraining decision spaces, thus opening up potential opportunities, or also promote CA livelihoods within existing decision spaces.

This Chapter built on literature critical of standardized and generalized approaches to adaptation policies through providing an approach capable of identifying *and* operationalizing 'context' to design relevant livelihood adaptation policies. It therefore provided an approach that is in stark opposition to those that reduce diversity and complexity in policy design. Future research around this approach is needed to empirically showcase the framework's successes and deficiencies. Both Chapters, taken together, hope to have provided a comprehensive analysis of the Angat River Basin and its rice-farming households where social-ecological change is actively occurring and tailored adaptation policies are duly needed.

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Appendix

Appendix A: Household Survey

- This survey is intended to understand how irrigation services are meeting your household needs.
- Participation in this study is **completely voluntary**. If you feel uncomfortable during any point of this survey, you do not need to answer the question as posed or any of the remaining questions.
- This survey will take approximately 40 minutes to complete.
- This survey can be completed with one or more members of the household.
- Seven (7) people will have access to this survey. They include three research assistants, and the project team: Dr. Leila Harris, Dr. Hisham Zerriffi, Dr. Leonora Angeles, and Mr. Sameer Shah (UBC, Canada).
- **Your personal information will be completely anonymized.**
- Completion of this household survey means agreeing to participate in the survey.
- **If you have any questions or need clarification, please ask me.**

Location		
Barangay and Landmark		**Example**: B, 6th home on John Street.
Date		**Example:** July 10, 2014
Barangay Codes: A = Bonga Mayor; B = Bonga Menor; C = Buisan; D = Camachilihan; E = Cambaog; F = Catacte; G = Liciada; H = Malamig; I = Malawak; J = Poblacion; K = San Pedro; L = Talampas; M = Tanawan; N= Tibagan; O = Do not live in Bustos		

SECTION A. Qualification Questions *I would like to ask some general questions to determine your suitability to participate in this study.*		
I.D.	**Question**	**Circle one option**
A1	Has/does your household participate(d) in farming activities in Bustos? Exclude those that are just labourers.	Yes No
A2	Have/do you use irrigation water from the Angat-Maasim River Irrigation System (AMRIS) for rice-farming? (The National Irrigation Administration (NIA) owns the AMRIS).	Yes No South main canal: _____ Lateral: _____ No.____ Sub-lateral: ____No.____ Pump system: _____
A3	Have you grown rice in the last 15 years using the AMRIS?	Yes No
If yes to the above questions proceed to Section B. If no to any, do not proceed.		

SECTION B. Household Characteristics *I would like to ask some questions about who belongs to your household.*								
I.D	**#**	**Relationship to Head of Household**	**Sex**	**Age**	**Education (code)**	**Agricultural farm savings (PHP)**	**Secondary occupation**	**Secondary occupations savings (PHP)**
B1	01	Head of HH (A)	M F					
	02		M F					
	03		M F					
	04		M F					
	05		M F					
	06		M F					
	07		M F					

SECTION B. Household Characteristics
I would like to ask some questions about who belongs to your household.

Relationship codes to HH:	Education codes	Codes for Secondary Occupation
A = Household head; B = Wife or husband; C = Son or daughter; D = Sibling; E = Son or daughter-in-law; F = Grandchild; G = Grandparent; H = Cousin; I = Uncle or Aunt; J = Friend; K = Other (list):_____	A = No schooling B = Elementary C = Elementary graduate D = High school E = High school graduate F = Vocational G = College H = College graduate I = Other (list):_____	A = Fishing; B = Livestock; C = Textiles; D = Food production; E = Furniture production; F = Bag making; G = Leather tanning; H = Driver; I = Labourer; J = Other (list):_____ K = No secondary occupation.

I.D.	Question	Circle one option for each column	
B2	What is the ethnicity and religion of your household?	**Ethnicity:** Tagalog Bisaya/Binisaya Bicol/Bikol Ilocano Cebuano Other: _____	**Religion:** Roman Catholic Islam Evangelical Iglesia ni Kristo Aglipayan Other: _____
B3	Does your household access any of the following items? *Owns = your household privately owns this item.* *Borrows = your household uses this item from others without repayment.* *Rental = your household pays to use this item from others.* **Please read the options**	**Asset**	**Circle all that apply**
		Motorized vehicle	Owned Borrowed Rental
		Bicycle	Owned Borrowed Rental
		Telephone	Owned Borrowed Rental
		Tractor	Owned Borrowed Rental
		Machine pulled plow	Owned Borrowed Rental
		Animal pulled plow	Owned Borrowed Rental
		Carabao	Owned Borrowed Rental
		Livestock	Owned Borrowed Rental
		Rice thresher	Owned Borrowed Rental
		Water pump	Owned Borrowed Rental
B4	How far downstream the canal do you farm? If you farm multiple pieces of land, please list the average estimated distance.	**Circle one option**	
		Very far Far Near (to Bustos Dam) Very near (to Bustos Dam)	**_____ km (distance *along* canal from Bustos Dam)**
B5	What is your household's	**Circle all that apply and list**	

SECTION B. Household Characteristics *I would like to ask some questions about who belongs to your household.*				
	relationship to the land you farm? Please include all members of your household. **Read all the options after the question.**	Own and farm all land (owner-cultivator) Own but do not farm (landlord) Amortizing owner (repayment for ownership of farm land) Lease tenant of farm land (fixed rent for farm land) Provide labour to a farm in return for a share of the crop Provide labour to a farm in return for money	Yes No Yes No Yes No Yes No Yes No Yes No	**_____cavans** **_____cavans** **_____cavans** **_____cavans** **_____cavans** **_____cavans**
B6	On average, how much irrigation water does your household use for each of the following uses? **Read all the options after the question.**	**Describe the % of irrigation water used for each.**		
		Palay (rice) Other crop production Livestock Fish ponds Leather tanning Cooking and cleaning Drinking water Sanitation Cultural or religious use Other (list): _____	_____ % _____ % _____ % _____ % _____ % _____ % _____ % _____ % _____ % _____ %	
B7	In an average year, which crops does your household grow and harvest? **Read all the options after the question:**	**List the percentage of average land area for each crop**		
		Wet season Palay: _____% Corn: _____% Ampalaya: _____% String beans: _____% Okra: _____% Fruit: _____% Eggplant: _____% Mung beans: _____% Other (list): _____%	***Dry season*** Palay: _____% Corn: _____% Ampalaya: _____% String beans: _____% Okra: _____% Fruit: _____% Eggplant: _____% Mung beans: _____% Other (list): _____%	
B8	On average, what do you do with	**Please describe for each harvested crop**		

SECTION B. Household Characteristics *I would like to ask some questions about who belongs to your household.*			
	the crops your household grows and harvests? *Examples include: Consumption, selling to distributors, whole sale, or sharing with other households.* Can you please describe why you do this for each planted crop?		
B9	On average, does your household accumulate savings, or extra money each year? (*Savings = expenses minus revenue)*	**Circle one option**	
		Yes No	
B10	**If yes, to B9**: On average, what does your household prefer to do with savings, or extra money? **Please read out options before answering**. Please describe why you do this with your extra savings.	**Rank from most to least preferred**	
		1. 2. 3. 4. 5.	A = Pay off debts or loans B = Store in a bank C = Invest in farm equipment D = Invest in livestock E = Invest in other secondary occupations (e.g. skill building, equipment) F = Purchase crop insurance G = Invest in education H = Other (list): _____ I = We do not have savings

SECTION C. Exposure to Irrigation Variability *I would like to ask some questions about changes in your irrigation quality and quantity over time.*				
I.D.	**Question**			
C1	Please rank up to five (5) concerns that affect irrigated farming of major crops using AMRIS during dry and wet seasons. **Please read out the options.**	**Rank using the codes provided** **1=Most concerned; 10=Least concerned**		
		Dry season 1. 2. 3. 4. 5.	***Wet season*** 1. 2. 3. 4. 5.	***Codes*** A = Unpredictable irrigation amount B = Unpredictable irrigation quality C = Drought E = Flooding F = Typhoons and cyclones G = Low market prices H = Inability to afford farming costs I = Agricultural pests J = Land tenancy K= Other (list): _____
C2	As compared to 15 years ago, have you	**Please circle the relevant option.**		

SECTION C. Exposure to Irrigation Variability *I would like to ask some questions about changes in your irrigation quality and quantity over time.*		
I.D.	**Question**	
	experienced changes in the timing (arrival) of irrigation water to your household? As compared to 15 years ago, have you experienced changes in the duration (length of time) irrigation water remains at your household? As compared to 15 years ago, have you experienced changes in the amount of irrigation water at your household? ***If 'No' to all: 'Has there been any change since 1997-1998?'**	Yes No Please describe: Yes No Please describe: Yes No Please describe:
C3	As compared to 15 years ago, your household can predict water timing, duration, and amount…: ***Probe: before and after Manila received water.**	**Please fill out each column**

	Better	Same	Worse
Water timing (arrival)			
Water duration (length of time it remains)			
Water amount			

C4	In the future, do you expect irrigation service (timing, duration, **or** amount) at your household to be:	**Please circle the relevant option.** Highly predictable Predictable Unpredictable Highly unpredictable

SECTION D. Sensitivity to Irrigation Variability *I would like to ask some questions about how irrigation variability affects your household.*		
I.D.	**Question**	
D1	How dependent is your household irrigation services for the following? **Please read out each and answer:**	**Please circle the relevant option for each.** 1 = Strongly dependent; 3 = Somewhat dependent; 5 = Strongly independent; N/A = Irrigation water not used

Activities in the dry season						
Quality/quantity of major crop	1	2	3	4	5	N/A
Quality/quantity of other crops	1	2	3	4	5	N/A
Agricultural income	1	2	3	4	5	N/A
Raising of livestock	1	2	3	4	5	N/A
Fish ponds	1	2	3	4	5	N/A
Other (list): _____	1	2	3	4	5	N/A
Activities in the wet season						
Quality/quantity of major crop	1	2	3	4	5	N/A
Quality/quantity of other crops	1	2	3	4	5	N/A
Agricultural income	1	2	3	4	5	N/A
Raising of livestock	1	2	3	4	5	N/A
Fish ponds	1	2	3	4	5	N/A
Other (list): _____	1	2	3	4	5	N/A

SECTION D. Sensitivity to Irrigation Variability *I would like to ask some questions about how irrigation variability affects your household.*				
I.D.	**Question**			
D2	For those needs using irrigation water, does your household also use other sources of water to help satisfy them? *First determine whether each activity uses irrigation water. Next, determine what other sources of water exist to supplement irrigation water.*	**Please circle one or more options using the codes**		
		Needs	**Use of irrigation**	**Other water sources**
		Major crop production	Y N	
		Other crop production	Y N	
		Raising livestock	Y N	
		Fish ponds	Y N	
		Other (list):_____	Y N	
		Codes: A: Surface water collections (river, ditch, reservoir) B: Groundwater collections C: Rainwater collections D: Connection to tap E: We do not have access to other sources of water F: Other (list):_____		
D3	If you have noticed changes in irrigation services (timing, duration, **or** amount), your household needs met through are irrigation are: Please describe why this affects your household needs.	**Circle one option** 1 = Not met; 3 =Some met; 5 = All met; N/A = Not applicable		
		Household needs: 1 2 3 4 5 N/A		
D4	If you expect future irrigation services to be *unpredictable*, do you expect your household needs met through irrigation to be: Please describe why this affects your household needs.	**Circle one option** 1 = Not met; 3 =Some met; 5 = All met; N/A = Not applicable		
		Household needs: 1 2 3 4 5 N/A ***Note: If answers for D3 and D4 are different, ask why:**		

SECTION E. Adaptation to Irrigation Variability *I would like to ask some questions how your household is dealing with potential irrigation variation.*		
I.D.	**Question**	
E1	If you have noticed changes in irrigation services (timing, duration, **or** amount), what happens to the irrigated crops you grow? (e.g. crop failure, quality problems, more pests).	**Please describe**
E2	If you have noticed changes in irrigation services (timing, duration, **or** amount), does your household find ways to help *continue* irrigated farming of the major crop using AMRIS?	**Circle one option** Yes No N/A
E3	**If 'yes' to above (E2):**	**Please list using the codes provided**

SECTION E. Adaptation to Irrigation Variability *I would like to ask some questions how your household is dealing with potential irrigation variation.*			
	Please list in order of first to last the strategies adopted to help *continue* irrigated farming of the major crop? **Please read out options.**	**Dry season** 1. 2. 3. 4. 5.	**Wet season** 1. 2. 3. 4. 5.
	Why did you select the option you did?	A = Water resource substitution B = Selling off assets C = Reducing expenses D = Purchasing insurance E = Acquiring loans or credit F = Securing remittances from friends or family G = Obtaining seeds or farm input from friends or family H= Changing the cropping schedule I= Other (list):_____	
E4	Do the strategies you listed above (**E3**) meet household needs (connected farming needs) otherwise served by irrigation?	**Circle one option** 1 = Not met; 3 =Some met; 5 = All met; N/A = Not applicable **Household needs:** 1 2 3 4 5 N/A	
E5	If you have noticed changes in irrigation services (timing, duration, **or** amount), has your household undertaken *different* livelihoods to better meet needs otherwise served by irrigation from AMRIS?	**Circle one option** Yes No N/A	
E6	**If 'yes' to above (E5):** Please list in order of first to last the different strategies to better meet household needs otherwise served by irrigation. **Please read out options.**	**Please list using the codes provided** **Dry season** 1. 2. 3. 4. 5.	**Wet season** 1. 2. 3. 4. 5.
	Why did you select the option you did? Why not a different option? (e.g. for health, age, access to resources, skills, education reasons).	A=Planting different crops B=New agricultural employment (labour, livestock production) C=Off-farm employment (labour, fish ponds, etc.) D=Migration E = Remittances from friends or family F=Other (list):_____ G= Other (list):_____	
E7	Do the strategies listed above (**E6**) meet the household otherwise served by irrigation?	**Circle one option** 1 = Not met; 3 =Some met; 5 = All met; N/A = Not applicable **Household needs:** 1 2 3 4 5 N/A	

SECTION F Social Connections to Adaptation Strategies *I would like to ask some questions about your social circle and how they help your household in time of need.*		
F1	If you have noticed changes in irrigation services	**Circle one option**

SECTION F Social Connections to Adaptation Strategies *I would like to ask some questions about your social circle and how they help your household in time of need.*		
	(timing, duration, **or** amount), do you receive assistance from other individuals, households, or groups to meet your needs?	Yes No N/A
F2	**If 'yes' to F1:** Please list the people or groups your household has relied on for help. Help includes: ***pagbibigayan*** (sharing or giving), ***pagbibigay*** (give and take), ***pakikisama*** (reciprocity, neighbourliness). **Read out examples of help received first.**	**Please list using the codes provided below** **Who?** / **What help?** Son /daughter In-laws Siblings Grandchildren Cousins Uncle/Aunt Neighbour Other farmers Government Non-government agency Bank Other (list):_____ **Example codes for help received** A=Access to water sources B = Farm inputs C =Access to new crops D =Access to on-farm labour E =Access to off-farm opportunities F = Borrowing money G =Remittances (money transfer) H = Expanding social group
F3	Overall, do these people or groups help provide opportunities to meet the household needs that are otherwise met through irrigation?	**Circle one option** 1 = Not met; 3 =Some met; 5 = All met; N/A = Not applicable **Household needs:** 1 2 3 4 5 N/A

After completion:
Thank you very much for your time in participating in this survey. I want to assure you that your identity will not be disclosed to anyone.