LAND-USE/LAND-COVER CHANGE AND VULNERABILITY TO LANDSLIDE DISASTERS IN KURSEONG (DARJEELING HIMALAYAS), INDIA

By

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Abstract: This three-article dissertation (TAD) examines the drivers and impacts of Land-use/land-cover Change (LULCC) on the social-ecological system (SES) in a Himalayan region, prone to landslide disasters. The study region is based in Kurseong, a district subdivision in eastern India, and is home to agrarian communities who work primarily in tea plantations and smallholdings. This dissertation is grounded in integrated theoretical frameworks of Land System Science (LSS), Disaster research and Political Ecology (PE), and employs a mix of remote sensing, archival and ethnographic research methods. Article one identifies LULCC subjected to landslides over the last three decades (1988 – 2019), and explores the proximate and underlying drivers behind local land-use practices and decisions. Article two computes the multidimensional ways in which local people are vulnerable, by adopting a multidimensional livelihood vulnerability index (MLVI) framework, and explores with a political ecology chain of explanation, why vulnerabilities continue to exist. Article three illustrates farmer adaptations to a postcolonial agricultural system, their vulnerabilities and resilience with limited entitlements and access to resources. The GIS and Remote Sensing analyses show an increase in forest cover from 1988 to 2019 (45 – 54%), and a decrease in total landslide area (225.54 – 162.56 ha) over the same period. However, landslide vulnerabilities intensified in heavily settled and deforested areas, inferring a more complex influence of broad land changes at local levels. The MLVI in selected areas further shows farming communities to be multidimensionally vulnerable in varying degrees to several socio-economic stressors. Finally, a decentralized and decolonized political ecology approach tracks the historical and social roots of local adaptations to infrastructural constraints, limited social and economic capitals, and environmental disasters. Such adaptations to the SES are both sustainable and maladaptive, and is defined by adopting the phrase ‘clumsy solutions to wicked problems.’ The frameworks employed in this research brings together multiple paradigms to help identify the underlying socio-economic and political drivers behind environmental changes, and complex ramifications of environmental impacts on society. Thus, this study simultaneously contributes to a local geography in the Himalayas, as well as transdisciplinary and integrated research concepts for Global Environmental Change research.

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CHAPTER I

INTRODUCTION

1. Overview

This three-article dissertation (TAD) is a study of the drivers and impacts of land-use/land-cover change (LULCC) on the socio-ecological system in Kurseong, India. Located in the tectonically active Himalayan mountains in eastern India, the land- and 'socio-scape' of Kurseong are vulnerable to disasters such as earthquakes, floods and landslides. Hence, this study focuses on the drivers and impacts of land-use/land-cover changes on farmer vulnerabilities to landslide disasters.

Theoretically, this spatiotemporally cross-sectional study is grounded in an integrated Land Systems Science (LSS) and Political Ecology (PE) framework that uses mixed methods of research. In other words, this study is based on a) the LSS premise that human-driven alterations of the land in the form of LULCC are major drivers of global environmental change (Turner et al. 1994, Lambin et al. 2001, Goldewijk et al. 2011, Lambin and Meyfroidt 2011, Houghton and Nassikas 2017); and b) the PE premise that stresses ecological changes are byproducts of human-environment interactions, operationalized by political or structural processes at different hierarchical levels in the society (Blaikie and Brookfield 1987, Robbins 2012, Schulz 2017). In order to understand the processes and impacts of environmental outcomes, PE seeks to explore the chain of explanation, in this case, from environmental problems to farmer adaptations, to resource access of land-users, to political allocation of land resources, back to socio-natural outcomes (Watts and Peet 2004, Robbins 2012).

This dissertation as a whole, employs both LSS and PE embedded within a context of disaster risk/vulnerability research in order to a) identify regional level LULCC that are prone to landslides, b) identify the drivers of LULCC in terms of land management and local land-use practices, c) explore local land-use choices through political allocation of resources, constraints of land users, etc., d) illustrate how these chains of processes translate into farmer vulnerabilities, and finally, e) understand local adaptations that foster some resilience to the coupled human-environment system in Kurseong.

First (Article one, Chapter II), broad LULCC between 1988 and 2019 in Kurseong are mapped, and patterns of LULCC vulnerable to landslides are identified. Then land-management and farmer land-use decisions are analyzed. This part of the study uses GIS and Remote Sensing techniques to monitor land system changes at a regional level; and data from household surveys to identify the common land-use practices that accentuate people's vulnerability to landslides. In this article, the complexities of the top-down approach of LSS to monitor regional-level LULCC are discussed. This article advocates for a more detailed local scale analysis within the LSS framework to better understand complexities of environmental outcomes and the human drivers behind them.

Article two (Chapter III) expands on identifying and exploring an assemblage of variables that makes a household multidimensionally vulnerable. Here, a multidimensional livelihood vulnerability index (MLVI) framework, and a political ecology analytical framework are integrated to a) understand the varied indicators of local vulnerability, and b) explore the interactive human-environment processes involved in the production of vulnerability in Kurseong. This study uses data from 146 household surveys because the basic unit of this study is a household. The combined MLVI computed from individual household data shows people's vulnerability at a community level. The MLVI is an effective method in deconstructing vulnerability indicators at a household level. But, it falls short in explaining the reasons why these indicators are in place or how they function. Incorporating PE helps explain these processes in terms of socio-economic and political structures and functions of these indicators in this region.

Article three (Chapter IV) explores farmer adaptations and vulnerabilities within a postcolonial plantation system. Expanding and integrating ideas of colonial legacies in a post-colonial plantation agricultural system, hegemonies, conflict and adaptation within decolonized political ecology framework, the study explores how colonial roots of plantation agriculture has translated within a postcolonial society in terms of wages and access to resources in labor-intensive plantations. A chain of explanation, from farmer adaptations and land-use choices based on their livelihoods, the drivers of regional livelihood generations as dominated by tea plantations, and the historical context in which a socio-political structure of marginalization of the major work force of the region is discussed using a political ecology approach. For this article, archival research was conducted to review historical colonial politics of land grabbing and erasure of indigenous history; and primary data were collected using field methods of key-informant interviews, community meetings and household surveys. The results together illustrate that the colonial system of control over land and labor have profoundly translated within the postcolonial agroecosystem, and reflects on socio-economic and political conditions of local farmers, their choices and constraints of sustainable land-use. Still, land-managers and land-users have adapted resorting to both sustainable (e.g., having small vegetable gardens, planting trees, etc.), and unsustainable ways (waste dumping, plastic burning, etc.). Following Rittel and Weber's (1973) and later Hartmann's (2012) conceptualization of the terms, the phrase "clumsy solutions to wicked problems" is used here.

Chapter V concludes by summarizing the findings, limitations, and scope of the study. The utility of integrating multiple theoretical frameworks and research methods as exhibited in this study are discussed. The following paragraphs of this introductory chapter begins with illustrating the background of this research. Then, the study area, research frameworks, and methodology are described. Finally, the pertinence and necessity of conducting this study is explained.

2. Background

2.1. Disaster as a Socio-Ecological process

Land systems, or the earth's terrestrial surfaces are continuously altered by human processes (Turner et al. 1990, Verburg et al. 2013). Agriculture, urbanization, industrial expansion, forest cover conversion, etc. are predominant forms of land-use/land-cover changes (LULCC) produced through human actions, which contributes significantly to changes in the global environment (Lambin and Geist 2006, Lambin and Meyfroidt 2011, Ellis et al. 2013, Vadjunec et al. 2018). Hence, land systems are considered as integrated socio-ecological systems (SES) consisting of natural land-based resources (e.g., forests, water, soil), provisioning a vast range of ecosystem services that are used and altered by humans (Veldkamp 2009, Verburg et al. 2013, 2015). While the extensive human-induced environmental alterations have made the world hospitable and conducive to thrive, a lot of such changes have impacted in negative environmental outcomes as well (e.g., through deforestation, land degradation, climate change, etc.). Either way, human processes within the environment have far-reaching consequences as feedback effects that impact societies at multiple scales (Turner et al. 1994, Geist and Lambin 2002, Foley et al. 2005, Lambin and Geist 2006, Turner et al. 2007, Lambin and Meyfroidt 2011, Verburg et al. 2015, Dong et al. 2019).

Research shows large-scale LULCC in marginal ecosystems poses a great risk to expose the SES to extreme events, or disasters (Glade 2003, Wisner et al. 2004, Nathan 2008, Froude and Petley 2018). Much of the research conducted by risk-hazards/disaster scholars acknowledge the contribution of coupled socio-ecological processes on disaster outcomes. However, as Tierney (2012) observed, the gap in multi-disciplinary overlap of expertise is still prevalent in the field of disaster studies. While mathematical modeling and prediction of land system changes and natural disasters have advanced independently (e.g., Li et al. 2017, Fu and Weng 2016, Alcantara-Ayala 2017, Broeckx et al. 2020), social research on disaster and vulnerabilities have been published independently as well (e.g., Pelling and Dill 2006, Adger 2006, Cutter 2016, de Loyola Hummell et al. 2016, Rumbach 2016). The present study bridges the gap with a transdisciplinary approach of studying landslide disasters, based on the idea that although disasters appear to be sudden and extreme events, they are actually manifestations of long-term systemic changes accumulated over time (Claus et al. 2015).

2.2. Pertinence of Research on Landslide Disaster Using an Integrated Research Framework

In Geology, mass movements or landslides are studied as a major contributor to landscape evolution (Broeckx et al. 2020), and therefore, are a driver of land systems change. However, compared to other disasters, landslides are less explored due to the inaccessibility of mountains. Landslide inventories are often incomplete due to the scarcity of data (Ghosh et al. 2012a, Petley 2012, Froude and Petley 2018). The Durham Fatal Landslide Database is one of the few agencies that record losses incurred by landslides by compiling various government and non-government databases. 4,862 landslides, recorded in the database, caused a total 55,997 deaths globally between January 2004 and December 2016 (Froude and Petley 2018, 2161). The maximum loss was seen in the Himalayas and China (Petley 2012, see also Biswas and Pal 2016, Zhang and McSaveney

2018). Some other regions, severely vulnerable to landslides, include Southeast Asia (Chan 1998, Edwards et al. 2019), New Zealand (Dymond et al. 2006, Glade 2003, Rosser et al. 2017, Massey et al. 2018), Uganda (Knapen et al. 2006, Jacobs et al. 2017, Broeckx et al. 2019), Kenya (Mundia and Aniya 2006, Mwaniki et al. 2017); the Caribbean Islands (Petley 2012, Kirschbaum et al. 2016), Mexico (Alcantara-Ayala 2008, Diaz et al. 2020), and Chile (Petley 2012, Panek et al. 2018) among others.

Most of these countries are also economically less developed, where poor socio-economic conditions may force individuals to earn their livelihoods in marginal lands if resources are available (Wisner et al. 2004, Mundia and Aniya 2006, Collins 2008, Nathan 2008). These countries have unique local adaptations to the existing environmental, political, and economic conditions. The International Consortium of Landslides (ICL), an international organization supported by UNESCO, WMO, UNISDR, among others is currently promoting a holistic research on landslides integrating technological and social sciences especially in developing countries (Alcantara-Ayala et al. 2017). With this objective in mind, integrated transdisciplinary studies in the hazards, risk and disaster field are necessary to understand the complex pathways in which social processes impact vulnerability (Lambin et al. 2001).

2.3. Connecting Land-use/ land-cover Changes and Landslide Disasters

LULCCs in mountains are largely observed in places experiencing population growth, urbanization, and agricultural or industrial expansion that increase vulnerability to landslides (Guthman 1997, Crozier and Preston 1999, Pant 2003, Miral et al. 2003, Alcantara-Ayala 2008, Biswas and Pal 2016). For example, in Uganda and Kenya, built-structure constructions to support a growing population increased landslides along urbanized highlands (Knapen et al. 2006, Mundia and Aniya 2006). However, such direct, observable or ‘proximate’ causes of land change are often driven by underlying (invisible hand) factors (Lambin et al. 2001, Geist and Lambin 2002). They may include political/institutional resource management, market demands for land-based resources, risk perceptions and land rights/tenure of land-users, among others (Geist and Lambin 2002, Turner et al. 2007, Lambin and Meyfroidt 2011, Lim et al. 2017).

The combined effects of proximate and underlying drivers have a significant bearing on land-use decisions and environmental change (Geist and Lambin 2002, Turner et al. 2007). For example, Nathan (2008) explored that economic stressors among local inhabitants in the hills of La Paz, Bolivia contributed to unsatisfactory risk awareness to the environment's natural susceptibility to landslides, mudflows and earthquakes, leading to inadequate risk response. The functioning of underlying drivers was complex, and had a profound bearing on people's vulnerability. In another research, Chan (1998) showed rapid economic development, outpacing environmental protection initiatives increased landslide vulnerability in Malaysia. In China, the Three Gorges Dam, established to improve agriculture and industrial development, increased the risk of landslides in the farmlands downstream (Jackson and Sleigh 2000, Chen and Wang 2010).

The concepts of "proximate and underlying drivers" of land change, impacts of social processes on environmental outcomes across geographical scales (e.g., local, regional, global) can be very well formulated within the Land Systems Science framework. Additionally, cross-scalar analyses of social, political and ecological processes behind treatment of a disaster can be explored effectively from a soft-constructivist bottom up approach of a Political Ecology framework (Claus et al. 2015). This research attempts to integrate these two frameworks conjunctively to incorporate multiple perspectives on the drivers of land changes and farmer vulnerabilities in Kurseong.

3. Theoretical Framework

3.1. Land Systems Science for assessing LULCC and its Impacts

Land systems science (LSS) is a transdisciplinary research framework that is extensively used to analyze the social and ecological dynamics of land-use/land-cover changes (LULCC), tradeoffs and feedbacks with an end goal to better understand and model the processes that lead to global environmental change (Reenberg 2009, Meyfroidt et al. 2018, Vadjunec et al. 2018). According to the proponents of LSS, land systems, or the terrestrial component of the earth, include all forms of land-based resources (e.g., forests, soil, rocks and minerals, rivers and lakes, etc.) as well as all forms of human land-use and management, e.g., "socioeconomic, technological and organizational investments and arrangements" on the land (Verburg et al. 2013, 433-4). Hence land is a coupled system that encompass the naturally endowed resources as well as the beneficial and adverse ecological outcomes that ensue from human processes of alteration (Verburg et al. 2013, 433). LSS is an integrated framework focusing on the "drivers and impacts of land change" that includes human adaptations to the land and their socio-ecological outcomes (Lambin and Geist 2006, Verburg et al. 2013).

LSS (also referred to as Land Change Science (LCS)) research developed from interdisciplinary research frameworks established by the International Geosphere Biosphere Program (IGBP) and International Human Development Program (IHDP) (Turner et al. 2007, Reenberg 2009). In the past two decades, scientific communities from social, technological and earth systems science collaborated to conduct interdisciplinary research with an aim of understanding the biophysical and societal processes that contribute to global environmental change (Kates et al. 2001, Lambin and Geist 2006, Turner et al. 2007, Reenberg 2009). The Global Land Project (GLP) designed LSS "to study land system dynamics as a complex interaction between societal, natural and mixed processes at various spatial and temporal scales" (GLP 2005, Reenberg 2009, 1).

The major focus of LSS is “monitoring and describing patterns of land cover change, explaining drivers of land-use change, and understanding the linkages between these two” (Meyfroidt et al. 2018). Monitoring and modelling earth system changes within the LSS framework became possible with the advancement of accurate scientific mapping techniques using GIS and Remote Sensing (Turner et al. 2007, Haberl et al. 2007, Goldewijk et al. 2011, Ellis et al. 2013, Krausmann et al. 2013, Hassan et al. 2016, Findell et al. 2017, Bartel et al. 2017, Krylov et al. 2019). LULCC remained the predominant focus of research and analyses because land use is critical in contributing to changing environmental conditions as conceptualized within LSS (Rounsevell et al. 2012, Verburg et al. 2013, Houghton and Nassikas 2017, Meyfroidt et al. 2018).

In addition to mapping and modelling land-use changes, LSS focuses on the social aspects of environmental changes as well (Turner et al. 2007). LSS integrates society and ecology by analyzing social processes behind observed land system changes with a goal of developing often elusive middle-range theories (Rounsevell et al. 2012, Verburg et al. 2015, Meyfroidt et al. 2018). Meyfroidt (et al. 2018, 53) explains middle-range theories as standard generalizations beyond place-based specificities but narrower in reach than universal or high-range theories. Middle range theories can be applied to several case studies without ignoring the spatial complexities. That LULCC is produced through the functioning of proximate and underlying drivers is one of the widely used theories within LSS research, first theorized by Lambin and colleagues (2001, 2002). Linking apparent or proximate causes of land-use change, for example, population growth, agricultural intensification, rangeland degradation, deforestation, among others to distal and underlying drivers such as market economies, changes in conservation or land-use policies, changes in land ownership/tenure, demand for new consumer goods elsewhere in the world became an important focus of LSS studies (for examples see, Müller et al. 2009, Seto et al. 2012, Lim et al. 2017, Kleemann et al. 2017, Machado 2018, Nyberg et al. 2019, Krylov et al. 2019).

Müller and colleagues (2009) observed cropland abandonment in eastern Europe due to changes in market-oriented economies. They used Landsat images to map LULCC in Romania and found isolated patches of croplands were abandoned in post-socialist Romania.

Lim and colleagues (2017) investigated the proximate causes and underlying drivers of deforestation and land degradation in Myanmar to find that often political and economic drivers inadvertently contribute to deforestation and destruction of biodiversity hotspots. Here, the proximate causes of agricultural intensification, timber extraction and infrastructural development were made possible through political concessions for economic reforms leading to changes in the local environment.

Krylov and colleagues (2019) compared two regions of the neotropical biogeographic realm, viz. the Yucatán peninsula in Mexico, and Chaco region of Argentina to contrast the nature of forest cover loss. They used probability sampling and satellite image surveys to find that the character of forest loss is temporary in the primitive swidden agricultural region of Yucatán; but is extensive, permanent and equally distributed among crop and pastureland in the Argentine Chaco region that had started highly mechanized farming. Their work established a quantitative model and framework to characterize socio-economic drivers of land changes.

Simultaneously, Veldkamp (2009) introduced the concept of land as a multi-scape whose realities depend on how different stakeholders approach land. For example, land-use can be approached as geo-, bio-, econo-, mind-scapes according to the agenda of a stakeholder (Veldkamp 2009, Reenberg 2009). Hence, he urged researchers to be explicit about the end goal of a land-based phenomenon to understand the best way to approach the land change dynamics. Since land-use choices also depend on individual motivations, Rueda et al. (2019) developed the framework beyond proximate and underlying drivers of land change to encompass the psychological drivers of land-use. They drew upon empirical analyses of environmental psychology to understand the links between a land-user's motivations and environmental behavior to study drivers of deforestation.

Another salient theory within the LSS community includes land-use intensification (Turner and Ali 1996, Keys and McConnell 2005, Kuemmerle et al. 2013). Kuemmerle (2013) stressed the importance to understand land-use intensification lay in analyzing the multidimensional complexities resulting in land system changes. The ultimate objective of this framework is to fill the gaps to form comprehensive datasets logging the dimensions of land change to project future global changes. They reviewed the technologies such as advanced remote sensing, statistical, census, survey, cadaster data collection and analyses that strives to fill the knowledge gaps. Ellis and colleagues (2013) found that land-use intensification has been central to the ecological changes and impacts on human societies throughout the Holocene period. Similar work by Findell and colleagues (2017) corroborated that LULCC intensification led to extremes in temperature regimes.

However, the challenge to upscale localized changes to model patterns of environmental change, and large-scale future change simulations is still faced by the LSS community (Reenberg 2009, Rounsevell et al. 2012, Verburg 2013, Meyfroidt et al. 2018). Several interdisciplinary efforts have been undertaken to map global transformation through human actions (Turner et al. 1990, Goldewijk et al. 2011, Ellis et al. 2013, Krausmann et al. 2013, Prestele et al. 2016, Houghton and Nassikas et al. 2017). However, upscaling from empirical analyses to global models becomes a challenge because of the exponential complexities of material transfers and energy flows through higher levels (Reenberg 2009, Rounsevell et al. 2012, Meyfroidt et al. 2018). To address this knowledge-gap the conceptual framework of tele-coupling or understanding the linkages of distant regional pull of goods and services on local land-use decisions was incorporated within the LSS framework (Seto et al. 2012, Meyfroidt et al. 2013, Friis et al. 2016, Zaehringer et al. 2018).

Although Meyfroidt and colleagues (2018, 53) reckoned one of the challenges of LSS to develop independently is due to its interdisciplinary nature resulting in its borrowing from theories in geography, anthropology, landscape ecology and economics; other scientists (see e.g., Seto et al. 2012, Reenberg 2009, GLP 2005) advocate the use of disparate field expertise to understand land system changes. Seto et al. (2012) claimed that traditional remotely sensed land cover classification often gave misleading outcomes if not studied jointly with other contextual analyses. For the purpose of sustainability science, interdisciplinary research communities advocate transdisciplinary production of design, theories and dissemination of knowledge to crack the socio-ecological complexities such as those of land change, climate change, and social-ecological vulnerabilities, among others (GLP 2005, Grove et al. 2015, Turner et al. 2016, Djenontin and Meadow 2018, Zscheischler et al. 2017). This research aims to incorporate the LSS framework through exploring the complexities behind LULCC at regional as well as local scales and contextualizing the changes by analyzing the social practices and imperatives behind land-use choices and decision-making.

3.1.1. Socio-Ecological Vulnerability and Resilience

LSS has distal connections with the development of the "Chicago risk-hazards school" (White, Kates and Burton 2001), and the related field of risk-hazards/disaster studies have contributed to LSS research both within and outside its banner (e.g., Turner et al. 2003, Adger et al. 2009, Messerli et all. 2013, Garriano and Guzzetti 2016, Alcantara-Ayala 2017). Risk-hazards/disaster scholars stress on the importance of human induced environmental changes to have bearing on the earth's carrying capacity, something studied in depth within the LSS community (Wisner et al. 2004, Adger 2006, Messerli et al. 2013). Although more recent research in hazards/disaster fields stress that purely 'natural' disasters do not exist, they classify disasters within natural, social and technological realms (O'Keefee et al. 1976, Wisner et al. 2004, Gould et al. 2016).

Disaster research acknowledges natural causes such as earthquakes occurring as a result of active tectonism, or cyclones with heavy rainfall flooding into destruction and social vulnerabilities (Cutter and Emrich 2006, Gill 2007). Some risk-hazards/disaster research explore combinations of human and natural factors, such as continued transformation of a land system already at a risk of disasters (Wisner et al. 2004, Adger 2006). Some again, investigate purely technological reasons as witnessed during the Bhopal gas leak, Chernobyl nuclear reactor burst, or the Exxon-Valdez oil spill (Gill et al. 2014, Tierney 2012). But all instances of disasters have been shown to disrupt the ecosystem services at various scales and endangers the human habitation and livelihoods.

Often drawing on Risk-Hazards/Disaster studies, LSS seeks to assess the outcomes of the broad systemic changes within the SES in terms of impacting the vulnerability and resilience of the system (Turner et al. 2007, Turner and Robbins 2008). For example, Millette and colleagues used Landsat images in the middle Himalayas to predict "criticality" and "environmental endangerment" through LULCC (1995, 367). They found that land degradation and landslides occurred in places where economies depending upon local resources made local people more vulnerable when there were declines in local businesses (Millette et al. 1995, 368 - 70). Adger and colleagues (2009) linked vulnerabilities caused by environmental changes are both nested within a local spatial unit, as well as tele-connected to distal regions. Ghosh and colleagues (2012) found urbanization and population clusters to be located in medium to high risk areas of landslides in Darjeeling, in their study of landslide hazard zonation.

Vulnerability and resilience are essential concepts in disaster research (Cutter et al. 2003, Wisner et al. 2004, Turner and Robbins 2008). Vulnerability is defined as "the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt." (Adger 2006:268). Resilience is "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al. 2004:2). The concepts of vulnerability and resilience originated from separate, but parallel fields of research. While vulnerability originated from social sciences focusing on a community or an individual's ability to cope with natural hazards, resilience was conceptualized within ecological sciences to signify the ability of the socio-ecological system (SES) to regain its normal functioning after a disaster (Turner 2010). Thus, vulnerability is socially produced, and can be linked with human adaptations to the environment (Wisner et al. 2004, Adger 2006). Vulnerability also depends on the system's resilience as a more resilient SES can reduce vulnerability of a community, a household, or an individual (Adger 2006).

3.1.2. LSS and Disaster Research

LSS generally assesses vulnerability and resilience using a top-down approach with research questions framed towards understanding the outcomes of the broad changes within the SES (Turner and Robbins 2008, Brannstrom and Vadjunec 2013). A predominant "empirical focus with ad hoc interpretations based on contingent factors," and a methodological attention for advancing spatial analysis kits of GIS and Remote Sensing remains at large within LSS research (Meyfroidt et al. 2018, 54). LSS thus continues to be an extensive and largely post-positivist research framework useful for statistical testing and pattern identification of land system processes and changes. LSS explores the social drivers of environmental change by "linking people to pixels" (Turner et al. 2007: 20668). However, modeling land change continues to face methodological challenges such as over-generalization or the omission of complexities of social process of land change, in part, due to the framework's more top-down approach (Lambin and Geist 2006, Turner and Robbins 2008, Rounsevell et al. 2012, Brown et al. 2013). Another factor often neglected in LSS includes the differences in vulnerability among different social groups exposed to similar environmental hazards (Ajibade and McBean 2014). Socio-economic constraints of households in terms of access to resources and adequate amenities, and policies governing resource-use often impact adaptation and land-use (Robbins 2012).

Similarly, assessments of vulnerability to disasters have place-based limitations with expertise in social conditions that produce vulnerability. While hazards/disaster research often struggles to effectively link social processes to the systemic changes within an ecosystem at a broader scale, LSS often lacks the critical methodological framework to critically explore such socio-economic and political aspects to a smaller, local or individual scale. While individually each set of framings may have different strengths and shortcomings, especially related to scales and approach, taken together, a combined mixed approach can capitalize on each of their strengths while minimalizing their limitations. However, there remains a considerable gap or challenge faced by both LSS and hazard/risk and disaster communities in combining scientific understanding and provide sustainable solutions for policy and practice (Reenberg 2009, Tierney 2012). To foster the dialogue between both of these human-environment research frameworks, LSS could be further integrated with other frameworks that complement it by having theories to approach human adaptations and agencies at multiple levels. Friis et al. (2016) stressed on coupling transdisciplinary theoretical expertise that can help LSS research, once such framework being Political Ecology (PE).

3.2. Exploring Drivers of LULCC and Vulnerability with a Political Ecology Approach

Political Ecology consists of a wide range of research based on the general idea that environmental changes are results of human-environment interactions influenced by political, economic, and social, processes that are often not apparent in apolitical ecologies (Bassett 1988, Robbins 2012, Le Billon 2015). PE aims at understanding the structural influences within the society in terms of control over land-based resources that impact the environment and different groups of society (Watts and Peet 2004, Brannstrom and Vadjunec 2013). PE has a special focus on environmental degradation, marginalization of some groups of people, and conflicts that arise from and result in human-environment processes and outcomes (Blaikie and Brookfield 1987, Watts and Peet 2004, Robbins 2012, Schulz 2017).

Political Ecology often critically analyzes decision-making processes at multiple levels, e.g., the political/institutional structures that govern ecosystem management, as well as the "anarchic or romantic localism" that influence local adaptations and land-use decisions (Robbins 2012:208). A prime focus of PE studies lies in understanding power relations in resource governance (Ahlborg and Nightingale 2018). Several foundational works on political ecology draws on postcolonial studies to understand third world social-ecological systems (Bryant and Bailey 1997). Contextualizing political processes behind ecological changes in the "Third World" Bryant discussed the approaches to understand the impact of political powers behind control of environmental resources and creation of "socially-disadvantaged groups" (1992, 14). Third World political ecology stresses that creation of capitalistic production process flourished with colonialism. Postcolonial societies, to date, carry an indelible influence of colonialism in power relations, environmental decisions and capital generation (Bryant and Bailey 1997, see also Huber 2019). Recently, conversations within political ecologists to decolonize from Anglo-American meaning-making and "learning from the South" (Schindler 2017, Schulz 2017, Loftus 2019 [2017]) opens up new avenues for decolonized political ecologies.

Thus, political ecology pays special attention to environmental degradation, and acknowledge that often, policies regarding environmental resource-use or conservation benefit some groups of people while depriving others whose actions in turn impact the environment (Blaikie and Brookfield 1987, Escobar 2006, Boafo and Lyons 2019). Land-use decisions may also vary among contending groups of people based on their livelihoods, perceptions, and social relations (Bassett 1988, Escobar 2006). In this regard, environmental conflict is an important topic within PE research. Bassett's (1988) work on peasant-herder conflicts in Ivory Coast during the 1970s Sahelian drought explored how environmental policies, and peasant resistances marginalized a group of pastoralists who lost their rangelands. Political Ecology often emphasizes these issues within colonial and post-colonial systems of exploitation, focusing on marginal tropical laborers of the land, the power dynamics of their exploitation, and environmental and social outcomes (Duncan 2002, Schulz 2017, Boafo and Lyons 2019).

Political Ecology has antecedent roots in Cultural Ecology (Turner and Robbins 2008), and has one of its several foci on disaster and vulnerability (Pelling and Dill 2006, Claus et al. 2015) as it often deals with adaptations of human groups to environmental changes and perturbations. Bassett and Fogelman (2013) reviewed PE's renewed interest in the concepts of adaptation to explore environmental issues such as climate change. They analyzed initial PE criticisms of the concept of adaptation, key in Cultural Ecology (Netting 1986), as it focused on choices rather than on constraints in shaping adaptive capacity of groups or individuals. PE focused largely on policy implications in mitigating environmental change issues. With the failure of climate change mitigation policies, the need to incorporate revised notions of adaptation, to better connect science with policy, was recognized in PE. Gould and colleagues (2016) proposed the field of political ecology of hazards to address the nature/state dichotomies that exist in post-disaster politics.

Political Ecology studying disasters critically explores variations in social vulnerabilities of people exposed to similar environmental vulnerability (biophysical exposure to hazards) due to variations in adaptation, access to land resources controlled by invisible power structures, etc. (Harrison 2017). Claus et al. (2015, p. 301) noted that "political ecology has raised new questions about the operation of power and politics in contexts of disasters", as research have suggested contrasting evidences of how disasters may cumulatively marginalize vulnerable groups while powerful groups benefit from it. For example, Ajibade and McBean (2014) examined that flood risk in Lagos, Nigeria was greater for people living in slums compared to other social groups living in the same region. They found that the Federal Government's inadequate land allocation deprived slum dwellers of proper housing and access to road networks. The constraints in basic amenities reduced their adaptive capacity and increased their vulnerability to recurrent floods.

Another example includes Birkenholtz's (2012) Network PE approach that explored how different hierarchical levels of the social structure influenced vulnerability to climate change in Rajasthan, India. Bryant (1998) combined vulnerability, marginality, and risk to everyday, episodic and systemic changes in the environment respectively. He focused on how daily processes, such as soil erosion, affected socio-economically marginal people more and impacted their long-term vulnerability. Research in PE also indicates that local adaptations can aid in sustainable land-uses, even in areas with a different historic past. For example, Lanckriet et al. (2015), in their work on land degradation and regional land policies in northern Ethiopia, found that current local conservation practices reduced soil erosion at places with high population density. However, land-use during feudal periods (19^{th} and early 20^{th} century), resulting from unequal land-rights caused land degradation with long-term impacts on agricultural productivity.

Much PE emphasizes multi-scalar analysis of human-environment interactions often with a bottom-up approach (Turner and Robbins 2008, Yeh et al. 2014). Yeh et al. (2014) examined vulnerability of Tibetan pastoralists to climate change using a PE framework. They first focused on increased vulnerability of pastoralists at an individual level. Moving up to a national level, they identified that political fragmentation of administrative boundaries reduced mobility of pastoralists. It limited their coping mechanisms in severe winter months increasing their vulnerability. In sum, the PE literature mentioned above focuses on the multi-scalar human-environment dynamics in terms of conflicts, social representation, and marginalization (Robbins 2012). They also identify the winners and losers of environmental change asking critical questions e.g., who is vulnerable, and why. However, PE's emphases on the social subsystem in terms of resource use often overlooks the ecological dynamics at hand (Walker 2005), something more extensively analyzed within the LSS framework. Hence, a hybrid framework, integrating LSS and PE, enables adoption of methodologies to 1) quantitatively measure and model land system changes, and 2) logically explore the dynamics of the social processes of environmental changes (Turner and Robbins 2008, Birkenholtz 2012, Brannstrom and Vadjunec 2013).

3.3. An Integrated LSS and PE Framework Within Hazards/Disaster Research

LSS and PE are separate yet complementary frameworks with a common aim of studying systemic outcomes of environmental change (Turner and Robbins 2008). Both frameworks recognize the complexity of human-environment dynamics, while stressing different approaches to understanding the proximate and underlying drivers of land change. In this regard, both frameworks are attentive towards land degradation, vulnerability and resilience. Acknowledging the multi-scalar and multi-temporal nature of land change processes and outcomes, LSS and PE differ in their analytical approaches towards a problem (Turner and Robbins 2008). For example, Messerli and colleagues (2013) discussed land grabbing or acquisition of land of dominant groups as underlying drivers of land system changes. Much of it is prevalent in developing countries. But much of this type of work remain less explored by the LSS community (Messerli et al. 2013). Integrating LSS and PE can lead to a better understanding of land-use choices resulting from such systemic coercions.

Hybrid ecologies linking LSS and PE were suggested by researchers to link a combined top-down and bottom-up approach (Brannstrom and Vadjunec 2013). Beymer-Farris' (2013) work on rice cultivation in Tanzania's mangrove forests is an example of such integrated research. Using an LCS (Land Change Science, used interchangeably with LSS) framework, revealed that rice cultivation and mangrove growth had a symbiotic relationship. Drawing on PE, she then showed that misinformed policies, displacing the farmers to conserve the mangrove forests, actually deteriorated the mangrove ecosystem. LCS helped in identifying the changes within the mangrove ecosystem, and PE helped to explore the causal variables of changes within the SES with its implications. Following the lead of hybrid ecologies, Siewe and colleagues (2017) linked LCS/LSS and PE frameworks to understand the drivers of deforestation in the Korup National Park in Cameroon. They found land-use policies of conservation induced higher deforestation than the growth of population in the region. They used remote sensing analysis to identify land-cover changes and ethnographic studies used in PE research to understand the drivers of such change.

While the quantitative spatial techniques of modelling earth changes have continued to develop under LSS, theories of coupling social connections of land-use change have also progressed. Hence, a further coupling with PE studies help approach more complexities of environmental change if that is the purpose of a research. The commonality of purposes of both frameworks, coupled with distinct and complementary approaches compel an increasing number of scholars to integrate LSS and PE frameworks for better synthesis of findings (Turner and Robbins 2008, Brannstrom and Vadjunec 2013).

The theoretical contribution of this dissertation is understanding the effectiveness of integration and hybridization of paradigms, e.g., from disasters, to LSS to a postcolonial political ecology in the study area. In the following chapters, LSS is broken down to small scale regional mapping of LULCC and identifying the social factors driving land-use change. Then positivist vulnerability index results are coupled with a constructivist PE chain of explanation to understand the rationales behind the existence of the indicators of vulnerability within the study area context. Lastly, an interpretive approach is used to link PE and postcolonial historiography to understand the structural socio-political context where farmer adaptations continue within a precarious system constantly producing vulnerabilities and resiliencies in a disaster-prone region.

4. Study Area

4.1. The Himalayan Degradation

The Himalayan Mountain Range constitutes a natural boundary, separating the Indian subcontinent from the cold northern climate (Ives and Messerli 1989). These mountains are important ecosystems that provide rich resources (e.g., water, minerals, forest resources) to support livelihoods in the Indian subcontinent (Ives and Messerli 1989). The Himalayas regulate the climate of most of the countries of South Asia and the entire Indian Subcontinent. It is also home to several major drainage systems of the world namely, The Indus, Ganges, Brahmaputra, Yangtze River systems along with numerous smaller river systems (Immerzeel et al. 2010, Shrestha et al. 2012). These rivers not only provide water within the mountain ecosystem but also to 1.4 billion people in Pakistan, Nepal, Tibet, Bhutan, China, India and Bangladesh where its river waters flow (Immerzeel et al. 2010, 1383). In India, the drainage system of the Himalayas is responsible for all agriculture in the north Indian plains. The Middle and Outer Himalayas (Himachal and Siwaliks) are extremely biodiverse (Shrestha et al. 2012). The dense forests not only help in maintaining the carbon budget; numerous plants are used for commercial (e.g., apples, oranges, various nuts), and medicinal purposes (e.g., cinchona).

The Himalayas are located along tectonically active subduction zones with ongoing processes of upliftment (Ghosh et al. 2012 a). Earthquakes, floods and landslides are common natural hazards owing to these biophysical conditions (Jodha 2005). This region has also experienced population growth with natural hazards more often recorded in places of human activities, such as slope cutting, deforestation, etc. (Guthman 1997, Basu and De 2003, Miral et al. 2003, Froude and Petley 2018). Since the British colonial regime in India, a large part of the Himalayan forests ranging from the deciduous foothills to the sub-alpine and alpine regions have been transformed into agricultural lands, settlements and industrial hubs, continuously expanding to cope up with an advancing globalized society. Subsequently, the overall Himalayan ecosystem started experiencing profound impacts across local and regional scales having a bearing on a vast swath of connected regions.

Scientists, media and political stakeholders concur that population growth and unplanned resource-uses are responsible for the Himalayan degradation (Das et al. 2011, Arsenault et al. 2012, Biswas and Pal 2016, Pal et al. 2016). This 'belief' is so common, it is known as the "Theory of Himalayan Degradation" (Ives and Messerli 1989). Although some assertions regarding human responsibilities behind the degradation might hold true, in reality, the understanding of the underlying factors behind environmental degradation in the Himalayas still remains adequately unexplored and hence uncertain (Ives and Messerli 1989, Forsyth 1996, Gerlitz et al. 2017). As Ives and Messerli (1989), Pant (2003), Jodha (2005), among other scholars have been suggesting for several decades, degradation of the Himalayan landscape and societies need to be studied with a more critical approach (see Ghosh et al. 2012, Yeh et al. 2014, Getlitz et al. 2017). This study attempts to do so by connecting land system changes and disaster vulnerabilities in the eastern Himalayan subdivision of Kurseong.

4.2. Study Area - Location and Environment

Kurseong is a subdivision of the Darjeeling district of West Bengal (Fig. 1.1) that lies along the southern slope of the Senchal-Mahaldiram range of the Himalayas (Das et al. 2011, Biswas 2013). The subdivision consists of two municipalities, Kurseong and Mirik, and 20 Community Development (CD) blocks. It covers a total area of 501.9 square kilometers with an average elevation of 1482 m (4862 feet) above sea level (Census of India 2011:30). Kurseong is interspersed by steep ridges and spurs (steepness up to 84° angle) (Ghosh et al. 2012b, Lepcha 2015). Geologically, Kurseong falls under a tectonically active thrust-fold belt (Ghosh et al. 2012a). This geological disposition is coupled with local climate where heavy monsoon rains (500 cms.) make the region susceptible to landslides (Basu and De 2003, Khawas 2009). However, the monsoons also enhance biodiversity in the region, as is still evident in the existing forested areas. With colonial expansion and massive transformation of the land to tea plantations, much of the forest cover was lost to the plantations and associated LULCC (Das et al. 2011, Das 2014). Currently, the majority of land-use is comprised of tea plantations, reserve forests, settlements, smallholdings, and urban areas (Census of India 2011, Bandyopadhyay Field Notes 2016 - 2018). Vulnerability to landslides has increased over time and is linked with land-use and management of local people who lack capital and planning to live sustainably in the naturally fragile mountains (Biswas 2013, Lepcha 2015).

Figure 1.1. Location of the Study Area

4.3. Demography and Livelihoods

The population of Kurseong is 140,721 (30,854 households) in both municipalities as well as rural areas (Census of India 2011: 30). The majority of the workforce (37% of the population) is engaged in tea plantations as laborers (Census of India 2011). During the colonial regime, people migrated from Nepal and adjoining regions of India to work in the plantations. The British provided them basic needs and amenities, e.g., school education for children, houses, as well as compensations for property loss in case of a disaster event, a tradition that is still in effect under the 1951 Labor Act of Independent India (Besky 2008, 2017, Khawas 2005, Bandyopadhyay Field Notes 2016-2018). In rural areas, some households grow vegetables and fruits for subsistence (Bandyopadhyay Field Notes 2016-2018).

4.4. Economy, Urbanization, and Political Pressure

Much of Kurseong's economy depends on revenues from tea plantations. However, there has been a decline in the global market for Darjeeling tea, grown extensively in the study area due to changing global market economies (Khawas 2005). Additionally, dwindling productivity of Darjeeling tea (from 15 million Kgs. of tea produced in 1960-1970 to < 9 million Kgs. produced since 2000) (Khawas 2005:3); a rising competition from tea producers, such as, Sri Lanka, Kenya, Japan, and Germany entering the global market; and rising demand for coffee grown in Latin America are responsible for the decline in global demands (Khawas 2005, Elias 2018). However, to keep profits high, the plantation management pay the workers minimal wages (Tirkey and Nepal 2012, Sarkar and Reji 2019). In some plantations, only one person from a household is allowed to work as a permanent worker, who earns daily wages of 132.50 rupees (converts to a monthly income of 43.71 USD). Most families have unemployed/minor/elderly dependents. In peak harvesting season (April-November), sometimes family members are allowed to work as temporary workers. To make ends meet, people, not working in plantations work as cab drivers, or in shops, or resort to smallholding for subsistence and minimal business (Census of India 2011, Bandyopadhyay Field Notes 2016-2018).

The development of the tea industry also facilitated transport and communication during the colonial period (Baker 2014, Basu Roy and Saha 2011, Roy 2010, Sharma 2016). Since then, these road and railway networks have accelerated population growth and urbanization (Basu Roy and Saha 2011, Biswas 2013, Roy 2010). Currently, there are two urban areas in the Kurseong subdivision that have separate municipalities, namely Mirik in the west and Kurseong in the east. In the Kurseong municipality alone, the total population is 42,346 occupying an area of only 7.5 sq. miles (Census of India 2011).

These economic and demographic situations operate in a political context subjected to years of political turmoil between the Gorkha Territorial (local) Administration (or GTA), and the State Government of West Bengal (Benedikter 2009, Jana 2012, Wenner 2013, 2015). Infrastructural development in the subdivision depends much on such political relations. Rumbach (2016) explores the factors that hindered infrastructural development in the hilly terrains of North Bengal of which Kurseong is a part. The primary factors, according to him, are physical, cultural, and political distances from major urban areas, e.g., the state capital, Kolkata. The Left Front Government that ruled West Bengal for 34 years (1977 – 2011) did not invest adequately for infrastructural development of the hills due to the physical distance and inaccessibility of the hills. Moreover, the fact that the population in the mountains is only 2% of the total population of the State makes the situation worse (Mayers 2001, Jha 2010, Rumbach 2016).

Inadequate initiative of the Government for infrastructural development generated a common distrust among local people to claim separate Statehood (Palit 2008, Wenner 2013, 2015). The current State Government's efforts to build infrastructure and a sustainable environment has not yet come out of the historical constraints as a result, the political contention and local resistance towards State actions has not ceased. In 2017, while this research fieldwork was still ongoing, a 100-day strike against the West Bengal Government and intermittent riots affected the livelihoods of the majority of plantation and smallholder farmers. Irrespective of their inconveniences that affected wage earners, school going children and women, they took part in the strike in protest of the State Government.

Being largely of tribal origin, the people of Kurseong are also economically marginal and culturally distinct from West Bengal's mainstream population (Jana 2012). The indigenous people face an identity crisis in their day-to-day life through implicit behavioral exclusion by the mainstream population, consisting of both local people and tourists. These identity issues are politicized by conflicting administrations upholding the demand for separate Statehood (Bandyopadhyay, Field Notes 2016-2018). However, local administrators are not well equipped with scientific understanding of environmental impacts if not helped by the State or Central Governments. Rumbach's statement that "urbanization in small cities outpaces environmental learning" holds true here (2016:109).

4.5. LULCC and Vulnerability to Landslides

In the study area, places especially vulnerable to landslides are found mainly along tea plantations, rural areas, and roads (e.g., areas with moderate to high slopes, impervious surfaces and areas with loose soil, etc.) (van Westen et al. 2012, Bhattacharya 2012). Ghosh and colleagues (2012b) modeled landslide susceptibility in the Darjeeling-Sikkim Himalayas based on past data from multi-source aerial photos, satellite images and topographic maps to conclude that urban and deforested land-covers had moderate to high susceptibility of landslide disasters.

There are 20 wards or CD blocks in the subdivision, 8 of which exceed the permissible limit of population (Das 2014). For example, the average population density in the municipality of Kurseong is 1050 persons/sq. km. (Das 2014). Slums have developed along ephemeral streams (locally called '*jhoras*'), with very poor amenities. The drainage system is primitive, consisting of man-made drains (Arsenault et al. 2012). Solid wastes are often dumped in the drains and streams that block the course of water flow (Basu and De 2003, Ghosh et al. 2012b, Das 2014). Thin topsoil over impervious granite and schist compounded by the steep gradient of the land does not allow rainwater percolation (Starkel and Basu 2000, Starkel 2010). Disastrous landslides in Tindharia, and Gayabari along poor drains and waste disposal sites bear testimony to this fact. In rural areas, significant deforestation occurred between the periods of 1901 and 1981 with expansion of settled area and opening of new tea gardens, where the overall forest cover decreased from 51.54% - 38.26% (Das et al. 2011). However, the archives do not record major LULCC in Kurseong, because deforested areas within the tea estates are not accounted for. Tea plantations have encountered some of the most devastating landslides (Ambootia, 1968 – Tingling, 2015).

In summary, human-environment dynamics of the subdivision of Kurseong are marked by large numbers of low-income plantation workers, political contention, and inadequate infrastructure where people constantly adapt to the increasing threat of landslides.

5. Research Questions

Linking the integrated theoretical frameworks of LSS and PE with hazards/risk and disaster research this dissertation answers three overarching questions related to the study area:

A. a) What broad patterns of LULCC can be observed in Kurseong? b) What LULCCs are more prone to landslides in the study area among the existing ones? c) What underlying factors drive local LULCC that are prone to landslides?

B. a) What factors impact local people's vulnerability to landslides in Kurseong? b) How have these drivers of vulnerability existed and continue to function in the study area?

C. a) How have Local and State Governance managed land and society amidst a landslide-prone environment? b) How have local land-users' adaptation to the management system impacted their vulnerability and resilience?

Although these questions are specific to the study area, the frameworks aim to be reproducible in design. Further, the methods of approaching this problem, and recognition of socio-ecological linkages between land system changes and disaster vulnerabilities can be projected for a larger region as well.

6. Methodology

Table 1.1 Spatial Scale and Research Component, Questions and Methodology

Spatial Scale & Research Component	Questions	Methodology
Regional-Level • *Remote Sensing & GIS:* LULCC in Kurseong Subdivision and land-use vulnerable to landslides	A	• Land-Cover Classification of Satellite Images and digital change detection spanning 4 decades • Landslide distribution maps and computing landslide areas under each land-use/land-cover
Household-Level • *Ethnographic Research:* Demographic and socio-economic conditions, land-use practices, and perceptions of vulnerability	B	• HH Survey data compiled and classified under the dimensions of vulnerability, viz. exposure, sensitivity and adaptive capacity • The political ecology analysis of the drivers of MLVI
Local/Community-Level • *Ethnographic Research:* *a)* Plantation and smallholder land management *b)* Disaster management policies of the Government	C	• Archival Research • Key-Informant Interviews • Community Meetings • Compilation and analysis of the qualitative data collected in field

A mix of quantitative and qualitative methods was used for data collection and analysis to answer and synthesize the broad research questions (Table 1.1). After a preliminary reconnaissance of the study area for two weeks in December 2015 and January 2016, this research was executed in three stages over a span of 36 months, including 4.5 months of fieldwork (July 2017 – January 2020). The methods involve a mix of quantitative and qualitative methods of field research as well as GIS and Remote Sensing methods conducted using the Oklahoma State University student license of ArcGIS software. The field methods include: geospatial data collection and remote sensing analyses, key-informant (K-I) interviews, archival research, community meetings, and household (HH) surveys. Five study sites in the broader study region were chosen to conduct fieldwork, i.e. community meetings and household surveys (Table 1.2). The study sites consist of three tea plantations and two smallholder regions with varying landslide histories. They were chosen to provide a comparison of the commonalities and differences in land management and accompanying vulnerability. Interviews, meetings and household surveys were approved by the Institutional Review Board (IRB) at Oklahoma State University, and ensured no personal harm to respondents who willingly participated in the research process.

Table 1.2. Basic Demographics of Study Sites in Kurseong

Study Sites	Agricultural Type and Primary Crops	Estimated Households (n = total surveyed)	Household Demographics	Landslide History
Makaibari	Tea plantation; Crops: corn, mustard greens, cauliflower, cabbage, other vegetables	307* (n=30)	All rural tea worker households. 58% of total population are plantation workers. 44.4% - SC & ST ethnicities *	Sporadic, mostly along constructed roads within plantation. Houses relocated but no recorded casualty. $^{\Delta}$
Tingling	Tea plantation; Crops: mustard greens	340* (n=30)	All rural tea worker households. 36.5% of total population are plantation workers. 13.4% SC & ST ethnicity. *	Recent landslide in 2015. At least 19 people killed, major loss of property $^{\Delta}$ (Giri, 2015)
Goomtee	Tea plantation; Crops: mustard greens, cauliflower, cabbage, other vegetables	250$^{\Delta}$ (n=25)	All rural tea worker households. ~300 permanent and temporary workers work in tea plantation. $^{\Delta}$ Ethnic division data not available	Major landslide events in 1993 and 1998. One plantation worker died. Several households displaced. $^{\Delta}$
Sittong	Subsistence/ Smallholding; Ag. produce: Orange, cinchona, ginger, cardamom, chillis, vegetables, broomgrass	605* (n=31)	24.4% of total population practices agriculture. 30.41% - SC & ST ethnicities. *	Current landslide recurring since 1982. 11 households displaced. Casualty (number not available).
Sirubari	Subsistence/Small holding. Ag. Produce: rice, spices, vegetables, mustard greens, broomgrass	99* (n=30)	54% of total population practices agriculture. 28.7% - SC & ST ethnicities. *	Current landslide since 2011. Landslides every year blocks roads and hinders transport to school, work and nearest town.

(Source: * Census Data 2011; $^{\Delta}$ Key-Informants)

Ethnicity: SC- Scheduled Caste, ST – Scheduled Tribe

6.1. Remote Sensing Analysis

RS analysis of satellite images spanning 4 decades (1988-2019) were executed to create land-use/land-cover maps of the study-area for each decade. Ultimately, in the final stage of research, change detection of broad land-use/land-covers, and an overlay analysis of landslide distribution in each land-use/land-cover for each decade were conducted to answer the first two questions (a and b) of Q. A. Landsat 5 images of 1988, and Landsat 8 OLT/TIRS data of 1999, 2009, and 2019 were obtained from the US Geological Survey (USGS) and used for land-use/land-cover classification. The starting year for satellite image acquisition is selected for 1988 because maps with a 30-meter spatial resolution were unavailable before that date. Images between December and March were chosen as these months have the least cloud cover.

The RS analysis involved supervised land-use/land-cover classification of each satellite image using the Maximum Likelihood Classification in ArcGIS 10.6.1 – 10.8 software. The Red and NIR bands were used for classification as they reflect vegetation best (Jensen 2006). For the supervised classification training samples were identified and created for each class (depending on the area covered by each class). The training samples were taken in abundance spread throughout the study area where each LULC was available. It was observed that a minimun of 70 samples were created for the smallest LULC area, and around 300 samples were created for the largest LULC area. Finally, the training samples in a single class was merged together to create 6 broad classes of land cover. After the generation of supervised classified images of the study area, kappa coefficients of accuracy assessments were conducted. Then the maps were vectorized to calculate the areas under land-use/land-cover classes. Finally, four study areas out of the five studied, were clipped and the land cover changes were analyzed combining the data from landslide overlay maps created separately.

The 5 study sites (Table 1.2) were also used for ground truth verification of land-use/land-cover (LULC) using a GPS and a DJI drone with special permission from the State Government to use them in a border region of India (with Nepal). The sites were traversed along roads to verify major LULC. LULC waypoints (e.g., settlement, deforested slopes) were collected, and images were taken to later compare with the classified images. Landslide waypoints were taken on 6 landslide areas visited and helped prepare landslide distribution maps (Q. A a) b)).

6.2. Archival Research

Research of literature that documents historical origins of the colonial legacy in Darjeeling were conducted in the form of archival research. The district gazetteer of India, Darjeeling by M.S.S. O Malley (1999 [1907]), is the most comprehensive documentation of the colonial rule and expansion in Darjeeling, and was reviewed to understand the colonial establishment of tea plantations, labor immigration, and transformation of the land in the Darjeeling hills. Research on transformation of the frontier land of Darjeeling, erasure of indigenous history and its subsequent commodification was extensively analyzed by Rune Bennike (2017), and was reviewed as archival research (in chapter 4). Other literature used for the archival research include literature on tea plantations, colonial infrastructure and peasant survival by authors Vimal Khawas, Jayeeta Sharma, and Sarah Besky. The historical review of literature was necessary to understand the present-day land management system and governance that is largely based on the colonial plantation legacies. It partly answers Q. C. a).

6.3. Key-Informant (K-I) Interviews

30 key-informant interviews were conducted with plantation managers/owners, smallholders, and government and local administrators spanning the entire subdivision of Kurseong. At least two K-Is were selected from each of the five study areas, but the rest were chosen from a) tea plantations in both Mirik and Kurseong municipalities having varied histories of landslide recovery and stabilities; b) government officials (from West Bengal Government and the Gorkha Territorial Administration); c) local teachers; d) erstwhile panchayat heads and e) people involved with tourism business to get a general idea of the region as a whole. Themes on land management and land-use, livelihood dynamics, and administrative policies concerning environmental protection, were chosen to form a semi-structured questionnaire based on the expertise of the K-Is.

Purposive and snowball (respondent-driven) sampling were used to select K-Is where a few experts were chosen initially. The participants then referred to other potential interviewees who have expertise in their respective fields (Longhurst 2012). To ensure maximum coverage of the geographical area, K-Is were chosen from different locations as well as sectors of work, with the help of local connections with people, developed during fieldwork. To ensure minimum bias in choosing K-Is, a maximum of one reference were taken from one interviewee. The interviews were based on themes related to: i) land-use trajectories within tea plantations, ii) infrastructure of rural and semi-urban areas, iii) disaster management policies, and iv) vulnerability to disasters.

Semi-structured questionnaires were prepared (Cope 2012) to obtain information and informed perceptions on one of the aforementioned themes. The interviews took 60-90 minutes to complete. Data collected from K-I interviews were transcribed in digital format and then coded using grounded coding techniques (Strauss and Corbin 1994, Charmaz and Thornberg 2020) to generate variables that impact land-use, livelihoods, and land-management policies and actions during a disaster event (Q. B). Several K-Is also helped select the 5 study sites for community meetings and household surveys: three areas that are perceived to be vulnerable to landslides and two that are perceived to be relatively stable areas.

6.4. Community Meetings

After selecting the 5 study areas, community meetings with local residents and land-managers were conducted to introduce the research topic to each of the five communities and to help with the recruitment of possible HHs for surveys. Additionally, the community meetings were used as a focus group in each community. An open-ended discussion with local managers and HH members were conducted regarding the environmental vulnerabilities, infrastructure, land use, and other social issues the communities face in their every-day life. This helped answer Q. C.

6.5. Household Surveys

Based on the K-I interviews and Community Meetings, HH surveys were developed and pre-tested with local assistants. Households (n=146) were selected from 5 locations using stratified random sampling, i.e., 30-31 random HHs were selected from each of 4 study areas, and 25 households were surveyed in one study area. The choice of the locations was based on K-I information, but with the following criteria: 3 locations were chosen with a history of new or recurring landslides (91 sample HHs), and the remaining 2 locations were chosen with more resilient/stable histories (55 sample HHs). The area of each location was within 25 sq. kms (size of a moderate tea estate, or landslides with surrounding land-use buffers).

HH surveys consisted of structured, both closed and open-ended questions. The surveys took approximately 30 minutes to complete and involved both male and female heads of households. The questions covered: household size and structure; family income and sources of livelihoods; size of smallholdings, amenities; land-use; aids during disaster events; recovery period; and perceptions about landslide vulnerability. Data from HH surveys were transcribed digitally, and coded to obtain variables that impact local vulnerability to landslides (Gerlitz et al. 2017). Results were explained later through descriptive statistics, creation of MLVI tables by combining 150 variables into 24 indicators of vulnerability (Q.B.), and other tables that depict adaptations through land-use practices and their impacts on landslide vulnerability (Q. C).

6.6. Triangulation of Methods for Analysis and Synthesis

Data obtained from both Remote Sensing, and Ethnographic methods were triangulated to analyze the results and synthesize the findings. In chapter 2, LULCC maps and landslide distribution maps were used to identify the land-use types that are particularly prone to landslide occurrences. The maps helped to draw an inference with regards to the human contributions to slope failures in a naturally landslide prone region (Q. A. a), b) and c)).

In chapter 3, data from household surveys were processed to obtain information on the multidimensional ways in which local land-users (plantation and smallholder farmers) are vulnerable. Key-informant interviews and community meeting information were used for a political ecology explanation of how such socio-ecologically vulnerable situations come to persist (answering Q. B. a), b)).

In chapter 4, land management at institutional and government levels were analyzed from key-informant interviews and community meetings. Archival research explored the origin of the establishment of the post-colonial management system. Finally, part of the household survey data was analyzed in the form of descriptive statistics, and synthesized to understand farmer adaptations and resilience in the face of a complex land management system (answering Q. C. a), b)).

7. Dissertation Structure

This dissertation follows the TAD structure established by the Department of Geography at Oklahoma State University. The next three chapters (chapters 2, 3, and 4) consist of independent articles addressing the three broad research questions. The concluding chapter synthesizes the findings, scopes and limitations of this study. In this section, I include the abstracts of the three articles along with the journal names for publication.

ARTICLE I

LAND-USE/LAND-COVER CHANGE AND IMPACTS ON LANDSLIDE VULNERABILITY IN KURSEONG

Target journal: Journal of Land Use Science

Samayita Bandyopadhyay, Dr. Jacqueline Vadjunec

Abstract: *This research uses the Land Systems Science (LSS) framework and mixed methods of research to understand the role of Land-Use and Land-Cover Changes (LULCC) as a driver of landslide disasters in Kurseong, a district subdivision of the Darjeeling Himalayas in eastern India. Supervised land-use/land-cover classification and digital change detection of land-use/land-cover were conducted using Landsat Images between the years 1988 and 2019. Land-use/land-cover areas, destroyed by landslides, were identified by preparing landslide distribution maps, and their overlay analysis with classified images of the respective years. Additionally, primary data were collected via in-site key-informant interviews and household surveys of local farmers. Remote Sensing results show deforested and settled areas consistently share the greatest percentage of landslide areas. On a regional level, forest covers increased and total areas of landslides in Kurseong have decreased. However, vulnerability to landslides enhanced in smaller pockets of heavily settled areas, and along rivers. The proximate drivers of farmer land-use include a diverse mix of both sustainable and unsustainable land-use practices. An inadequate infrastructure of farmer living conditions is an underlying driver of land-use decisions and a higher landslide vulnerability. This research validates the necessity of an integrated and transdisciplinary framework. Small scale implications are often invisible. Hence, to understand the nuanced implications of broad land system change on human societies collaboration between disciplines and scholars is an absolute necessity.*

Keywords: LSS; mixed methods; LULCC; proximate, underlying drivers; vulnerability

Article 2

THE POLITICAL ECOLOGY OF MULTIDIMENSIONAL DISASTER VULNERABILITY: A CASE STUDY IN KURSEONG, INDIA

Target Journal: International Journal for Disaster Risk Reduction (IJDRR)

Abstract: *This article assesses multiple dimensions of social vulnerability to natural disasters by integrating a vulnerability framework and a political ecology (PE) analytical framework. The study is based in a landslide-prone Himalayan Mountain region called Kurseong, in eastern India. First, this paper identifies the various indicators in which, a household becomes vulnerable to landslides, using the Multidimensional Livelihood Vulnerability Index Framework (MLVI). Then, a critical PE focus analyzes the processes that make households vulnerable, based on the identified indicators. Five field sites were selected in Kurseong, and 24 indicators of vulnerability were identified within households. The indicators were first categorized under various socio-economic components, which were further nested under the three dimensions of vulnerability, namely, exposure, sensitivity, and adaptive capacity. Primary data, obtained through household surveys, were used to identify the indicators, and calculate the degree of vulnerability within each of the five communities, using the MLVI framework. Results show the five field sites having varying intensities of vulnerability depending on land management for disaster recovery. However, commonly, in some aspects all field sites are vulnerable in terms of sensitivity and adaptive capacity. Through key-informant interviews, community meetings and field observations, the political process behind control and distribution of resources and amenities; as well as ecological constraints of accessing resources in a mountain environment were analyzed to be major factors behind vulnerability.*

Keywords: indicators, multidimensional livelihood vulnerability index, political ecology

Article 3

THE POLITICAL ECOLOGY OF ADAPTATION IN A HIMALAYAN PLANTATION LANDSCAPE – A CASE STUDY IN KURSEONG, INDIA

Target Journal: Geoforum

Samayita Bandyopadhyay, Dr. Jacqueline Vadjunec

Abstract: *This article explores farmer adaptations and vulnerabilities in a postcolonial plantation system in Kurseong, located in the Indian Himalayas. This study reviews the historical roots of plantation agricultural systems, and collects qualitative data on land management, vulnerabilities, livelihoods and adaptations of farmers in the study area. Using a decolonized political ecology approach, the study finds that the remnants of a colonial system of exploitation has translated within the existing plantation agriculture system, and profoundly in the society in the form of poor governance towards livelihood generation, infrastructural development, disaster management and political conflicts in the post-colonial period. The combined effect of such socio-ecological systems poses a "wicked problem" to local land users. Local adaptations to such problems are explored. Archival research on the colonial establishment of the plantation agricultural system in Kurseong, and information from key-informant interviews, community meetings and household surveys reveal that in spite of past colonial histories, local farmers adapt, and even build resilience, using rudimentary sustainable practices, such as vegetable farming and afforestation programs. The socio-ecological outcomes have resulted in the sustenance of households living below the poverty line, as well as an increase in forest cover. Maladaptations such as inabilities to relocate, burning or dumping non-degradable wastes, contribute to the prevailing vulnerabilities. Such land-use decisions are constrained by infrastructural obstacles such as lack of drainage, waste disposal, and water supply systems. Hence, together, the assemblage of adaptations is called "clumsy solutions".*

Keywords: postcolonial agroecosystems, political ecology, wicked problems, clumsy solutions

References:

Adger, W. N. 2006. Vulnerability. *Global environmental change*, 16(3): 268-281.

Adger, W. N., H. Eakin and A. Winkels 2009. Nested and teleconnected vulnerabilities to environmental change. *Frontiers in Ecology and the Environment*, 7(3): 150-157.

Ahlborg, H. and A. J. Nightingale 2018. Theorizing power in political ecology: the 'where' of power in resource governance projects. *Journal of Political Ecology*, *25*(1), 381-401.

Ajibade, I. and G. McBean 2014. Climate extremes and housing rights: A political ecology of impacts, early warning and adaptation constraints in Lagos slum communities. *Geoforum*, 55: 76-86.

Alcántara-Ayala, I. 2008. On the historical account of disastrous landslides in Mexico: the challenge of risk management and disaster prevention. *Advances in Geosciences*, 14(14): 159-164.

Alcántara-Ayala, I., K. Sassa, M. Mikoš, Q. Han, J.cRhyner, K. Takara, ... and S. Briceño, 2017. The 4th World Landslide Forum: landslide research and risk reduction for advancing the culture of living with natural hazards. *International Journal of Disaster Risk Science*, *8*(4), 498-502.

Arsenault, N., L. Hale, P. Khedkar and Y. Morimoto 2012. Integrated Water Management in Kurseong. *Energising Local Capacities*, 81.

Baker, J. C. 2014. Mobility, tropicality and landscape: the Darjeeling Himalayan Railway, 1881–1939. *Journal of Historical Geography*, *44*, 133-144.

Bandyopadhyay, S. 2016-18. Field Notes. Kurseong, West Bengal, India.

Bartels, L. E., A. Mayer and K. H. Erb 2017. Exploring potential socio-ecological impacts of changes to the Loliondo Gamed Controlled Area, Northern Tanzania: the case of the pastoral village Ololosokwan. *Journal of Land Use Science*, 12(1): 87-103.

Bassett, T. J. 1988. The Political Ecology Of Peasant-Herder Conflicts In The Northern Ivory Coast. *Annals Of The Association Of American Geographers*, 78(3): 453-472.

Bassett, T. J. and C. Fogelman 2013. Déjà Vu Or Something New? The Adaptation Concept In The Climate Change Literature. *Geoforum*, 48: 42-53.

Basu Roy, T., and S. Saha 2011. Article: Study on Landslide Incidents of Paglajhora and Adjacent Areas–An Overview; Kurseong Block, Darjeeling, India.

Basu, S. R. and S. K. De 2003. Causes and consequences of landslides in the Darjiling-Sikkim Himalayas, India. *Geographia Polonica*, 76(2): 37-52.

Benedikter, T. 2009. Gorkhaland: autonomy is no longer the issue. In, *Solving Ethnic Conflict through Self-Government*. EURAC 104.

Bennike, R. 2017. Frontier commodification: Governing land, labour and leisure in Darjeeling, India. *South Asia: Journal of South Asian Studies*, 40(2): 256-271.

Besky, S. 2008. Can a plantation be fair? Paradoxes and possibilities in fair trade Darjeeling tea certification. *Anthropology of Work Review*, 29(1): 1-9.

Besky, S. 2017. Fixity: On the inheritance and maintenance of tea plantation houses in Darjeeling, India. *American Ethnologist*, 44(4): 617-631.

Beymer-Farris, B. 2013. Producing biodiversity in Tanzania's Mangrove Forests? A combined political ecology and ecological resilience approach to "Sustainably utilized landscapes". In, *Land Change Science, Political Ecology, and Sustainability: Synergies and Divergences,* eds. C. Brannstrom and J. Vadjunec, 84-106. Routledge.

Bhattacharya, S. K. 2012. Zonation mapping techniques of the landslide hazard in Darjeeling Hills, West Bengal, India. *Geo-Analyst* 2(1): 12–17.

Birkenholtz, T. 2012. Network political ecology method and theory in climate change vulnerability and adaptation research. *Progress in Human Geography*, 36(3): 295-315.

Biswas, S. 2013. Urban Growth Centers In Darjeeling Hills Of West Bengal: A Geographical Analysis. *The Journal of Bengal Geographer,* 2(1): 30 – 48.

Biswas, S. S. and R. Pal 2016. Causes of landslides in Darjeeling Himalayas during June–July, 2015. *Journal of Geography and Natural Disasters*, 6(173): 2167-0587.

Blaikie, P. and H.C. Brookfield 1987. Defining and debating the problem. In, *Land Degradation and Society.* London: Methuen.

Boafo, J. and K. Lyons 2019. Expanding cashew nut exporting from Ghana's Breadbasket: A political ecology of changing land access and use, and impacts for local food systems. *The International Journal of Sociology of Agriculture and Food*, 25(2): 152-172.

Brannstrom, C. and J. M. Vadjunec 2013. Notes for avoiding a missed opportunity in Sustainability Science. In, *Land Change Science, Political Ecology, and Sustainability: Synergies and Divergences*, 1- 23. Routledge.

Broeckx, J., M. Maertens, M. Isabirye, M. Vanmaercke, B. Namazzi, J. Deckers,... and L. Vranken, 2019. Landslide susceptibility and mobilization rates in the Mount Elgon region, Uganda. *Landslides*, 16(3): 571-584.

Broeckx, J, M. Rossi, K Lijnen., B. Campforts, J, Poesen …, and M. Vanmaercke, 2020. Landslide mobilization rates: A global analysis and model. *Earth-Science Reviews*. 102972.

Brown, D. G., P. H. Verburg, R. G. Pontius and M. D. Lange 2013. Opportunities to improve impact, integration, and evaluation of land change models. *Current Opinion in Environmental Sustainability*, 5(5): 452-457.

Bryant, R. L. 1992. Political ecology: an emerging research agenda in Third-World studies. *Political geography*, 11(1): 12-36.

Bryant, R. L. and S. Bailey, 1997. *Third world political ecology*. Psychology Press.

Bryant, R. L. 1998. Power, Knowledge And Political Ecology In The Third World: A Review. *Progress In Physical Geography*, 22(1): 79-94.

Census of India, 2011. District Census Handbook – Darjeeling, Government of India.

Chan, N. W. 1998. Responding to landslide hazards in rapidly developing Malaysia: a case of economics versus environmental protection. *Disaster Prevention and Management*, 7(1): 14-27.

Charmaz, K. and R. Thornberg 2020. The pursuit of quality in grounded theory. *Qualitative Research in Psychology*, 1-23.

Chen, Z. and J. Wang 2010. Land use and land cover change detection using satellite remote sensing techniques in the mountainous Three Gorges Area, China. *International Journal of Remote Sensing*, 31(6): 1519-1542.

Claus, C. A., S. Osterhoudt, L. Baker, L. Cortesi, C. Hebdon and A. Zhang 2015. Disaster, degradation, dystopia. In, *The International Handbook of Political Ecology*. Edward Elgar Publishing.

Collins, T. W. 2008. The political ecology of hazard vulnerability: Marginalization, facilitation and the production of differential risk to urban wildfires in Arizona's White Mountains. *Journal of Political Ecology*, 15(1): 21-43.

Cope, M. 2012. Semi-structured interviews and focus groups. In, *Key methods in geography*, eds. N Clifford, S. French and G. Valentine, 445-459. Sage, London.

Crozier, M. J. and N. J. Preston 1999. Modelling changes in terrain resistance as a component of landform evolution in unstable hill country. In *Process modelling and landform evolution,* 267-284. Springer Berlin Heidelberg.

Cutter, S. L., B. J. Boruff and W. L. Shirley 2003. Social vulnerability to environmental hazards. *Social Science Quarterly*, 84(2): 242-261.

Cutter, S. L. and C. T. Emrich 2006. Moral hazard, social catastrophe: The changing face of vulnerability along the hurricane coasts. *The Annals of the American Academy of Political and Social Science*, 604(1): 102-112.

Cutter, S. L. 2016. The landscape of disaster resilience indicators in the USA. *Natural hazards*, 80(2): 741-758.

Das, N., S. Chatterjee and U. Roy 2011. An assessment of anthropogenic impact on natural landscape–The case of Kurseong Town, Darjeeling, West Bengal. *Indian Journal of Geography & Environment*, 12: 40-50.

Das, R. 2014. Impact of civilized intervention on the eco-fitness of Kurseong municipality, West Bengal, India. *International Journal of Advanced Research in Management and Social Sciences*, 3(9): 217-237.

de Loyola Hummell, B. M., S. L. Cutter and C. T. Emrich 2016. Social vulnerability to natural hazards in Brazil. *International Journal of Disaster Risk Science*, 7(2): 111-122.

Díaz, S. R., E. Cadena, S. Adame and N. Dávila 2020. Landslides in Mexico: their occurrence and social impact since 1935. *Landslides*, 17(2): 379-394.

Djenontin, I. N. S. and A. M. Meadow 2018. The art of co-production of knowledge in environmental sciences and management: lessons from international practice. *Environmental Management*, 61(6): 885-903.

Dong, J., G. Metternicht, P. Hostert, R. Fensholt and R. Roy Chowdhury 2019. Remote sensing and geospatial technologies in support of a normative land system science: Status and prospects. *Current Opinion in Environmental Sustainability*, 38: 44-52.

Duncan, J. S. 2002. Embodying colonialism? Domination and resistance in nineteenth-century Ceylonese coffee plantations. *Journal of Historical Geography*, 28(3): 317-338.

Dymond, J. R., A. G. Ausseil, J. D. Shepherd and L. Buettner 2006. Validation of a region-wide model of landslide susceptibility in the Manawatu–Wanganui region of New Zealand. *Geomorphology*, 74(1): 70-79.

Edwards, S., E. R. Anderson, A. B.Thomas, A. Markert, 2019. Assessing the Accuracy of Landslide Runout Simulations within Myanmar, Southeast Asia. *AGUFM*, *2019*, GC43K-1417.

Elias, K. A. 2018. *Value Creation: The Dynamic Position of Policy Change in the Global Tea Industry* (Master's Thesis, University of Oregon).

Ellis, E. C., J. O. Kaplan, D. Q. Fuller, S. Vavrus, K. K. Goldewijk and P. H. Verburg 2013. Used planet: A global history. *Proceedings of the National Academy of Sciences*, 110 (20): 7978-7985.

Escobar, A. 2006. Difference and conflict in the struggle over natural resources: a political ecology framework. *Development*, 49(3): 6-13.

Findell, K. L., A. Berg, P. Gentine, J. P. Krasting, B. R. Lintner, S. Malyshev ... and E. Shevliakova 2017. The impact of anthropogenic land use and land cover change on regional climate extremes. *Nature communications*, 8(1): 1-10.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, ... and P. K. Snyder 2005. Global consequences of land use. *science*, 309 (5734): 570-574.

Forsyth, T. 1996. Science, myth and knowledge: testing Himalayan environmental degradation in Thailand. *Geoforum*, 27(3): 375-392.

Friis, C., J. Ø. Nielsen, I. Otero, H. Haberl, J. Niewöhner and P. Hostert 2016. From teleconnection to telecoupling: taking stock of an emerging framework in land system science. *Journal of Land Use Science*, 11(2): 131-153.

Froude, M. J. and D. Petley, 2018. Global fatal landslide occurrence from 2004 to 2016. *Natural Hazards and Earth System Sciences*, 18: 2161-2181.

Fu, P. and Q. Weng 2016. A time series analysis of urbanization induced land use and land cover change and its impact on land surface temperature with Landsat imagery. *Remote Sensing of Environment*, 175: 205-214.

Gariano, S. L. and F. Guzzetti 2016. Landslides in a changing climate. *Earth-Science Reviews*, 162: 227-252.

Geist, H. and E. Lambin 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation. *BioScience*, 52(2): 143-150.

Gerlitz, J.Y., M. Macchi, N. Brooks, R. Pandey, S. Banerjee and S.K. Jha. 2017. The multidimensional livelihood vulnerability index–an instrument to measure livelihood vulnerability to change in the Hindu Kush Himalayas. *Climate and Development*, 9(2): 124-140.

Ghosh, S., C. J. van Westen, E. J. M. Carranza, V. G. Jetten, M. Cardinali, M. Rossi, and F. Guzzetti 2012a. Generating event-based landslide maps in a data-scarce Himalayan environment for estimating temporal and magnitude probabilities. *Engineering Geology*, 128: 49-62.

Ghosh, S., C. J. van Westen, E. J. M. Carranza and V. G. Jetten 2012b. Integrating spatial, temporal, and magnitude probabilities for medium-scale landslide risk analysis in Darjeeling Himalayas, India. *Landslides*, 9(3): 371-384.

Ghosh, S., T. B. Ghoshal, J. Mukherjee and S. Bhowmik. 2016. Landslide Compendium on Darjeeling-Sikkim Himalaya. Eds. Govt. of India: Kolkata.

Gill, D. A. 2007. Secondary trauma or secondary disaster? Insights from Hurricane Katrina. *Sociological Spectrum*, 27(6): 613-632.

Gill, D. A., L. A. Ritchie, J. S. Picou, J. Langhinrichsen-Rohling, M. A. Long and J. W. Shenesey 2014. The Exxon and BP oil spills: a comparison of psychosocial impacts. *Natural hazards*, 74(3): 1911-1932.

Giri, P. 2015, July 1. 'At least 30 killed, houses swept away in Darjeeling landslides.' *Hindustan Times: India News.* https://www.hindustantimes.com/india/at-least-30-killed-houses-swept-away-in-darjeeling-landslides/story-4vB1BUERJX3rZ2PJm6OXhP.html

Glade, T. 2003. Landslide occurrence as a response to land use change: a review of evidence from New Zealand. *Catena*, 51(3): 297-314.

GLP, 2005. ''Science Plan and Implementation Strategy,'' IGBP Report No. 53/IHDP Report No. 19.

Goldewijk, K. K., A. Beusen, G. Van Drecht and M. De Vos 2011. The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years. *Global Ecology and Biogeography*, 20(1): 73-86.

Gould, K. A., M. M. Garcia and J. A. Remes 2016. Beyond "natural-disasters-are-not-natural": the work of state and nature after the 2010 earthquake in Chile. *Journal of Political Ecology*, 23(1): 93-114.

Grove, J. M., R. R. Chowdhury and D. Childers. 2015. Co-design, co-production, and dissemination of social-ecological knowledge to promote sustainability and resilience: Urban experiences from the US. *Global Land Project News. 11 (April): 6-11.*

Guthman, J. 1997. Representing Crisis: The Theory of Himalayan Environmental Degradation and the Project of Development in Post-Rana Nepal. *Development and Change*, 28(1): 45-69.

Haberl, H., K. H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, ... and M. Fischer-Kowalski 2007. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. *Proceedings of the National Academy of Sciences*, 104(31): 12942-12947.

Harrison, E. and C. Chiroro 2017. Differentiated legitimacy, differentiated resilience: beyond the natural in 'natural disasters.' *The Journal of Peasant Studies*, 44(5): 1022-1042.

Hassan, Z., R. Shabbir, S. S. Ahmad, A. H. Malik, N. Aziz, A. Butt and S. Erum 2016. Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *Springer Plus*, 5(1): 812.

Hartmann, T. 2012. Wicked problems and clumsy solutions: Planning as expectation management. *Planning Theory*, 11(3): 242-256.

Houghton, R. A. and A. A. Nassikas 2017. Global and regional fluxes of carbon from land use and land cover change 1850–2015. *Global Biogeochemical Cycles*, 31(3): 456-472.

Huber, A. 2019. Hydropower in the Himalayan hazardscape: Strategic ignorance and the production of unequal risk. *Water*, 11(3): 414.

Immerzeel, W. W., L. P. Van Beek, and M. F. Bierkens 2010. Climate change will affect the Asian water towers. *Science,* 328(5984): 1382-1385.

Ives, J. D. and B. Messerli 1989. *The Himalayan Dilemma: Reconciling Development and Conservation*. Routledge: NY.

Jackson, S. and A. Sleigh 2000. Resettlement for China's Three Gorges Dam: socio-economic impact and institutional tensions. *Communist and Post-Communist Studies*, 33(2): 223-241.

Jacobs, L., O. Dewitte, J. Poesen, J. Maes, K. Mertens, J. Sekajugo and M. Kervyn 2017. Landslide characteristics and spatial distribution in the Rwenzori Mountains, Uganda. *Journal of African Earth Sciences*, 134: 917-930.

Jana, A. K. 2012. Backwardness and Political Articulation of Backwardness in the North Bengal Region of West Bengal. In, *Rethinking State Politics in India: Regions Within Regions*, ed. A Kumar, 153-196. Routledge: India.

Jensen, J. R. 2006. *Remote Sensing of the Environment: An Earth Resource Perspective*. Prentice Hall.

Jha, S. 2010. The struggle for democratizing forests: the forest rights movement in North Bengal, India. *Social Movement Studies,* 9(4): 469-474.

Jodha, N. S. 2005. Adaptation strategies against growing environmental and social vulnerabilities in mountain areas. *Himalayan Journal of Sciences*, 3(5): 33 – 42.

Kates, R. W., W. C. Clark, R. Corell, J. M. Hall, C. C. Jaeger, I. Lowe, J. J. McCarthy, H. J. Schellenhuber, B. Bolin, N. M. Dickson, S. Faucheaux, G. C. Gallopin, A. Grubler, B. Huntley, J. Jager, N. S. Jodha, R. E. Kasperson, A. Mabongunje, P. Matson, H. Mooney, B. Moore III, T. O'Riordan and U. Svedin 2001. Sustainability science. *Science*, 292: 641-642.

Keys, E. and W. J. McConnell (2005). Global change and the intensification of agriculture in the tropics. *Global environmental change*, *15*(4), 320-337.

Khawas, V. 2005. Status of tea garden labourers in eastern Himalaya: a case of Darjeeling tea industry. *Socio-Economic Conditions of Resident Tea Garden Labourers in Darjeeling Hills-A Pilot Study*.

Khawas, V. 2009. Environmental Challenges and Human Security in the Himalaya. *Environmental Concerns and Sustainable Development: some perspectives from India*, 1-36.

Kirschbaum, D., T. Stanley and S. Yatheendradas 2016. Modeling landslide susceptibility over large regions with fuzzy overlay. Landslides, 13(3): 485-496.

Kleemann, J., G. Baysal, H. N. Bulley and C. Fürst 2017. Assessing driving forces of land use and land cover change by a mixed-method approach in north-eastern Ghana, West Africa. *Journal of Environmental Management*, 196: 411-442.

Knapen, A., M. G. Kitutu, J. Poesen, W. Breugelmans, J. Deckers and A. Muwanga 2006. Landslides in a densely populated county at the footslopes of Mount Elgon (Uganda): characteristics and causal factors. *Geomorphology*, 73(1): 149-165.

Krausmann, F., K. H. Erb, S. Gingrich, H. Haberl, A. Bondeau, V. Gaube, ... and T. D. Searchinger 2013. Global human appropriation of net primary production doubled in the 20th century. *Proceedings of the national academy of sciences*, 110(25): 10324-10329.

Krylov, A., M. K. Steininger, M. C. Hansen, P. V. Potapov, S. V. Stehman, A. Gost, ... and E. A. Ellis 2019. Contrasting tree-cover loss and subsequent land cover in two neotropical forest regions: sample-based assessment of the Mexican Yucatán and Argentine Chaco. *Journal of Land Use Science*, *13*(6), 549-564.

Kuemmerle, T., K. Erb, P. Meyfroidt, D. Müller, P. H. Verburg, S. Estel ... and C. Levers 2013. Challenges and opportunities in mapping land use intensity globally. *Current opinion in environmental sustainability*, 5(5): 484-493.

Lambin, E. F., B. L. Turner, H. J. Geist, S. B. Agbola, A. Angelsen, J. W. Bruce, ... and P. George 2001. The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change*, 11(4): 261-269.

Lambin, E. F. and H. Geist 2006. Land-Use and Land-Cover Change: Local Processes and Global Impacts. *Global Change-The IGBP Series.*

Lambin, E. F. and P. Meyfroidt 2011. Global Land Use Change, Economic Globalization, And The Looming Land Scarcity. *Proceedings of the National Academy of Sciences*, 108(9): 3465-3472.

Lanckriet, S., B. Derudder, J. Naudts, H. Bauer, J. Deckers, M. Haile and J. Nyssen 2015. A Political Ecology Perspective Of Land Degradation In The North Ethiopian Highlands. *Land Degradation & Development*, 26(5): 521-530.

Le Billon, P. 2015. Environmental Conflict. In, *The Routledge Handbook Of Political Ecology*. (Eds.) Perreault, T., Bridge, G., and McCarthy, J. Routledge.

Lepcha, 2015. Changing Patterns of Population Density And Spatial Distribution In Kurseong Municipality: An Empirical Study. *International Journal of Informative & Futuristic Research,* 2(12): 2347-1697.

Li X., G. Chen, X. Liu, X. Liang, S. Wang, Y. Chen, ... and X. Xu 2017. A new global land-use and land-cover change product at a 1-km resolution for 2010 to 2100 based on human–

environment interactions. *Annals of the American Association of Geographers*, 107(5): 1040-1059.

Lim, C. L., G. W. Prescott, J. D. T. De Alban, A. D. Ziegler and E. L. Webb. 2017. Untangling the proximate causes and underlying drivers of deforestation and forest degradation in Myanmar. *Conservation Biology*, 31(6): 1362-1372.

Longhurst, R. 2012. Semi-structured interviews and focus groups. In, *Key methods in geography*, eds. N Clifford, S. French and G. Valentine, 103-115. Sage, London.

Loftus, A. 2019 [2017]. Political ecology I: Where is political ecology? *Progress in Human Geography*, 43(1): 172-182.

Machado, M. R. 2018. What's going on with land-use in Cuba?: Disparate data sets and the Cuban agricultural transition. *Journal of Land Use Science*, 13(4): 439-446.

Malley, L. O. (1999) [1907]. *Bengal district gazetteer: Darjeeling*. Concept Publishing Company.

Massey, C., D. Townsend, E. Rathje, K. E. Allstadt, B. Lukovic, Y. Kaneko,... and N. Horspool, 2018. Landslides Triggered by the 14 November 2016 Mw 7.8 Kaikōura Earthquake, New Zealand Landslides Triggered by the 14 November 2016 Mw 7.8 Kaikōura Earthquake, New Zealand. *Bulletin of the Seismological Society of America*, *108*(3B), 1630-1648.

Mayers, J. 2001. Economic reform and the urban/rural divide: Political realignment in West Bengal 1977–2000. *South Asia: Journal of South Asian Studies*, 24(1): 17-42.

Messerli, P., A. Heinimann, M. Giger, T. Breu and O. Schönweger 2013. From 'land grabbing' to sustainable investments in land: potential contributions by land change science. *Current Opinion in Environmental Sustainability*, 5(5): 528-534.

Meyfroidt, P., E. F. Lambin, K. H. Erb and T. W. Hertel 2013. Globalization Of Land Use: Distant Drivers Of Land Change And Geographic Displacement Of Land Use. *Current Opinion in Environmental Sustainability*, 5(5): 438-444.

Meyfroidt, P., R. Roy Chowdhury, A. de Bremond, E. C. Ellis, K. H. Erb, T. Filatova, ... and C. A. Kull. 2018. Middle-range theories of land system change. *Global Environmental Change*, 53: 52-67.

Millette, T. L., A. R. Tuladhar, R. E. Kasperson and B. L. Turner 1995. The use and limits of remote sensing for analyzing environmental and social change in the Himalayan Middle Mountains of Nepal. *Global Environmental Change*, 5(4): 367-380.

Miral, M. S., K. Kumar and R. K. Dumka 2003. Traditional Construction Practices in the Seismically Active Areas of Uttaranchal. *ENVIS Bulletin: Himalayan Ecology*, 11(1): 35-37.

Müller, D., T. Kuemmerle, M. Rusu and P. Griffiths 2009. Lost in transition: determinants of post-socialist cropland abandonment in Romania. *Journal of Land Use Science*, 4(1-2): 109-129.

Mundia, C. N. and M. Aniya 2006. Dynamics of landuse/cover changes and degradation of Nairobi City, Kenya. *Land Degradation & Development,* 17(1): 149-165.

Mwaniki, M. W., D. N. Kuria, M. K. Boitt and T. G. Ngigi 2017. Image enhancements of Landsat 8 (OLI) and SAR data for preliminary landslide identification and mapping applied to the central region of Kenya. *Geomorphology*, 282: 162-175.

Nathan, F. 2008. Risk perception, risk management and vulnerability to landslides in the hill slopes in the city of La Paz, Bolivia: A Preliminary Statement. *Disasters*, 32(3): 337-357.

Netting, R.M. 1986. Cultural Ecology. Long Grove: Waveland Press.

Nyberg, G., S. M. Mureithi, D. N. Muricho and M. Ostwald 2019. Enclosures as a land management tool for food security in African drylands. *Journal of Land Use Science*, 14(1): 110-121.

O'Keefe, P., K. Westgate and B. Wisner 1976. Taking the naturalness out of natural disasters. *Nature*, 260: 566-567.

Pal, R., S. S. Biswas, B. Mondal and M. K. Pramanik 2016. Landslides and floods in the Tista Basin (Darjeeling and Jalpaiguri Districts): Historical evidence, causes and consequences. *J. Ind. Geophys. Union*, *20*(2), 66-72.

Palit, S. 2008. Policy Issues of Land-Use and Land-Tenure Systems and Natural Resource Management in the Proposed Conservation Corridors in Darjeeling. *Biodiversity Conservation in the Kangchenjunga Landscape*, 143.

Pánek, T., O. Korup, J. Lenart, J. Hradecký and M. Břežný 2018. Giant landslides in the foreland of the Patagonian Ice Sheet. *Quaternary Science Reviews*, *194*, 39-54.

Pant, B. R. 2003. Degrading environment and growing population of the Indian Himalaya. *Envis Bull Himal Ecol Dev*, 11(1), 23-34.

Pelling, M. and K. Dill 2006. 'Natural' disasters as catalysts of political action. *Media Development*, 53(4): 7.

Petley, D. 2012. Global patterns of loss of life from landslides. *Geology*, 40(10): 927-930.

Prestele, R., P. Alexander, M. D. Rounsevell, A. Arneth, K. Calvin, J. Doelman... and P. Havlik 2016. Hotspots of uncertainty in land-use and land-cover change projections: a global-scale model comparison. *Global change biology*, 22(12): 3967-3983.

Reenberg, A. 2009. Land system science: handling complex series of natural and socio-economic issues. *Journal of Land Use Science*, 4(1-2): 1-4.

Rittel, H. W. and M. M. Webber 1973. Dilemmas in a general theory of planning. *Policy sciences*, 4(2): 155-169.

Robbins, P. 2012. *Political ecology: A critical introduction*. John Wiley & Sons.

Rosser, B., S. Dellow, S. Haubrock and P. Glassey 2017. New Zealand's national landslide database. *Landslides*, 14(6): 1949-1959.

Rounsevell, M. D., B. Pedroli, K. H. Erb, M. Gramberger, A. G. Busck, H. Haberl, ... and S. Lotze-Campen H. 2012. Challenges for land system science. *Land use policy*, 29(4): 899-910.

Roy, 2010. *A Cultural Politics of Mobilities and Post-Colonial Heritage: A Critical Analysis of the Darjeeling Himalayan Railway (DHR)* (Doctoral dissertation, University of Sunderland).

Rueda, X., M. A. Velez, L. Moros and L. Rodriguez 2019. Beyond proximate and distal causes of land-use change: linking Individual motivations to deforestation in rural contexts. *Ecology and Society*, 24(1): 4.

Rumbach, A. 2016. Disaster Governance in Small Urban Places: Issues, Trends, and Concerns. In, *Disaster Governance in Urbanising Asia* (p. 109-125). Springer Singapore.

Sarkar, S. and B. Reji 2019. A cup full of woes: wages & tea industry. *Indian Journal of Economics and Development*, 7(2).

Schindler, S. 2017. Towards a paradigm of Southern urbanism. *City*, 21(1): 47-64.

Schulz, K. A. 2017. Decolonizing political ecology: ontology, technology and 'critical' enchantment. *Journal of Political Ecology*. 24(1): 125-143.

Seto, K. C., A. Reenberg, C. G. Boone, M. Fragkias, D. Haase, T. Langanke, ... and D. Simon 2012. Urban land teleconnections and sustainability. *Proceedings of the National Academy of Sciences*, 109(20): 7687-7692.

Sharma, J. 2016. A Space That Has Been Laboured on: Mobile Lives and Transcultural Circulation around Darjeeling and the Eastern Himalayas. *The Journal of Transcultural Studies*, 7(1): 54-85.

Shrestha, U. B., S. Gautam, and K. S. Bawa, 2012. Widespread climate change in the Himalayas and associated changes in local ecosystems. *PloS one*, *7*(5).

Siewe, S., J. M. Vadjunec and B. Caniglia 2017. The politics of land use in the Korup National Park. *Land*, 6(1): 7.

Starkel, L. and S. Basu 2000. *Rains, landslides, and floods in the Darjeeling Himalaya.* Indian National Science Academy: New Delhi.

Starkel, L. 2010. Ambootia Landslide Valley—Evolution, Relaxation, and Prediction (Darjeeling Himalaya). *Landform Evolution in the mountain areas*, 113-133.

Strauss, A. and J. Corbin 1994. Grounded theory methodology. *Handbook of qualitative research*, 17(1): 273-285.

Tierney, K. 2012. A bridge to somewhere: William Freudenburg, environmental sociology, and disaster research. *Journal of Environmental Studies and Sciences*, 2(1): 58-68.

Tirkey, L. P., and P. Nepal 2012. Tea Plantations in the Darjeeling Hills Geo-Ecological Impact and Livelihood Implications. *Hydro Nepal: Journal of Water, Energy and Environment*, 10: 53-59.

Turner, B. L. II, WC Clark, RW Kates, JF Richards, JT Matthews, WB Meyer, eds. 1990. The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years.

Turner, B. L., W. B. Meyer and D. L. Skole 1994. Global land-use/land-cover change: towards an integrated study. *Ambio, Stockholm*, 23(1): 91-95.

Turner, B. L. and A. S. Ali 1996. Induced intensification: Agricultural change in Bangladesh with implications for Malthus and Boserup. *Proceedings of the National Academy of Sciences*, 93(25): 14984-14991.

Turner, B. L., R. E. Kasperson, P. A. Matson, J. J. McCarthy, R. W. Corell, L. Christensen, ... and C. Polsky 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the national academy of sciences*, 100(14): 8074-8079.

Turner, B. L., E. F. Lambin, and A. Reenberg 2007. The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences*, 104(52): 20666-20671.

Turner, II B. L. and P. Robbins 2008. Land-Change Science and Political Ecology: Similarities, Differences, and Implications for Sustainability Science. *Annual Review of Environmental Resource*. 33:295–316.

Turner, B. L. 2010. Vulnerability and resilience: coalescing or paralleling approaches for sustainability science? *Global Environmental Change*, 20(4): 570-576.

Turner, II B. L., K. J. Esler, P. Bridgewater, J. Tewksbury, N. Sitas, B. Abrahams, ... and P. Firth 2016. Socio-Environmental Systems (SES) Research: what have we learned and how can we use this information in future research programs. *Current opinion in environmental sustainability*, 19: 160-168.

Vadjunec, J. M., A. E. Frazier, P. Kedron, T. Fagin and Y. Zhao 2018. A land systems science framework for bridging land system architecture and landscape ecology: a case study from the Southern High Plains. *Land*, 7(1): 27.

van Westen, C. J., P. Jaiswal, S. Ghosh, T. R. Martha, and S. L. Kuriakose 2012. Landslide Inventory, Hazard and Risk Assessment in India. In, *Terrigenous Mass Movements*, 239-282. Springer: Berlin Heidelberg.

Veldkamp, A. 2009. Investigating land dynamics: future research perspectives. *Journal of Land Use Science*, 4(1-2): 5-14.

Verburg, P. H., K. H. Erb, O. Mertz and G. Espindola 2013. Land System Science: between global challenges and local realities.

Verburg, P. H., N. Crossman, E. C. Ellis, A. Heinimann, P. Hostert, O. Mertz, ... and L. Zhen 2015. Land system science and sustainable development of the earth system: A global land project perspective. *Anthropocene*, 12: 29-41.

Walker, B., C. S. Holling, S. R. Carpenter and A. Kinzig 2004. Resilience, adaptability and transformability in social--ecological systems. *Ecology and society*, 9(2): 5.

Walker, P. A. 2005. Political ecology: where is the ecology. *Progress in Human Geography*, 29(1): 73-82.

Watts, M. and R. Peet 2004. Liberating political ecology. *Liberation ecologies: Environment, development, social movements*, 2: 3-43.

Wenner, M. 2013. Challenging the state by reproducing its principles. The demand for "Gorkhaland" between regional autonomy and the national belonging. *Asian ethnology*, 72(2): 199-220.

Wenner, M. 2015. Legitimization through patronage? Strategies for political control beyond ethno-regional claims in Darjeeling, India. *Geoforum*, 66: 234-243.

White, G. F., R. W. Kates and I. Burton 2001. Knowing better and losing even more: the use of knowledge in hazards management. *Global Environmental Change Part B: Environmental Hazards*, 3(3): 81-92.

Wisner, B., P. Blaikie, T. Cannon, and I. Davis 2004. *At Risk: Natural Hazards, People's Vulnerability and Disasters.* London: Routledge.

Yeh, E. T., Y. Nyima, K. A. Hopping and J. A. Klein 2014. Tibetan Pastoralists' Vulnerability To Climate Change: A Political Ecology Analysis Of Snowstorm Coping Capacity. *Human Ecology*, 42(1): 61-74.

Zaehringer, J. G., A. Atumane, S. Berger and S. Eckert 2018. Large-scale agricultural investments trigger direct and indirect land use change: New evidence from the Nacala corridor, Mozambique. *Journal of land use science*, 13(3): 325-343.

Zhang, M. and M. J. McSaveney, 2018. Is air pollution causing landslides in China? *Earth and Planetary Science Letters*, *481*: 284-289.

Zscheischler, J., S. Rogga and M. Busse 2017. The adoption and implementation of transdisciplinary research in the field of land-use science—a comparative case study. *Sustainability*, 9(11): 1926.

CHAPTER II

LAND-USE/LAND-COVER CHANGE AND IMPACTS ON LANDSLIDE VULNERABILITY IN KURSEONG, INDIA

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Abstract: *This research uses the Land Systems Science (LSS) framework and mixed methods of research to understand the role of Land-Use and Land-Cover Changes (LULCC) as a driver of landslide disasters in Kurseong, a district subdivision of the Darjeeling Himalayas in eastern India. Supervised land-use/land-cover classification and digital change detection of land-use/land-cover were conducted using Landsat Images between the years 1988 and 2019. Land-use/land-cover areas, destroyed by landslides, were identified by preparing landslide distribution maps, and their overlay analysis with classified images of the respective years. Additionally, primary data were collected via in-site key-informant interviews and household surveys of local farmers. Remote Sensing results show deforested and settled areas consistently share the greatest percentage of landslide areas. On a regional level, forest covers increased and total areas of landslides in Kurseong have decreased. However, vulnerability to landslides enhanced in smaller pockets of heavily settled areas, and along rivers. The proximate drivers of farmer land-use include a diverse mix of both sustainable and unsustainable land-use practices. An inadequate infrastructure of farmer living conditions is an underlying driver of land-use decisions and a higher landslide vulnerability. This research validates the necessity of an integrated and transdisciplinary framework. Small scale implications are often invisible. Hence, to understand the nuanced implications of broad land system change on human societies collaboration between disciplines and scholars is an absolute necessity.*

Keywords: LSS; mixed methods; LULCC; proximate, underlying drivers; vulnerability

1. Introduction

Human processes of land-use/land-cover changes (LULCC)s, e.g., conversion of forests for agricultural, industrial and urban expansions contribute greatly in altering the environment globally (Lambin, & Geist, 2006; Lambin, & Meyfroidt, 2011, Verburg et al., 2013; Ellis et al., 2013; Turner et al., 1990; Vadjunec et al.; 2018). Human-induced LULCC is a significant process of environmental modification to facilitate human habitation and adaptation. Even harsh, less habitable environments, e.g., mountains, have seen significant transformations of their pristine environment into modern human habitation. However, often such ecosystems have a smaller threshold to withstand massive human-induced land changes, making the environment susceptible to extreme events, or disasters (Glade, 2003; Wisner et al., 2004; Nathan, 2008; Petley, 2012; Froude, & Petley, 2018). This study examines the role LULCC plays in exacerbating disasters in a landslide prone region in Kurseong, a subdivision of the Darjeeling district located in the Himalayan region of eastern India. It also explores the social drivers of land-use/land-cover change as it directly impacts local people's vulnerability to landslide disasters.

The factors driving LULCC involves options and choices of local land-users, as well as decisions of distant stakeholders who claim some control over the land and its resources (Geist, & Lambin, 2002; Ostwald et al., 2009; Lim et al., 2017). The structural and functional processes of LULCC are complex, and although some of their drivers can be readily identified, a large part of underlying drivers behind LULCC are not readily observable. This research explores LULCCs and the associated underlying drivers that have influenced local vulnerability to landslide disasters in Kurseong. This research uses the concepts of proximate and underlying drivers of land change, under the Land Systems Science (LSS) framework that encompass transdisciplinary ideas related to human alterations of the environment and their impact on the socio-ecological system.

Here, the LSS framework helps combine scientific Remote Sensing and GIS techniques to quantify LULCC and landslide histories, with primary data collected using ethnographic methods related to qualitative aspects of sociology and disaster research (e.g., decision making at multiple social levels). This integrated study is important to help address the gaps in decision-making regarding land-use and inform policies to better equip local population to foster resilience and ensure environmental sustainability. Additionally, the approach of this study ensures replicability to explore the drivers of human-induced environmental changes in other places around the world.

2. Theoretical Framework – Land Systems Science

Land systems science provides several heuristics "to study land system dynamics as a complex interaction between societal, natural and mixed processes at various spatial and temporal scales" (GLP, 2005; Reenberg, 2009, p. 1). The major focus of LSS is "monitoring and describing patterns of land cover change, explaining drivers of land-use change, and understanding the linkages between these two" (Meyfroidt et al., 2018). LULCC is the predominant focus of analysis in LSS research because land-use is seen to be critical in contributing to changing environmental conditions (Rounsevell et al., 2012; Verburg et al., 2013; Houghton, & Nassikas, 2017; Meyfroidt et al., 2013, 2018). Hence, the adoption of LSS framework in this research helps explore how LULCC correlate with disaster outcomes in Kurseong. LSS also helps address the human drivers behind land-use practices that increases the risk of landslides. The usefulness of this framework is in its embedded coupling of human and natural systems that helps understanding land system changes as inextricably linked with socio-ecological processes (Vadjunec et al. 2018, p. 7). The strength of this framework also lies in its transdisciplinary approach, i.e., incorporating expertise from disparate scientific fields with an aim of proposing sustainable solutions (Reenberg, 2009).

One of the more widely used models or theories within LSS research includes the consideration of proximate and underlying drivers of LULCC, theorized by Geist and Lambin (2002). Linking apparent or proximate causes of land-use change, for example, population growth, agricultural intensification, rangeland degradation, deforestation, among others to distal and underlying drivers such as market economies, changes in conservation or land-use policies, changes in land ownership/tenure, demand for new consumer goods elsewhere in the world became an important focus of LSS studies (Turner et al., 2007; Müller et al., 2009; Lim et al., 2017; Kleeman et al., 2017; Machado, 2018; Nyberg et al., 2019; Krylov, et al., 2019).

Müller et al. (2009) observed cropland abandonment in eastern Europe due to changes in market-oriented economies. They used Landsat images to map LULCC in Romania and found isolated patches of croplands were abandoned in post-socialist Romania. Lim and colleagues (2017) investigated the proximate causes and underlying drivers of deforestation and land degradation in Myanmar to find that often political and economic drivers inadvertently contribute to deforestation and destruction of biodiversity hotspots. Here, the proximate causes of agricultural intensification, timber extraction and infrastructural development were made possible through political concessions for economic reforms leading to changes in the local environment. Krylov and colleagues (2019) compared two regions of the neotropical biogeographic realm, viz. the Yucatán peninsula in Mexico, and Chaco region of Argentina to contrast the nature of forest cover loss. They used probability sampling and satellite image surveys to find that the character of forest loss is temporary in the primitive swidden agricultural region of Yucatán; but is extensive, permanent and equally distributed among crop and pastureland in the Argentine Chaco region that had started highly mechanized farming. Their work established a quantitative model and framework to characterize socio-economic drivers of land changes.

Expanding from the classification of causal factors into proximate and underlying drivers, in 2009, Veldkamp termed land as a multi-scape whose realities depend on how different stakeholders approach land. For example, land-use can be approached as geo-, bio-, econo-, mind-scapes according to the agenda of a stakeholder (Veldkamp, 2009; Reenberg, 2009). Hence, he urged researchers to be explicit about the end goal of a land-based phenomenon to understand the best way to approach the land change dynamics. Since land-use choices also depend on individual motivations, Rueda et al. (2019) developed the framework beyond proximate and underlying drivers of land change to encompass the psychological drivers of land-use. They drew upon empirical analyses of environmental psychology to understand the links between a land-user's motivations and environmental behavior to study drivers of deforestation. This research aims to use this heuristic to understand the underlying drivers of land-uses that are vulnerable to landslides.

LSS research uses cutting edge methods and techniques to observe, monitor and model historical, present and future LULCC respectively (see Haberl et al., 2007; Goldewijk et al., 2011; Ellis et al., 2013; Krausmann et al., 2013; Hassan, et al., 2016; Findell et al., 2017; Bartels et al., 2017; Krylov et al., 2019). Recent GIS and remote sensing techniques aimed at detecting LULCC include classification of land-use/land-cover from satellite images, and digital change detection (DCD) techniques to map and compute quantitatively such areal changes (Coppin et al.; 2004; Gomez et al., 2016). There are various methods in both land cover classification as well as digital land-cover change detection. Novel algorithms are used by researchers to improve efficiency and reduce errors in classification. Jin and colleagues (2017) used a comprehensive DCD technique to analyze land cover changes over Alaska by performing a knowledge-based integrated trajectory land cover labelling (SKILL) followed by a decision-tree land cover classification technique using multiple data sources. Harmosilla et al. (2015) adopt a pixel-based approach to create large image composites based on the best available pixels of several maps. The ultimate purpose is to perform land cover change detection with a higher accuracy. Fu and Weng (2016) used an algorithm called the continuous classification and change detection technique that first classifies landcover based on a time series model and detects inter-seasonal changes.

However, within the LSS framework, land system change modelling are often complemented by in-field qualitative methods to better understand the human-driven causal linkages of change and their present and future impacts on the social-ecological system.

2.1. Addressing Gaps in Socio-Ecological Disaster and Vulnerability Studies using LSS

Disasters extensively studied using the LSS framework largely involve slow human-induced impacts of environmental and climate change (Turner et al., 2007; Reenberg, 2009; Meyfroidt et al., 2018). However, sudden regional disasters in the form of landslides, earthquakes, forest fires, etc. are also intrinsic components of the earth system changes (Wisner et al., 2004). In this context, drawing from a disparate scientific field of landscape evolution, landslides have been seen as a common and effective erosional agent in landscapes with moderate and high slopes that aid in sediment transport, and stream flows among other landform processes (Campforts et al., 2020). Broeckx and colleagues (2020, p. 1) stressed that "landslides are a main driver of landscape evolution and a dominant sediment source of many regions worldwide".

In the related research field of hazards/risk and disaster, scholars have acknowledged the contribution of coupled social and ecological processes on disaster outcomes. However, as Tierney (2012) observed, a gap in multi-disciplinary expertise is still prevalent in the field of disaster studies. While mathematical modeling and prediction of land system changes and natural disasters have advanced independently (e.g., Li et al., 2017; Fu, & Weng, 2016; Alcántara-Ayala, 2017; Broeckx et al., 2020), social research on disaster and vulnerabilities have been published independently as well (e.g., Pelling, & Dill, 2006; Adger, 2006; Cutter, 2016; de Loyola Hummell, et al. 2016; Rumbach, 2016). The present study bridges the gap by investigating landslide disasters based on the idea that they are sudden and extreme manifestations of long-term and subtle systemic changes. The integrated framework of LSS helps understand the thresholds and feedbacks of

LULCC (Vadjunec et al., 2018) that alter the integrated social-ecological system to the brink of landslide disasters.

3. Study Area

3.1. Himalayan Degradation

The Himalayan mountains are an important ecosystem that provisions food and water resources to 20% of the world's population, or 1.4 billion people (Immerzeel et al., 2010, p. 1383; Shrestha et al., 2012). However, these mountain ranges lie along tectonically active subduction zones with ongoing processes of upliftment (Ghosh et al. 2012 a, b). Earthquakes, floods and landslides are common natural hazards owing to these biophysical conditions (Jodha, 2005). Even with such sensitive environmental condition the Himalayas have been experiencing a continuous influx of human population especially since the 1830s during the British colonial regime in India. Subsequently, large-scale LULCCs in the form of deforestation, urbanization, agricultural and pastureland degradation through industrialization, among others have been observed (Ives, & Messerli, 1989). These transformations have compounded landform and climate changes, e.g., through glacial retreats; changes in temperature and rainfall regimes; and increasing occurrence of disasters such as earthquakes, floods and landslides (Lemke et al., 2007; Immerzeel et al., 2010; Yao et al., 2012; Yeh et al., 2014; Gerlitz et al., 2017; Ishtiaque et al., 2017; Mishra, 2017; Huber, 2019).

Research related to disasters in the Himalayas largely document the apparent or proximate causes of human-induced environmental degradation culminating in landslide disasters. The most recognized human-induced trigger for disasters include population growth, infrastructural development beyond the carrying capacity, wastage of water resources, unplanned and unsustainable land-use planning, among others (Das, et al. 2011; Arsenault et al., 2012; Biswas, &

Pal, 2016; Pal et al., 2016). Although assertions regarding human responsibilities behind the Himalayan degradation depict part of the truth, in reality, much of the causal linkages driving LULCC still remains underexplored (Ives, & Messerli; 1989; Forsyth, 1996; Gerlitz et al., 2017). It is critical to add these complexities of human-driven changes in the equation in order to figure out a pathway to propose executable sustainable solutions and policies. For example, understanding the context in which individuals, communities and governments make land-use choices is important to find the gap in current sustainable development.

3.2. Kurseong

Kurseong is a subdivision of the Darjeeling district of West Bengal in eastern India (Fig. 2.1). Covering a total area of 501.9 square kilometers the region has a population of 140,721 (Census of India, 2011, p.30). The average elevation of Kurseong is 1482 m (4862 feet) above sea level and is interspersed by steep ridges and spurs (steepness up to 84° angle) (Ghosh et al., 2012a; Lepcha, 2015). Geologically, Kurseong falls under a tectonically active thrust-fold belt of the Himalayas (Ghosh et al., 2012a; Chawla et al., 2018). This geological disposition is coupled with local climate where heavy monsoon rains (500 cm) make the region susceptible to landslides (Basu, & De, 2003; Khawas, 2009; Chawla et al., 2018). However, monsoons also enhance biodiversity in the region, as is still evident in the existing forested areas.

Figure 2.1. Location of the Study Area

Kurseong underwent a massive transformation of the land during the British colonial regime in India. Much of the forested areas were converted to tea plantations (Das et al., 2011; Das, 2014).

Gradually a large number of Nepali immigrants joined the tea plantation labor force. This further changed the land-use into sprawling settlements, and other associated businesses to support the growing population (Baker, 2014; Basu Roy, & Saha, 2011; Roy, 2010). Previous research in Kurseong indicates that places vulnerable to landslides are mainly along tea plantations, rural areas, and roads (van Westen et al., 2012; Bhattacharya, 2012; also, Table 2.1)).

Table 2.1: Landslides and Impacts in Kurseong.

Years	Locations	Cause	Impacts
1899	In and around newly cut slopes	106.5 cms of monsoon rain	72 casualties, property loss along the 15 slide locations
1934	Darjeeling district	Bihar-Nepal earthquake	Property, agricultural damage (exact figures unavailable)
1950	Kurseong towns	83.41 cms of heavy rain	127 casualties, heavy damage to roads, railways, houses
1968	Ambootia Tea garden	112.14 cms rain between 3rd – 5th October	Hill-Cart Road, NH-31 washed away killing 677 people. Stabilized in 2009.
1980	Ambootia and Happy Valley tea gardens	30 cms of rain	215 casualties, 100 million rupees worth property loss
1991, 1993, 1998	Jungpana, Mahanadi catchment, Goomtee	Monsoon rains	26 reported casualties
2007, 2009, 2011, 2012, 2015	Tindharia, Gayabari, Dudhia, Tingling	Monsoon	Roads, buildings, plantations damaged, >30 killed in slums

Source: Basu & De 2003; Ghosh, & Ghoshal, 2016.

In this context, this research uses the concept of proximate and underlying drivers of land change (Geist, & Lambin, 2002, Lambin, & Geist, 2006) to understand the role of LULCC on landside vulnerability in Kurseong over a span of 4 decades. Specifically, this study answers the following questions:

A. What are the broad patterns of LULCC observed in Kurseong? What LULCCs are more prone to landslides in the study area?
B. What underlying factors drive local LULCC that are prone to landslides? How does the assemblage of these drivers impact local people's vulnerability to the disaster?

To derive answers to these questions, a mixed-methods approach and the concept of proximate and underlying drivers of land change is adopted under the Land Systems Science framework. The research aims to explore the causal linkages of land changes and their impacts.

4. Methodology

For the purpose of this research, the study area is classified according to the existing broad land-use/land-cover types by studying Landsat images of years 1988, 1999, 2009, and 2019. LULCC using digital change detection technique provided knowledge about changes within land-use/land-cover (LULC) over the period of study. Five study areas, or villages were chosen for detailed observation of LULCC and ethnographic data collection – two rural villages and three tea plantations. Landslide distribution maps of the same four years were created and overlaid on the classification maps of their respective years. This provided data on land-use and land-covers that are more vulnerable to landslides. Additionally, primary data were obtained through key-informant interviews, community meetings and household surveys, conducted in the five aforementioned study areas. Combining the varied types of data, the contribution of land-use/land-cover change on landslide vulnerability is inferred, and the drivers of LULCC are analyzed.

4.1. Remote Sensing

4.1.1. Land Use/ Land Cover Classification

In remote sensing, land cover classification extracts thematic, categorical information from (preferably) multispectral satellite image/s by statistically analyzing spectral data within images. Different statistical pattern recognition themes are used that automatically categorize all pixels in an image into land-cover classes or themes (Lillesand, & Kiefer, 2004). In this study, supervised classification of land-use/land-cover (LULC) using the Maximum Likelihood Classifier (MLC) is performed on Landsat images (30 m resolution) of the study area for each year of study (1988-2019). First, several training samples were created based on the proportion of each of the different land-covers present in the area. The training samples are chosen abundantly from all parts of the subdivision map based on the researcher's discretion. It was observed that around 70 samples were drawn for the smallest LULC and around 300 samples were drawn for the largest LULC present in the region. These representative training samples were used to compile a numerical "interpretation key" that described the spectral attributes of each features of interest. Each pixel in the dataset was then compared to each interpretation key and labeled with the category that is most similar (Lillesand, & Kiefer, 2004). In supervised classification techniques an increased contextual information increases the accuracy of classification (Franklin, & Wulder, 2002). To perform the supervised classification analysis, the first important steps include image acquisition and pre-processing.

i) Image Acquisition and Preprocessing of Reference Data

Landsat images were acquired from USGS for the study area of Kurseong (Path 139, Row 41) from Landsat 5 (TM) for 1988 and Landsat 8 (OLI/TIRS) for 1999, 2009, and 2019. These years were chosen roughly 10 years apart from the starting date where Landsat data were available. Incidentally, all years except 2019 were preceded by major landslide events, and thus these years contain information about post-disaster land cover. Landsat images were selected between the months of November and March due to minimal cloud cover. Cloud cover of all images was unidentifiable except in 2019 (cloud cover 0.07%). During this window, shadows in the images were not a problem. So, no atmospheric correction procedure was necessary.

Another reason to select this period is because in winter there are no harvests. Hence, the vegetation cover within these months remain homogenous within all years of study, an essential prerequisite for comparing LULCC spanning several years. GIS and remote sensing analyses were performed using the ArcGIS suite (versions 10.6.1. and 10.8.1). Image preprocessing involved assigning a projected coordinate system to the images to reduce distortion. The WGS84 Zone 45N under the World Projection System is the ideal projected coordinate system for the study area, hence the images were projected in the aforementioned projection. The Kurseong subdivision fit entirely within one Landsat scene. So, no mosaic was required to obtain a contiguous area for analysis.

Next, two paper topographic maps (1:50,000 scale) covering the subdivision of Kurseong were collected from the Geological Survey of India (Nos. 78 B/11 and 78 B/5). Maps were scanned to digital format and were saved as JPEG image files without any geographical reference or a coordinate system. The topographic maps contain detailed information on regional coordinates, boundaries, road networks, settlements, agricultural and forested areas, among other land-uses. So, they were used as one reference for land-cover classification, as well as for creating a boundary map of Kurseong. The topographic maps were pre-processed in the GIS environment by georeferencing the coordinates manually. Then the two maps were projected in the same coordinate system as the Landsat images. After pre-processing, the boundary of the study area was digitized using GIS tools to form a vector polygon layer. Using this polygon boundary over the satellite image for each year, the study area of Kurseong subdivision was extracted from the scene using the clip function under raster preprocessing tool within ArcGIS.

ii) Maximum Likelihood Classification

Maximum Likelihood Classification (MLC) uses variance and covariance matrices to determine the statistical probability of a pixel belonging to a particular class based on training data provided by the user (Srivastava et al., 2012). Supervised classification of the entire Kurseong subdivision was performed for each year (1988, 1999, 2009, 2019) within ArcGIS. To highlight vegetation cover (Coppin et al., 2004; Ganbold, & Chasia, 2017), images were visualized using the common near-infrared false color composite (e.g., RGB432 for Landsat 5 TM). Training samples were created for each class using the classification tool. The number of training samples for each class varied based on the proportion and contiguity of a specific land-use/land-cover type using standard protocols (Ma et al., 2017). For example, forests/tree cover is a homogenous class over Kurseong. It also covers roughly 50% of the study area. For this class, one training sample per 60 hectares were created, in other words, about 300 training samples were created for the entire map. LULC classes, such as water or sediment/debris comprise less than 5% of the study area and are available in narrow pixels, and spread out sporadically. For these classes, one training sample per 15 hectares were created, making about 70 samples for the entire area. While creating training samples, a more detailed base map (higher spatial resolution ranging between .46 m and 15 m) and the topographical maps were used for reference. Training polygons were drawn by selecting near-pure pixels to enhance separability of the eventual land-use/land-cover classes.

The training samples for each class gets stored within a training sample manager. Once all samples of a land cover class were created, they were merged under one class, and named according to the identified LULC, e.g., forest/tree cover. This process was repeated for each class, identified within an image. Six broad LULC classes were identified and categorized in all years of study. After the creation and categorization of all land-use and land-cover classes were completed, the training samples were saved as a shapefile for each image. The MLC method then required the creation of a signature file using the shapefile where the training samples can be edited. Using this signature file where all training samples are stored, the maximum likelihood classification tool is used to create a raster image of the subdivision according to the delineated land covers. Based on the training samples, the software uses the algorithm where each pixel is assigned a land cover class code closest to the pixel. After the initial LULC classifications, the classified images were re-classed with desired values for the classes and stored within a single geodatabase.

The classification was done based on the following contemplation. Any tree cover, belonging to agricultural, forest or settlement lands were delineated under class 1. All agricultural, plantation and shrublands that appeared lighter red than forests, or a brownish red during a post-harvest period were combined under class 2. So, this class also highlighted lighter forested areas that appeared to have the same reflectance as agricultural lands. Areas that were heavily deforested, such as in delineated forestlands, harvested agricultural lands, previous landslide areas that have stabilized and formed topsoil layers, as well as previous flood zones of rivers – all appeared brown in color. Training samples collected from brown pixels were combined under class 3. Land-use class 4 or built-up areas included all built-structures (e.g., settlements, roads, school and church buildings, parking areas) as well as building materials (often heaped along sites as well as along rivers). Class 5 consisted of water in rivers and lakes. These pixels medium to dark blue, and black colors as water absorbs sunlight. Lastly, class 6 consisted of barren rocky surfaces, debris and rocky sediments on the banks of rivers appearing gray in color. They typically had a shiny grey reflectance with a degree of similarity with built-up areas.

The following values were assigned for the different LULC classes consistent in each year:

Table 2.2. Land-Use/Land-Cover Classification Scheme

Class	Land-Use/ Land Cover	Class Identification Heuristics
1	Forest/Tree Cover	Homogenous deep red color, contiguous over most of the eastern part parts of Kurseong.
2	Agriculture/Shrubland	Light red, pink, and brownish pink patches where small density vegetation show lighter color. Tea bushes and shrubs have similar reflectance.
3	Deforested Area	Brown patches adjacent to agricultural land, deforested areas.
4	Human settlement/Built-up Area	Shiny, silver and gray color reflected because of asbestos or cement roofs of settlements. This class also contains construction materials, debris and cement retention walls.
5	Water	Dark blue or black color
6	Sediment/Debris	Dull gray to highly shiny materials especially along rivers. Barren surfaces exposed due to landslides. Often confused with class 4 if sediments are fine.
7	Cloud Cover	White spots. Rare. Only covers 0.07% of 2019 image of Kurseong, but no overlaps within the study areas.

iii) Accuracy Assessment

Following image classification, accuracy assessments (AA) of the classified images are a vital step to evaluate how close the image is classified in relation to the actual land cover of the study area (Rwanda, & Ndambuki, 2017; Ye et al., 2018). From AA, it is also possible to understand the degree of errors and where the errors are happening. There can be pixel-based or object-based assessments. A pixel-based AA is performed here by creating a confusion or error matrix using ArcGIS, Google Earth and Microsoft Excel software. First, random points were created on each classified image and compared their land cover from google earth images to identify similarities from the already classified images in the respective years. Next, the random points were converted to a KML file in ArcMap so that they can be added to a Google Earth Image. For each of the random points created, a land cover was identified from the Google Earth image. A limitation of this method is that the new land cover delineated from the Google Earth image also depends on the identification ability of the researcher. The land cover for each point was entered in the KML file table manually. This file with all land cover types recorded, were added back to ArcMap. The land cover values added to the random points were then extracted. Now, as this assessment is a pixel-based method, the random points were converted to pixels to align with the classification. After the random points were converted to pixels they were combined with the same pixels of the classification in an image. The combined image now had data from the previously classified image as well as the manual data on land cover identified from the google earth image. The attribute table were then exported to Microsoft Excel as a dBase file to calculate the confusion matrix.

In Excel, pixels for each land cover were added as a pivot table with the land cover classification values representing columns and the reference point values in the rows. From that table commission, omission, producer's accuracy and user's accuracy were calculated to find the overall accuracy and the Kappa coefficient (the measure of agreement between the classified image and the random pixels). The classified raster images have a minimum accuracy of 83%, which is extremely close to the average accuracy threshold of 85% for most research that conducted image analysis between 2003 – 2017 (Ye et al., 2018).

4.1.2. Digital Land Cover Change Detection

Change Detection (CD) is the "quantification of temporal phenomena from multi-date imagery that is most commonly acquired by multispectral satellite-based sensor" (Coppin et al., 2004: 1566). CD can be either a) bi-temporal or b) temporal trajectory analysis (Coppin et al., 2004). The bi-temporal change detection techniques are most abundant and involve two satellite images at a two-point timescale, to observe changes within the same area over consecutive periods of time. Temporal trajectory analysis involves multiple images obtained in a continuous timescale for monitoring processes and minute changes. In this study, a bi-temporal analysis is made, for example, changes in LULC for every decade is mapped and analyzed.

CD can be done in a per-pixel basis where two satellite images of the same area but of different times are analyzed. However, in this study a post-classification comparison was performed, because the classification process standardizes the images, thereby reducing the problem of radiometric calibration (Coppin et al., 2004). For example, the study area has a mountainous terrain. Slopes and ruggedness often change pixel values due to differential textures, and shadows. Further pre-processing is required to do a pixel-based CD. Post-Classification change detection have the advantage of reducing errors that can happen due to texture, shadows and slopes because it is only color differences that separate LULC. In this study, once the AA is completed, the area for each LULC class for the entire area of Kurseong was calculated using the 'Zonal Geometry as Table' tool. LULC areas table for each year of study was then exported in Microsoft Excel to compare how land covers have changed over the years.

LULCC In Five Study Areas Within the Kurseong Subdivision

To understand LULCC at a micro scale, four study areas were chosen throughout the Kurseong subdivision, where the researcher visited several times for fieldwork (Fig. 2.2.). Three tea plantations, namely Tingling, Makaibari and Goomtee, each having different degrees of past landslide experience, and one smallholder rural area, called Sittong in the northeastern part of Kurseong were chosen. The choice of these study areas developed from discussion with key-informants in the field. The purpose of choosing these communities were to compare and contrast land-use practices under separate plantation management systems as well as choices and constraints of rural smallholders with respect to impacts of landslides in the region (more of which will be discussed in the field methods section). These areas were clipped and the classification information were extracted in the form of separate classified images.

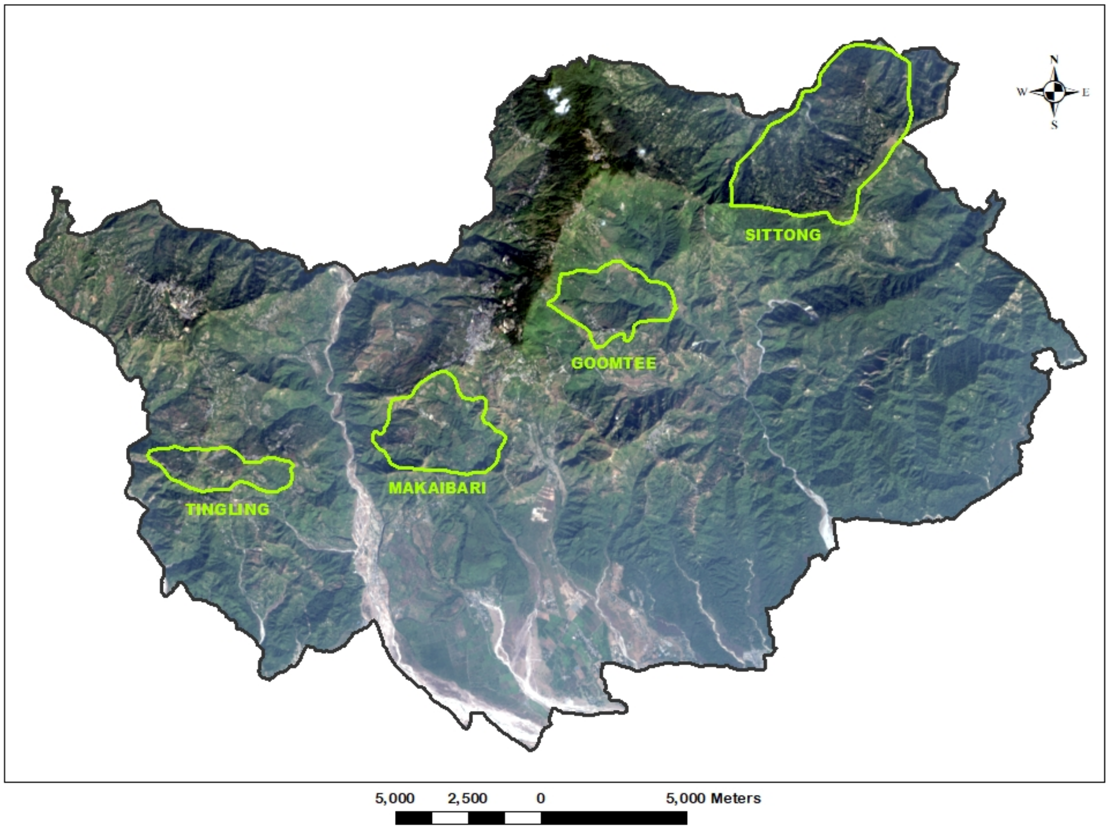

Figure: 2.2. Four Study Areas within Kurseong Subdivision

For each study area, the classified raster images were converted to vector shapefiles. This conversion transforms the pixels into polygons and the total area of each LULC class is calculated and automatically stored in the attribute table of the shapefile. Then, two LULC shapefiles belonging to consecutive decades were paired (e.g., 1988 – 99; 1999 – 2009; 2009 – 19) to detect changes using the Intersect function. After the change detection for each year was completed, the four study areas were extracted using the clip function. Once the study areas were extracted, LULCs were named corresponding to the unique 'GEO ID' field for each LULC ('GEO ID' represents the assigned classes of LULC during the classification process). Then adding another field, "AREA" was added to the attribute table and the area (in hectares) was calculated using the "Calculate Geometry" function. This gave areas for each polygon and LULC classes for the study area. Next, the attribute tables for each DCD map (total 12 maps – 4 study areas each for 3 years) were exported as dbase file in Excel. Pivot Tables with the starting year as row and the end year as column head were prepared. The total area for each LULC were summed together in each cell, as well as the changes from one land cover to another was recorded.

4.1.3. Landslide Distribution using GIS

In addition to the LULCC maps, visible landslides were digitized in a GIS environment from the Landsat images for each year of analysis. Landslide polygons were created within a feature class showing landslide distributions for each year of study. The digitization was performed using the same clipped Landsat images of Kurseong for all four years of study.

4.1.4. Overlay Analysis of Land-use/land-covers Destroyed by landslides

Overlay analysis was performed using landslide distribution maps and LULC maps. The same intersect function was used to measure the area of each land-use/land-cover that has been consumed by landslides for every year of study. After the overlay function, the summary statistics for each LULC under landslides were computed. The data was then converted to excel to create a chart showing the percentage of each LULC that were remained affected by landslide destruction in each respective year. The total area of landslides was also compared across years to see the expansion and shrinkage of landslide areas and their geographies related to the identified land-use/land-cover types.

4.2. Field Methods

To understand the human processes behind the observed LULCC, and individual land-use/land-cover susceptibility to landslides, key informant (K-I) interviews, community meetings (CM) and detailed household (HH) surveys were conducted in five selected areas, or "study areas". These study areas were chosen in a way that had varying degrees of landslide experiences. The areas were predominantly tea plantations and smallholder villages that make up a majority of land-use in Kurseong. The primary data were analyzed in conjunction with the remote sensing data. These methods generated data on land-use and livelihoods in these areas to identify land-use practices that are vulnerable to landslides. The methods are described below:

i) Key – Informant Interviews

30 key-informant (K-I) interviews were conducted with local land managers and administrators who have expertise about the local area. For example, plantation managers/owners, smallholders, and government and local administrators having knowledge on land management and land-use, livelihood dynamics, and administrative policies concerning environmental protection were interviewed. Purposive and snowball (respondent-driven) sampling methods were used to select K-Is where a few K-Is were chosen initially. The participants then referred to other potential interviewees who have expertise in their respective fields (Longhurst 2012). To ensure minimal bias a maximum one reference was obtained from each K-I. The interviews were based on themes related to: land-use trajectories within plantations and smallholder areas, infrastructure of rural and semi-urban areas, disaster management policies, and landslide vulnerability. Semi-structured questionnaires were prepared to obtain information and informed perceptions on each aforementioned theme. In this article, the relevant information from K-Is is explained as an

interpretive analysis on land management, and land-use practices that were perceived as unsustainable in a landslide-prone region.

ii) Community Meetings

Community meetings (CM) with local residents were conducted in the five study areas. For example, in smallholder regions, key-informants and their acquaintances were requested to gather local people. The participants of each CM acted as focus groups for their respective study area. In each community meeting, participants discussed their livelihoods, problems with or without the disaster, and about the help they get from the government during landslide events. Open-ended discussions with local managers and HH members were conducted regarding the environmental vulnerabilities, infrastructure, land use, and other social issues the communities face in their lives. The information from the community meetings were summarized, and discussed to identify the proximate and underlying drivers of observed LULCC and landslide patterns.

iii) Household Surveys

Household surveys (n=146), were conducted on the five study areas, with 30-31 HHs from each of 4 study areas, and 25 households in 1 study area. Households were chosen based on purposive and geographically stratified sampling. The choice of the locations was based on K-I information and with the following criteria: 3 locations were chosen with a history of new or recurring landslides (91 sample HHs), and the remaining 2 locations were chosen with more resilient/stable histories (55 sample HHs). The area of each location varied and depended on the size of tea plantations, and smallholder villages.

HH surveys consisted of structured, both closed and open-ended questions. The questions covered: household size and structure; family income and sources of livelihoods; size of smallholdings, amenities; land-use; aids during disaster events; recovery period; and perceptions about landslide vulnerability. Data from the HH surveys are used in this study to identify the land-use choices and the drivers behind it that have contributed to a higher percentage of landslide susceptibility.

4.3. Analysis and Synthesis

The Remote Sensing and the ethnographic methods together help identify regional and local level LULCC, LULC patterns that are more subjected to landslides, and the proximate and underlying drivers influencing local vulnerabilities to landslides in Kurseong. The remote sensing methods map changes in LULC and in landslide areas over the span of study. The ethnographic method analyzes the land-use decisions behind the observed mapping of LULCC in different ways. From key-informant interviews and community meetings, the common themes related to land-use practices, choices, past landslide management, among others are corroborated with household survey data, and are presented in the form of descriptive statistics. The immediate land-use practices are synthesized as apparent or proximate causes of LULCC, and the social drivers that influence land-use decisions but are not readily observable are the underlying drivers of LULCC.

5. Results

5.1. LULCC and Landslide Susceptibility in Kurseong

Results from land cover classification and CD reveals that contrary to the popular narrative of Himalayan deforestation and degradation, in the study area, there has been a continuous increase in forest cover over the four decades of study. Deforestation is more sporadic with spikes in a year especially after a landslide (e.g., 2009 and 1999). Table 2.3. and Figure 2.3 show the percentage distribution of land-use/ land-cover in the Kurseong subdivision of years 1988, 1999, 2009, and 2019.

Table 2.3: Land-Use/Land-Cover Percentage in Kurseong Between 1988 and 2019

Landcover	1988	1999	2009	2019
Forest/ Tree Cover	45.53	45.06	47.13	54.17
Agriculture/ Shrubland	35.83	31.81	27.93	30.72
Deforested Area	5.65	9.57	12.37	5.71
Built-up Area	10.45	10.38	7.44	6.69
Water	0.82	1.05	2.22	0.99
Sediment/Debris	1.72	2.13	2.91	1.66
Cloud Cover	0	0	0	0.07

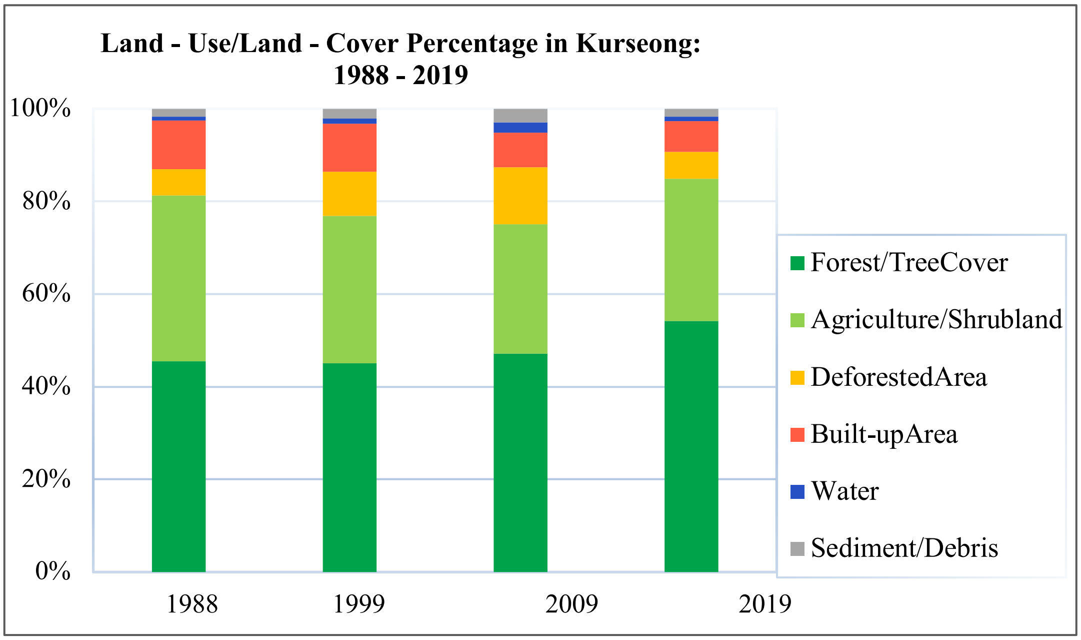

Fig 2.3. Land-use/land-cover Percentage in Kurseong Between 1988 and 2019

From 1988 through 2019, forest cover in Kurseong witnessed a general rise from 45.53 to 54 percent. Agricultural area fluctuated between 27 and 35% and depended largely on production of tea. 1998, 2007 and 2009 recorded landslides from heavy rainfall. Thus 1999 and 2009 data showed a higher deforested area. According to MLC, LULCC of built areas and materials declined from 1988 to 2019. A number of possible explanations can be made from this result. A) LULC classification errors are likely in hill-shade areas. More settlement density and shadows from settlements affect the reflectance value of the satellite images. An image having 30-meter spatial resolution failed to identify settlements in hill-shades. B) Built materials also consist of construction materials that often have similar reflectance of that of a settlement.

To explain LULC and LULCC results accurately, four study areas were extracted from the study area. The sites consisted of three tea plantations, namely Makaibari, Goomtee and Tingling, and a smallholder rural village called Sittong. These areas were studied in detail from ethnographic data collection. With a combination of all these data the LULC maps could be largely explained.

5.1.1. *LULCC in Makaibari Tea Plantation*

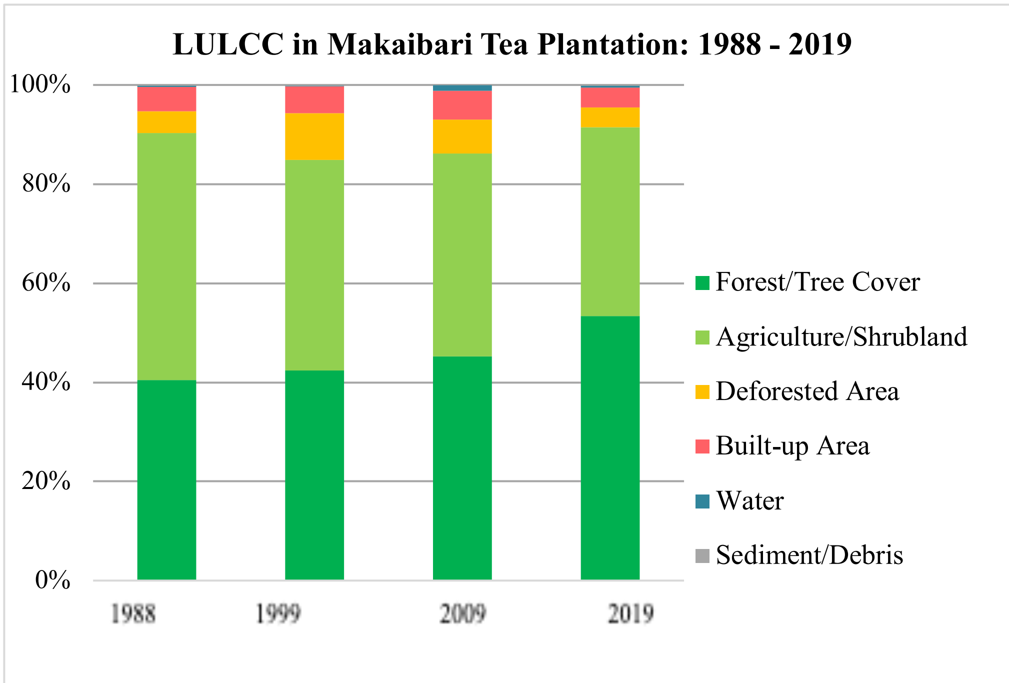

Fig 2.4a. Chart Showing LULC Percentage of Makaibari Tea Plantation: 1988, 1999, 2009, 2019

Figures 2.4a and b illustrate LULC and LULCC within the Makaibari tea plantation over the four years of study. Summarizing the metadata from these maps, out of 834.5 hectares (ha) in Makaibari, about 50% of land was under tea plantation and 40% under forest cover in 1988. About 5% area was labor lines or settlements of plantation workers. Agriculture reduced in area since 1988 to 2019, and in 1999 deforestation doubled (78 ha) from the previous decade. The maps also show debris along settlements and rivers. Since 2009, afforestation have stabilized the area, as minimal deforestation in 2019.

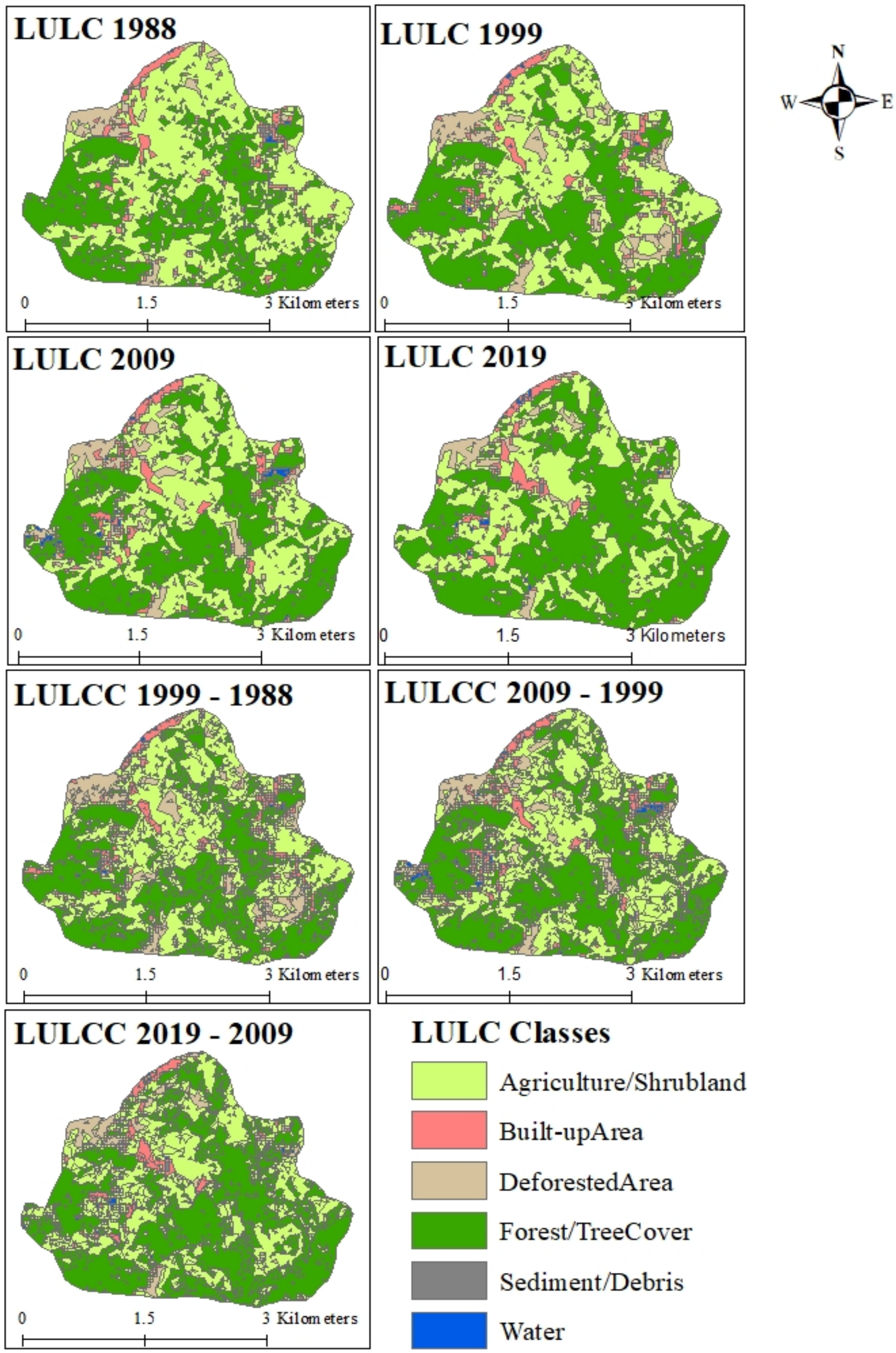

Fig 2.4b. LULC and LULCC Maps of Makaibari Tea Plantation: 1988, 1999, 2009, 2019

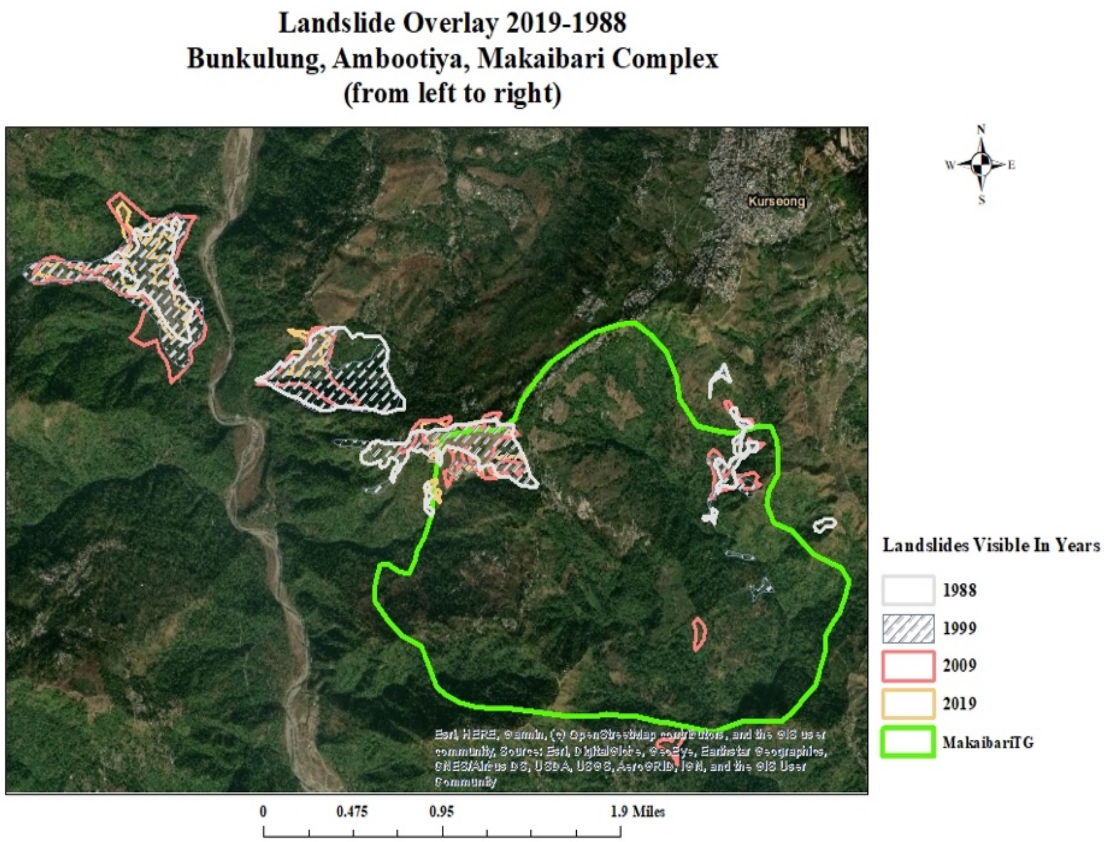

Fig.2.5. Landslide Distribution in Makaibari Tea Plantation: 1988, 1999, 2009, 2019

The distribution of landslides in the vicinity of Makaibari (Fig 2.5) includes the Bunkulung debris fan (located in a different spur), the Ambootia landslide and two landslides within the Makaibari plantation. The Ambootia landslide was the most infamous landslide that initiated in 1968 and stabilized in 2010 (Starkel 2010). All landslide areas in this region have reduced in size and shows signs of stability through vegetation covers.

5.1.2. LULCC in Goomtee Tea Plantation

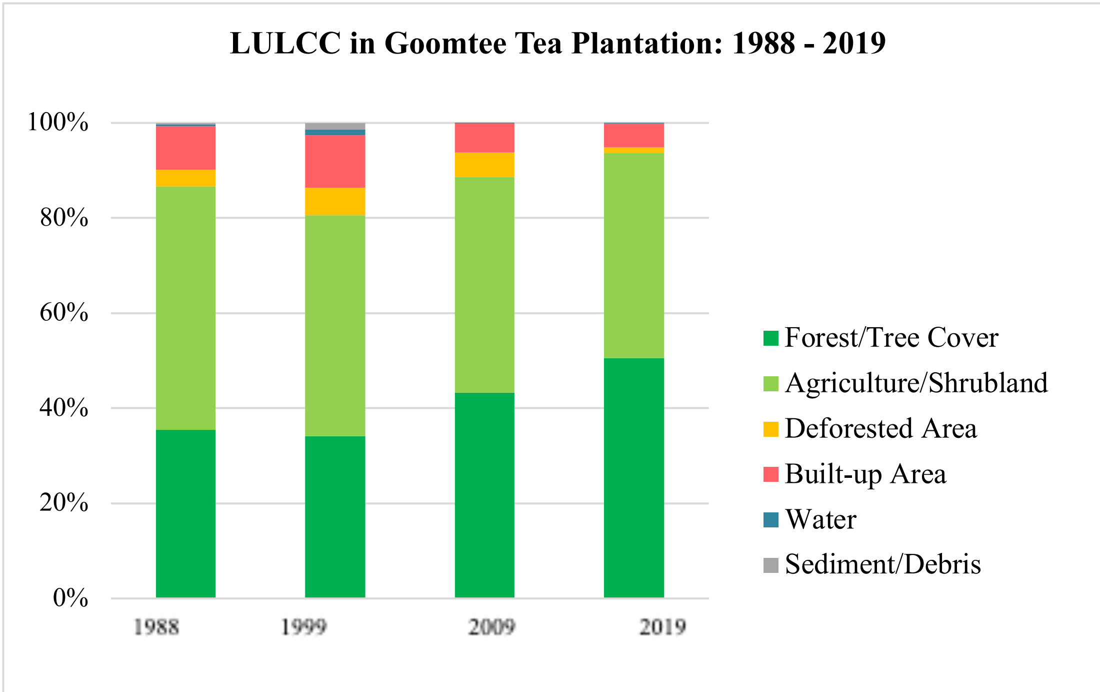

Fig 2.6a. Chart Showing LULC Percentage in Goomtee Tea Plantation:

1988, 1999, 2009, 2019

Figs 2.6a and b illustrate LULC and LULCC in Goomtee tea plantation over the respective years of study. Combined with the landslide distribution map of Goomtee (Fig 2.7) the LULCC maps also illustrate how landslide events affected farmer settlements and stream sides. Settlements (symbolized with red color in Fig. 2.6b) were likely abandoned near landslide areas and plantation workers relocated. LULC maps of 2009 already showed stability where shrublands appeared where there used to be settlements with further increase in tree cover in 2019 (Fig. 2.6b). Plantation agriculture area in Goomtee shrunk from 318 to 268 hectares between 1988 to 2019.

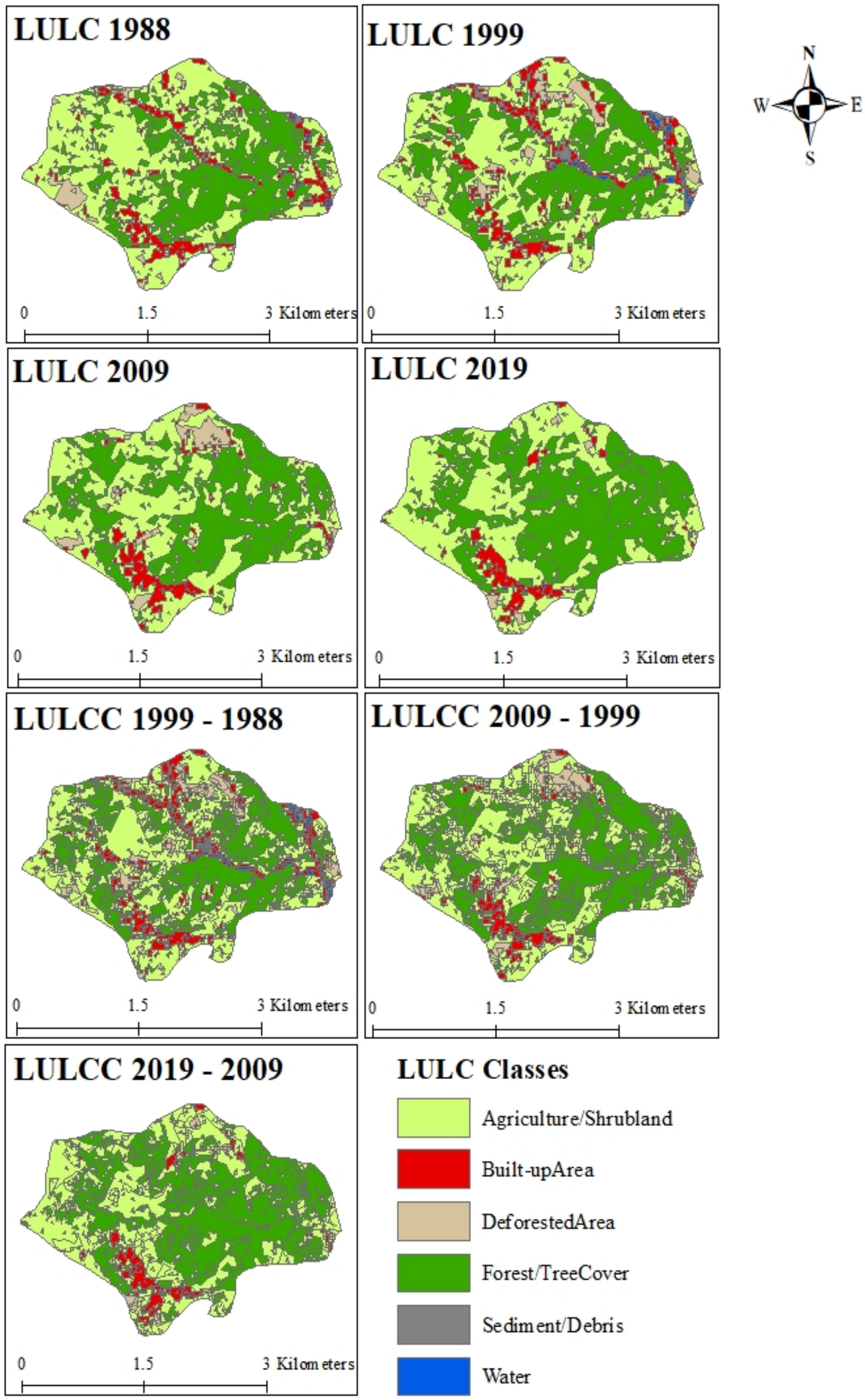

Fig 2.6b. LULC and LULCC Maps of Goomtee Tea Plantation: 1988, 1999, 2009, 2019

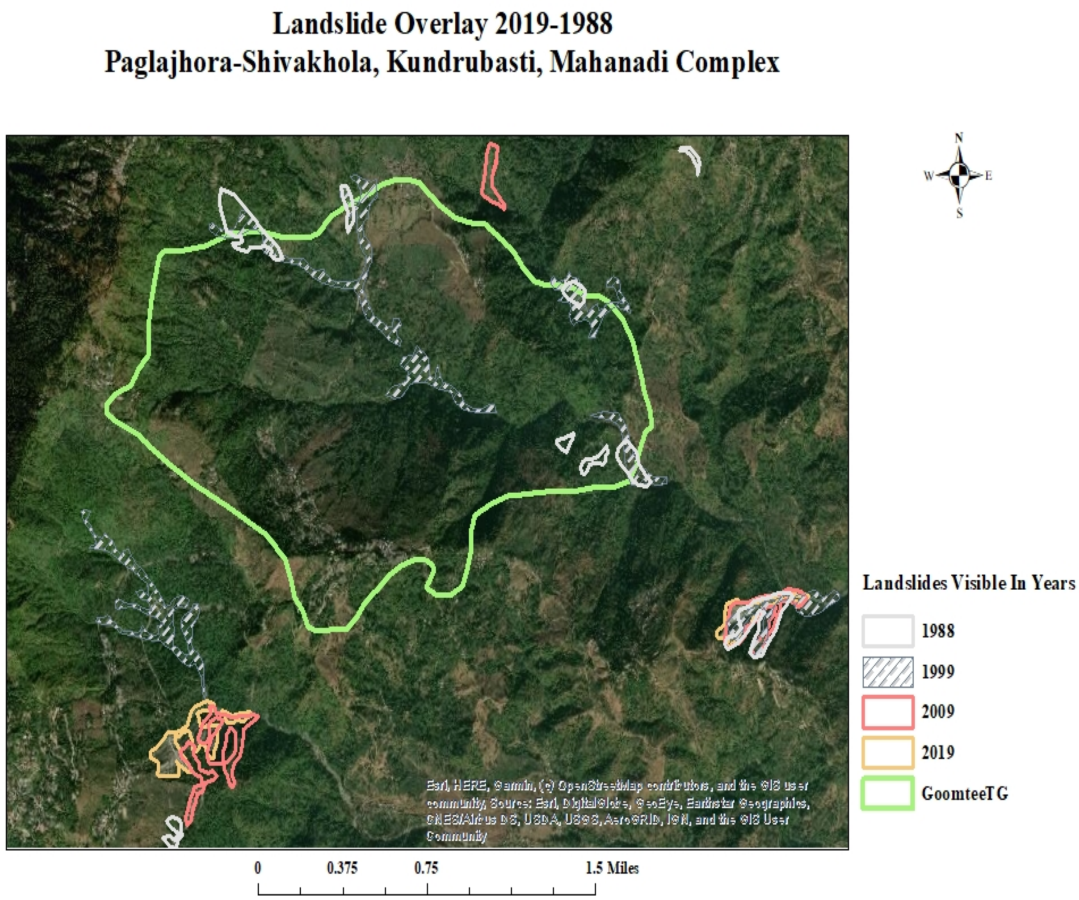

Fig 2.7. Landslide Distribution in and near Goomtee Tea Plantation:

1988, 1999, 2009, 2019

5.1.3. LULCC in Tingling Tea Plantation

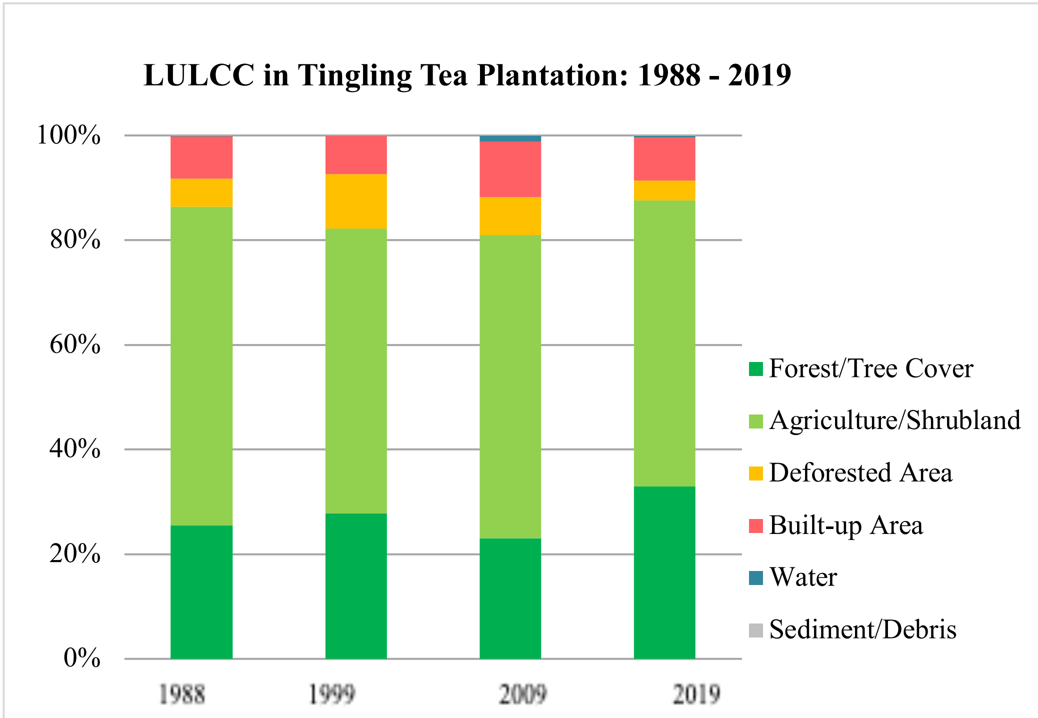

Fig 2.8a. Chart Showing LULC Percentage in Tingling Tea Plantation: 1988, 1999, 2009, 2019

From the above chart (Fig 2.8a), it is evident that agriculture is the most predominant land-use in Tingling. The Tingling tea plantation had the lowest forest cover among all study sites (25% in 1988). It fluctuated heavily over the years. After a landslide in 2015 that displaced around 600 people from 150 households ('Darjeeling: 600 in Relief Camps in Tingling" 2015; Chhetri, 2016), maps show afforestation programs in place (Fig. 2.8b).

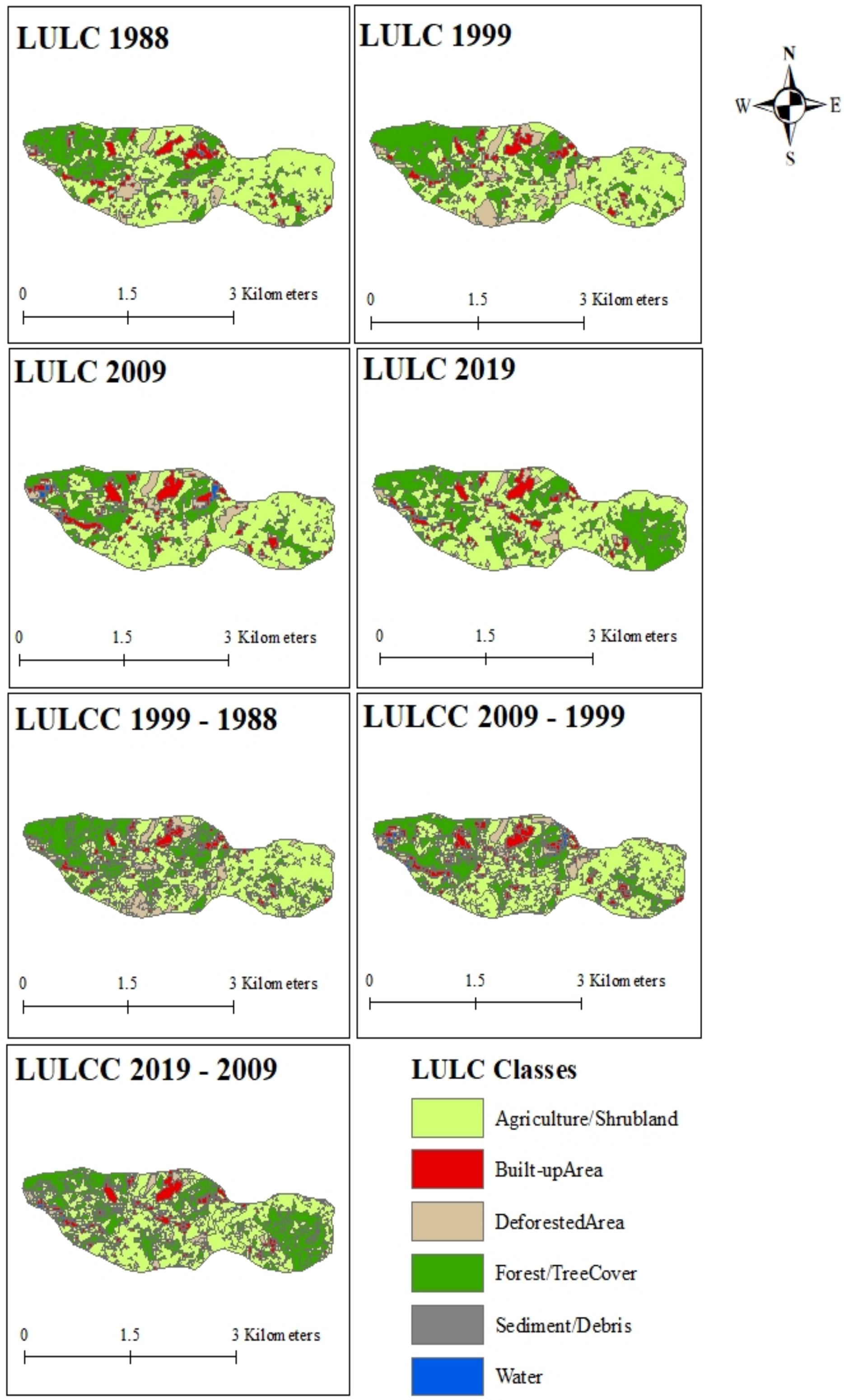

Fig 2.8b. LULC and LULCC Maps of Tingling Tea Plantation: 1988, 1999, 2009, 2019

5.1.4. LULCC in Sittong Khasmahal

Figure 2.9a. and b. together illustrate LULC and LULCC in the Sittong smallholder region. Sittong is a rural area situated in the north eastern spur of the Kurseong subdivision. Owing to its hillshade, LULCC maps likely shows the maximum error in built-area measurement. Sittong is the only area where landslide areas increased over time. Landslides in Latpanchar, Sittong and Selpu (Fig 2.10) initiated sometime between 1980-82 as illustrated in the landslide distribution map, recurred intermittently through 1993, 1999, 2015 (also K-I, 'Chasing landslides in Darjeeling', 2015).

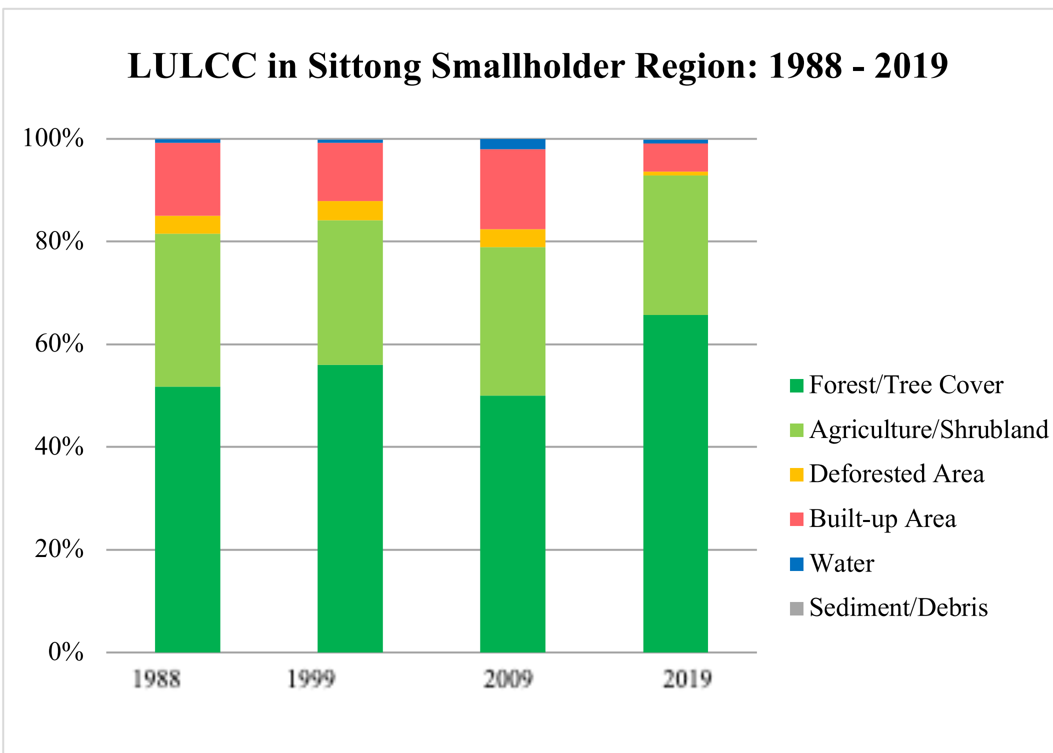

Fig 2.9a. Chart Showing LULC Percentage in Sittong Smallholder region: 1988, 1999, 2009, 2019

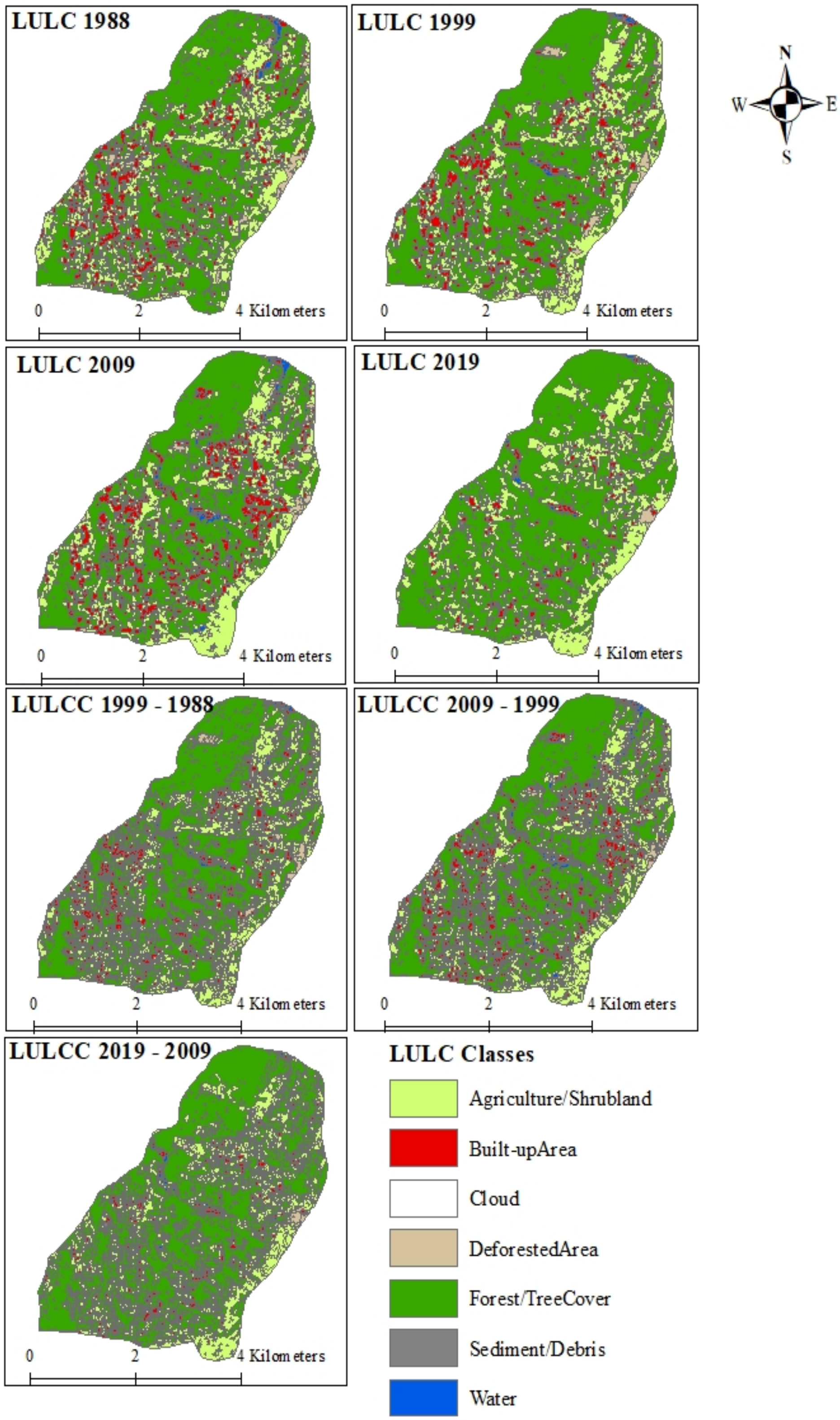

Fig 2.8b. LULC and LULCC Maps of Sittong Khasmahal: 1988, 1999, 2009, 2019

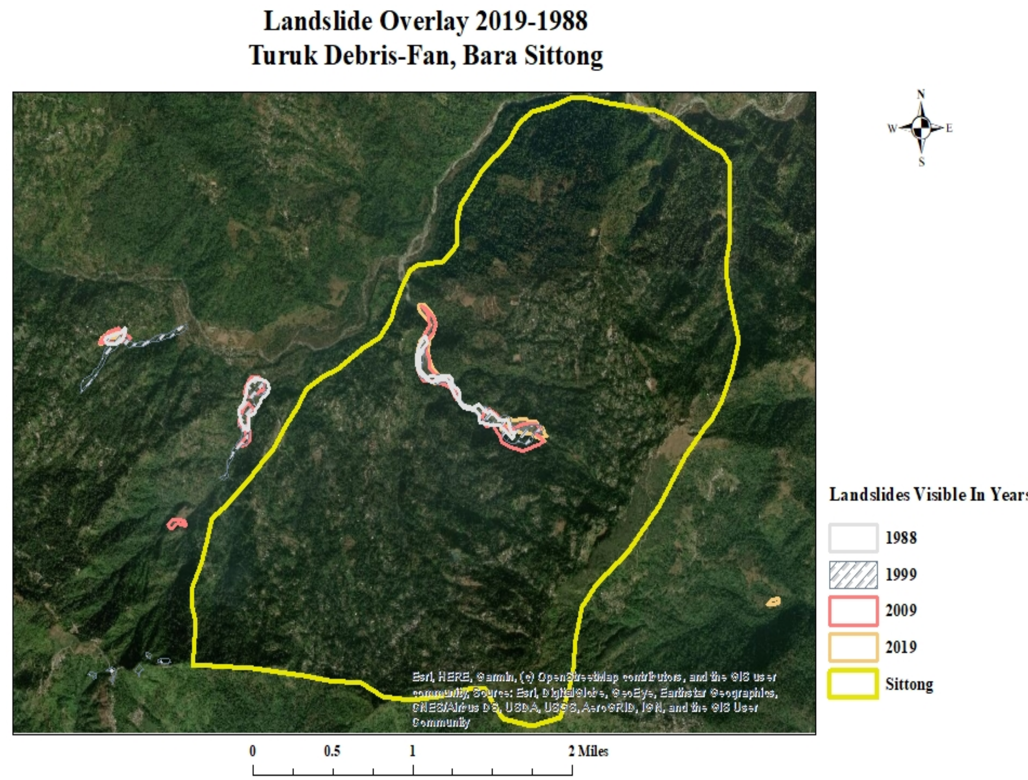

Fig 2.10. Landslide Distribution in Sittong: 1988, 1999, 2009, 2019

5.1.5. Landslide Susceptibility of Various LULC Classes

Table 2.4: Observed Landslide Areas (and Landslide Percentage for each LULC) in Kurseong: 1988 – 2019

	Land-use/land-cover Area Under Landslides (in Ha)				
Land-use/land-cover	**Year**	**1988**	**1999**	**2009**	**2019**
	Agriculture/Shrubland	7.36 (3.3%)	11.53 (3.4%)	18.61 (7.4%)	24.29 (14.9%)
	Built-upArea	47.93 (21.3%)	116.31 (33.9%)	57.28 (22.9%)	44.23 (27.2%)
	DeforestedArea	79.05 (35.1%)	99.94 (29%)	91.07 (36.3%)	44.18 (27.2%)
	Forest/TreeCover	8.29 (3.7%)	34.91 (10.2%)	23.01 (9.2%)	11.81 (7.3%)
	Sediment/Debris	39.03 (17.3%)	43.04 (12.5%)	15.37 (6.1%)	16.51 (10.2%)
	Water	43.89 (19.5%)	37.58 (11%)	45.24 (18.1%)	21.46 (13.2%)
	Total	225.54 (100%)	343.30 (100%)	250.59 (100%)	162.56 (100%)

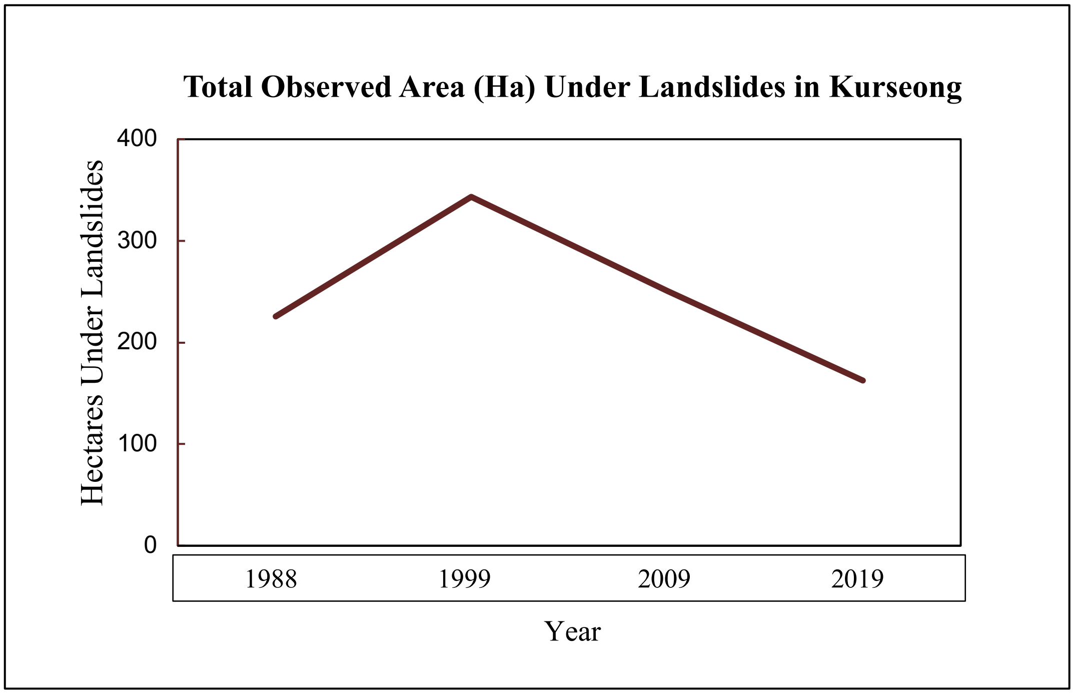

Fig 2.11 Total Observed Area (Ha) Of Landslides Between 1988-2019

Table 2.4 summarizes the distribution of landslides with respect to each LULC area obtained through the overlay analysis of landslide distributions of Kurseong over LULC maps of Kurseong for each respective year of study. The results (Table 2.4; Fig. 2.11) show an overall decline in the total area of landslides from 1988 to 2019, but the highest share of landslides throughout the years are under settlements, and deforested areas, followed by water. The only land-use where landslide areas have increased is agriculture, but that is likely because many of the deforested areas were brought under afforestation programs where previous landslides have not yet fully stabilized. 1999 had the highest area under landslides (343.3 hectares) due to the 1998 landslide events all over the region. 2009 showed the second highest landslide area probably from 2007, another major year of landslide occurrence.

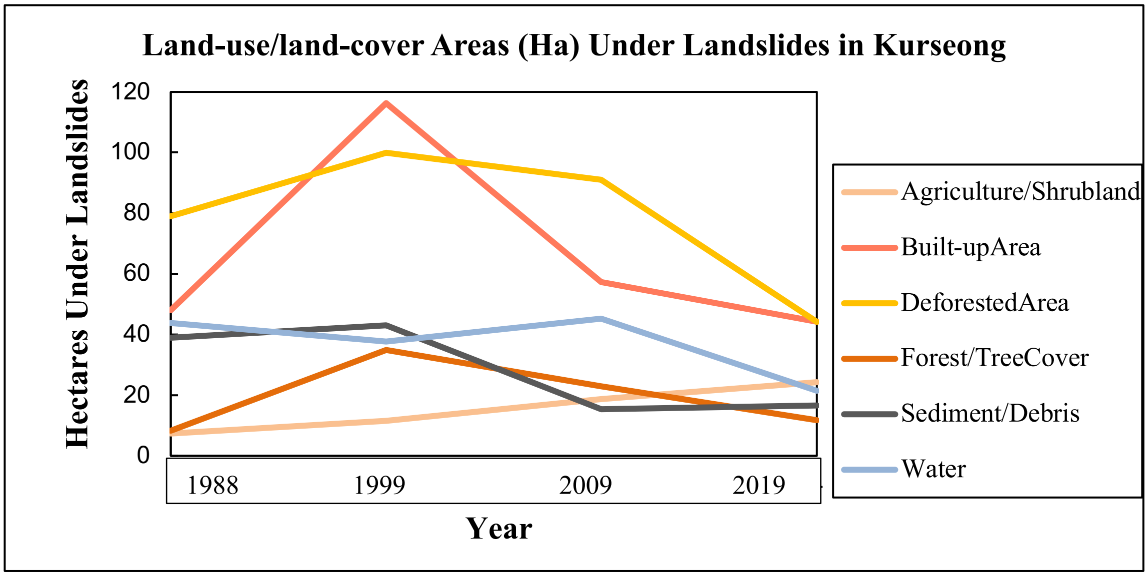

Fig 2.12 LULC Areas Under Landslides in Kurseong

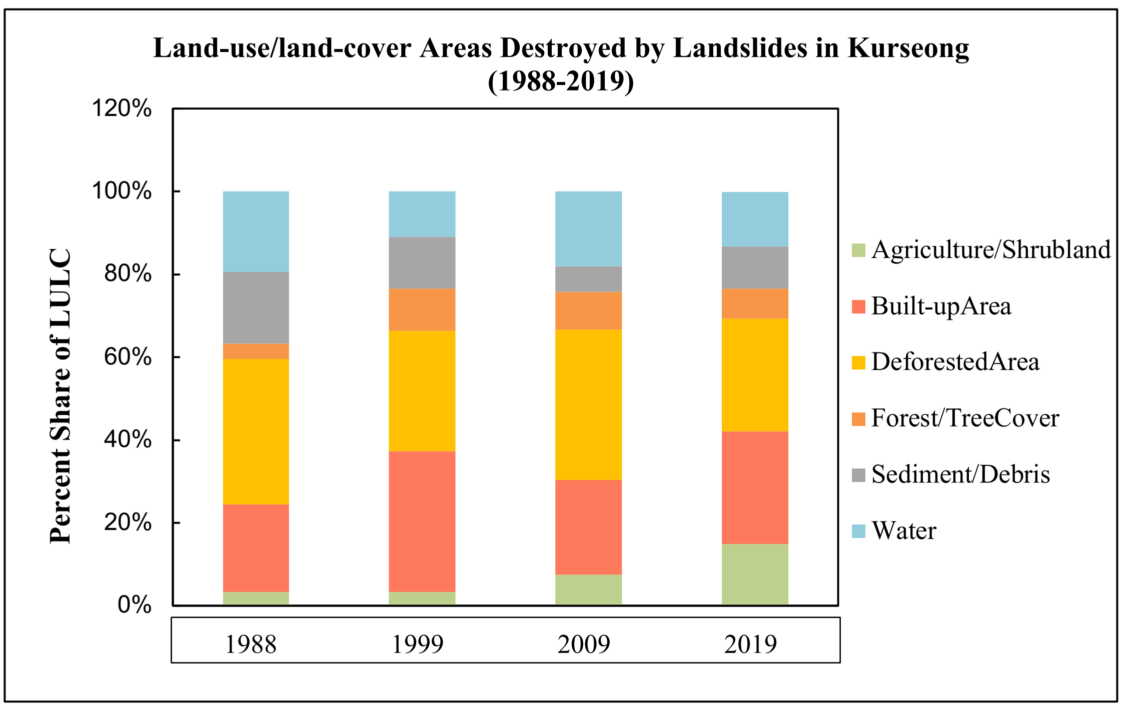

Fig 2.13 Percentage of LULC Areas Destroyed by Landslides in Kurseong

The landslide susceptibility of individual land-use/land-covers (Figs 2.12 and 2.13) show that built-up and deforested areas were consistently the most susceptible land-use/land-cover to landslide disasters. In 1999, the highest share of built-up areas was affected by landslides (34%). Deforested regions were very susceptible in 1988 and 2009, having 35 – 36% of share of total landslide areas covering all LULC types. The sedimented river beds were more susceptible to landslides in the 1980s but their share diminished over the later years.

Both built-up and deforested areas are human-altered environments. The proximate and underlying drivers of LULCC and their role in landslide vulnerability could be explained by the ethnographic research.

5.2. Proximate and Underlying Drivers of LULCC

The salient characteristics in tea plantations and smallholder regions according to K-I and CMs involve land management and land-use. Firstly, the proximate drivers are the land-use practices at local and regional levels. They include both ecofriendly measures, such as afforestation; and other practices, such as living near landslide areas, waste-dumping along slopes, streams, burning toxic wastes, and sporadic lumbering and mining (reported). For example, afforestation along slopes by planting soil-binding species of trees helps strengthening topsoil layers (K-I). Several landslide-affected areas (e.g., in Ambootia and Goomtee) with such afforestation programs have stopped further progression or relapse of landslides (K-I, ground verification). Unsustainable land-use practices that may aggravate sensitive soil conditions range from inhabiting in sinking areas and using the land to drain water, dump wastes and burn non-degradable products. Since hilly regions have a thin topsoil layer, these practices further make the soil brittle and susceptible to landslides and mudslides during the rainy season.

The underlying drivers of unsustainable land-use practices are the systemic and invisible socio-economic and political factors that mobilize such local actions (Geist and Lambin 2002). In Kurseong, they include an inadequate infrastructure for waste disposal grounds, drainage and sewerage system, and household relocation systems to safer places; inadequate institutional aids of landslide survivor households; and developmental programs involving slope cutting – all of which create obstacles for sustainable land-use at household level.

Afforestation practices within tea plantations and forested areas explains the increase in tree-cover, and stabilization/decrease in total landslide area. From the ethnographic research (interviews, meetings and surveys) the participants unanimously reported that afforestation programs were prevalent in landslide areas, tea plantations, as well as over the total area of Kurseong.

"Every year we plant upto 10,000 new trees here in this plantation" (K-I)

The landslide areas have been actively stabilized by the Conservation Division of the Soil and Landuse Survey of India (SLUSI) using bioengineering methods such as bamboo fencing, and terracing with soil binding plant species among other measures (K-I).

However, this broad improvement in environmental management did not mean a decline in local people's vulnerability to landslide disasters. When compared to the total land area of Kurseong, the maximum share of deforested area was 12.4% (1999). Deforested areas also had the maximum share of landslide areas. According to K-Is three underlying reasons might be responsible for deforestation. Although there is a strict mandate against lumbering in the forests of Kurseong, sometimes poor households could engage with lumbering to earn a living. Secondly, plantation and smallholder regions appeared deforested in seasons with low productivity. However, the extent of deforestation for sporadic personal usage are less likely to show up in regional scale maps. The third reason involved institutional deforestation in places of developmental programs.

In Tingling entire slopes are deforested to plant cable lines. In the north east, near river Kalijhora, a hydroelectric project involved deforestation and affected many households, upslope (K-I). Similar instances were reported at places of road expansion throughout the region.

Slope failures had also intensified within and near settlements. The land-use practices identified by local land-users and land managers included waste disposal in unstable areas, e.g., streams and along slopes near households. But the underlying causes for such land-use decisions were the absence of drainage and sewerage systems in the region. People dumped trash near designated areas, but the subdivision did not have required infrastructure to support household wastes.

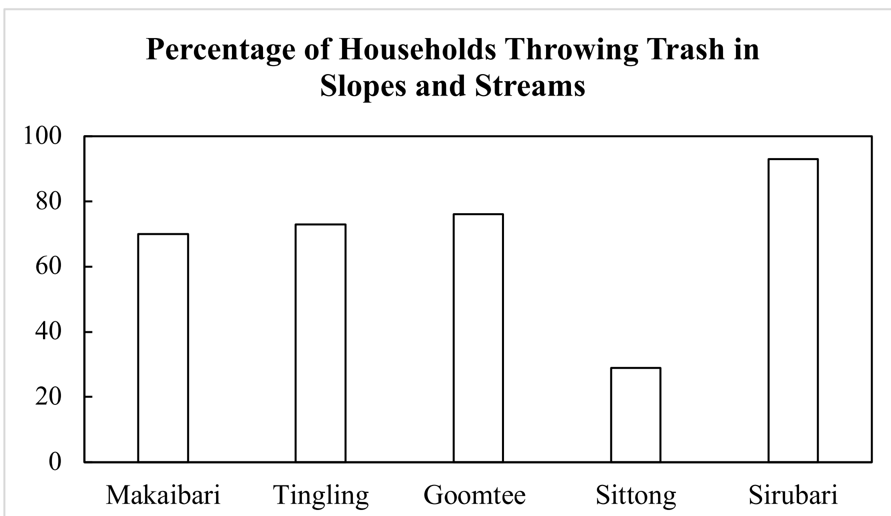

Fig 2.14 Percentage Households Throwing Trash in Slopes and Along Streams

Lack of amenities such as availability of toilets and baths also affected precarious land-use. For example, 40.2% of the farmer household surveyed, did not have a bathroom. Hence, they traveled to streams for ablution and washing clothes. Using streams for household and sanitation wastes are detrimental for slope stability when the mix with the already weak soil. Burning plastic in soil also burns the soil and creates air-pollution with the release of toxic chemicals. That has direct impact on soil stability and indirect impact on climate change. 93% of the households surveyed burned plastic.

Accommodation of smallholder and plantation farmers, evicted from their land and household (Fig 2.15) usually took a long time in Kurseong (CM). The stopgap relocations impacted the environment through similar land-use practices. In and near settlements due to the lack of capital, and difficulties of relocation in areas very prone to slope failures, such as sinking areas, neither government, plantation management, nor local farmers (usually low-income families) were able to take adequate measures to protect their households and land (Fig. 2.16).

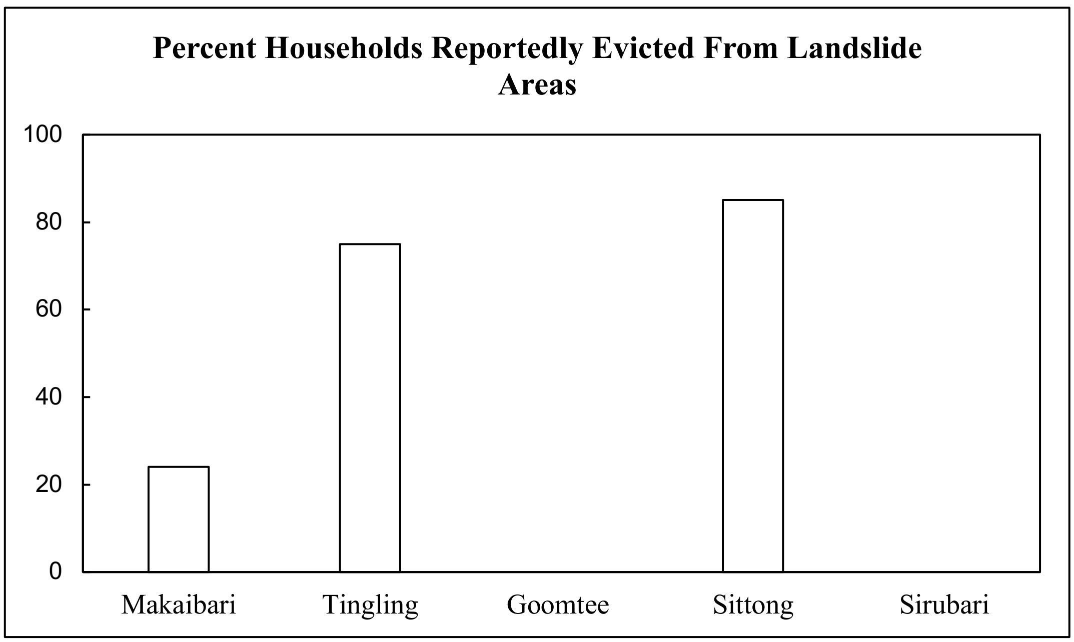

Fig 2.15 Percentage Households Displaced After Landslides

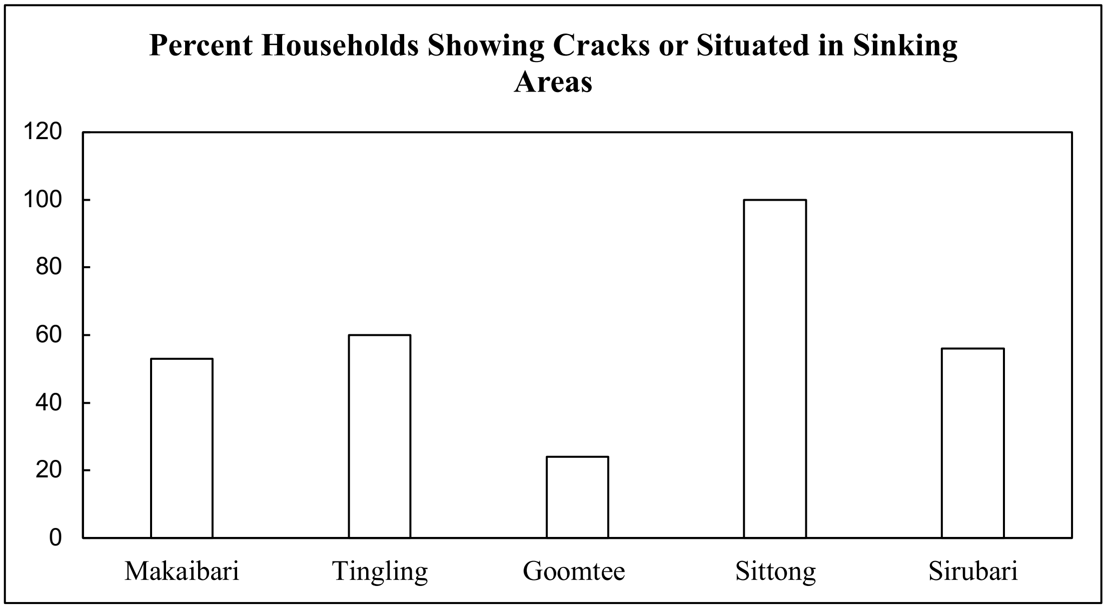

Fig 2.16 Percentage Households with Cracks/Living in Sinking Areas

The aforementioned land management, or the lack thereof, and land-use choices corroborated with land-use/land-cover changes and landslide vulnerabilities. The choices of land-use and constraints of sustainable practices were further situated within a socio-economic, political and ecological system.

6. Discussion

The conceptual framework, methods and results illustrated a complex role human-induced LULCCs played in influencing disaster vulnerability in the study area. Using the LSS framework, regional level LULCC was observed and individual LULCs affected by landslides were mapped for every year of study. The popular narratives that landslides increased due to human existence and associated land-use (e.g., loss of forest cover, urbanization) (Pant, 2003; Das et al., 2011; Biswas, 2013) have a more complex reality. Debunking the popular myth, regional level mapping showed a forest cover increase over the last 40 years and a shrinkage of landslide areas as a result of government initiatives of slope stabilization. Vulnerability to landslides continued to increase however, because existing and potential landslide areas have intensified along small pockets of settlement and deforested areas. Local vulnerabilities had a cumulative effect on the lives of plantation and smallholder farmers living in these areas.

The underlying drivers behind unsustainable land-use remained due to inadequate infrastructure to support local population, and government and capitalist decisions of deforestation for developmental purposes. Landslide vulnerability also depended on government and institutional responses to disasters and victim management. Plantation managements played a vital role in minimizing local vulnerability within tea plantations. The LULCC maps showed stabilized regions within tea plantations that had better environmental management. In smallholder regions, observed vulnerabilities to landslides were higher due to the sole dependence on government aids. In Sittong, landslide areas increased. The compensation for farming land was less than adequate because the compensated land was not arable. Ruggedness and inaccessibility were also a major hindrance in the Sittong region. In Sirubari, landslides continuously blocked communication during the monsoon period. The respondents unanimously and independently stated government inefficiencies in providing aid during and after disasters.

7. Conclusion

The integrated framework of LSS helped analyze the impacts of LULCC at both regional and local scales. A broad remote sensing analysis would likely fail to identify local vulnerabilities. On the other hand, detailed geological investigations (commonly done in this area) do not have the scope to study land-use decisions of social stakeholders. The robustness of the LSS framework lay in integrating the physical and social aspects of land change and their impacts on the society.

A limitation of this study lies in the difficulty to assess LULCC in hillshade areas with the 30-m spatial resolution of Landsat images. Integration of higher spatial resolution images, using small unmanned aerial systems (SUAS) have the scope to enhance the accuracy of detecting LULC over small areas (Mathews, 2019) for classification and change detection. Despite that, the study was able to debunk simplistic narratives of population pressure and forest cover loss on landslide vulnerability, address local land-use decisions, and the underlying social drivers behind such decisions that continued to increase local people's vulnerability to the disaster. The framework allowed employing a mix of remote sensing and ethnographic research methods to study the complex functioning of an integrated social-ecological system, i.e., the land system, that transcends beyond linear correlations of cause-effect analyses related to global environmental change.

References

Adger, W. N. (2006). Vulnerability. *Global environmental change*, 16(3): 268-281.

Alcántara-Ayala, I., Sassa, K., Mikoš, M., Han, Q., Rhyner, J., Takara, K., ... & Briceño, S. (2017). The 4th World Landslide Forum: landslide research and risk reduction for advancing the culture of living with natural hazards. *International Journal of Disaster Risk Science*, *8*(4), 498-502.

Arsenault, N., Hale, L., Khedkar, P., & Morimoto, Y. (2012). Integrated Water Management in Kurseong. *Energising Local Capacities*, 81.

Baker, J. C. (2014). Mobility, tropicality and landscape: the Darjeeling Himalayan Railway, 1881–1939. *Journal of Historical Geography*, *44*, 133-144.

Bartels, L. E., Mayer, A., & Erb, K. H. (2017). Exploring potential socio-ecological impacts of changes to the Loliondo Gamed Controlled Area, Northern Tanzania: the case of the pastoral village Ololosokwan. *Journal of Land Use Science*, *12*(1), 87-103.

Basu Roy, T., & Saha, S. (2011). Article: Study on Landslide Incidents of Paglajhora and Adjacent Areas–An Overview; Kurseong Block, Darjeeling, India.

Basu, S. R., & De S. K. (2003). Causes and consequences of landslides in the Darjiling-Sikkim Himalayas, India. *Geographia Polonica*, 76(2), 37-52.

Biswas, S. (2013). Urban Growth Centers In Darjeeling Hills Of West Bengal: A Geographical Analysis. *The Journal of Bengal Geographer,* 2(1), 30 – 48.

Biswas, S. S., & Pal, R. (2016). Causes of landslides in Darjeeling Himalayas during June–July, 2015. *Journal of Geography and Natural Disasters*, 6(173), 2167-0587.

Bhattacharya, S. K, (2012). Zonation mapping techniques of the landslide hazard in Darjeeling Hills, West Bengal, India. *Geo-Analyst* 2(1), 12–17.

Broeckx, J., Rossi, M., Lijnen, K., Campforts, B., Poesen, J., & Vanmaercke, M. (2020). Landslide mobilization rates: A global analysis and model. *Earth-Science Reviews*, *201*, 102972.

Campforts, B., Shobe, C., Steer, P., Vanmaercke, M., Lague, D., & Braun, J. (2020). HyLands 1.0: A Hybrid Landscape evolution model to simulate the impact of landslides and landslide-derived sediment on landscape evolution. *Geoscientific Model Development*.

Census of India, (2011). District Census Handbook – Darjeeling, India.

Chawla, A., Chawla, S., Pasupuleti, S., Rao, A.C.S., Sarkar, K., & Dwivedi, R. (2018). Landslide Susceptibility Mapping in Darjeeling Himalayas, India. *Hindawi Advances in Civil Engineering.* https://doi.org/10.1155/2018/6416492.

Chhetri, V. (February 3, 2016). Landslide victims call strike in Mirik. *The Telegraph, India.* E-paper.

Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B., & Lambin, E. (2004). Digital Change Detection Methods In Ecosystem Monitoring: A Review. *International Journal Of Remote Sensing*, 25(9): 1565-1596.

Cutter, S. L. (2016). The landscape of disaster resilience indicators in the USA. *Natural hazards*, *80*(2), 741-758.

Das, N., Chatterjee, S., & Roy, U. (2011). An assessment of anthropogenic impact on natural landscape–The case of Kurseong Town, Darjeeling, West Bengal. *Indian Journal of Geography & Environment*, 12: 40-50.

Das, R. (2014). Impact of civilized intervention on the eco-fitness of Kurseong municipality, West Bengal, India. *International Journal of Advanced Research in Management and Social Sciences*, 3(9): 217-237.

de Loyola Hummell, B. M., Cutter, S. L., & Emrich, C. T. (2016). Social vulnerability to natural hazards in Brazil. *International Journal of Disaster Risk Science*, *7(*2), 111-122.

Ellis, E. C., Kaplan, J. O., Fuller, D. Q., Vavrus, S., Goldewijk, K. K., & Verburg, P. H. (2013). Used planet: A global history. *Proceedings of the National Academy of Sciences*, *110*(20), 7978-7985.

Findell, K. L., Berg, A., Gentine, P., Krasting, J. P., Lintner, B. R., Malyshev, S. ..., & Shevliakova, E. (2017). The impact of anthropogenic land use and land cover change on regional climate extremes. *Nature communications*, *8*(1), 1-10.

Forsyth, T. (1996). Science, myth and knowledge: testing Himalayan environmental degradation in Thailand. *Geoforum*, 27(3), 375-392.

Franklin, S. E., & Wulder, M. A. (2002). Remote sensing methods in medium spatial resolution satellite data land cover classification of large areas. *Progress in Physical Geography*, *26*(2), 173-205.

Froude, M. J., & Petley, D. (2018). Global fatal landslide occurrence from 2004 to 2016. *Natural Hazards and Earth System Sciences*, *18,* 2161-2181.

Fu, P., & Weng, Q. (2016). A time series analysis of urbanization induced land use and land cover change and its impact on land surface temperature with Landsat imagery. *Remote Sensing of Environment*, *175*: 205-214.

Ganbold, G. and Chasia, S. (2017). Comparison between Possibilistic c-Means (PCM) and Artificial Neural Network (ANN) Classification Algorithms in Land use/Land cover Classification. *International Journal of Knowledge Content Development & Technology*, *7*(1), 57.

Geist, H., & Lambin, E. (2002). Proximate Causes and Underlying Driving Forces of Tropical Deforestation. *BioScience*, *52*(2), 143-150.

Gerlitz, J.Y., Macchi, M., Brooks, N., Pandey, R., Banerjee, S. & Jha, S.K., (2017). The multidimensional livelihood vulnerability index–an instrument to measure livelihood vulnerability to change in the Hindu Kush Himalayas. *Climate and Development*, *9*(2), 124-140.

Ghosh, S., van Westen, C. J., Carranza, E. J. M., Jetten, V. G., Cardinali, M., Rossi, M., & Guzzetti, F. (2012a). Generating event-based landslide maps in a data-scarce Himalayan environment for estimating temporal and magnitude probabilities. *Engineering Geology*, 128: 49-62.

Ghosh S., van Westen C. J., Carranza E. J. M., & Jetten, V. G. (2012b). Integrating spatial, temporal, and magnitude probabilities for medium-scale landslide risk analysis in Darjeeling Himalayas, India. *Landslides*, 9(3): 371-384.

Ghosh, S., & Ghoshal, T. B. (2016). *Landslide Compendium on Darjeeling-Sikkim Himalayas*. Geological Survey of India.

Glade, T. (2003). Landslide occurrence as a response to land use change: a review of evidence from New Zealand. *Catena*, 51(3): 297-314.

GLP, (2005). ''Science Plan and Implementation Strategy,'' IGBP Report No. 53/IHDP Report No. 19.

Goldewijk, K. K., Beusen, A., Van Drecht, G. and De Vos, M. (2011). The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years. *Global Ecology and Biogeography*, *20*(1), 73-86.

Gómez, C., White, J. C., & Wulder, M. A. (2016). Optical remotely sensed time series data for land cover classification: A review. *ISPRS Journal of Photogrammetry and Remote Sensing*, *116*, 55-72.

Haberl, H., Erb, K. H., Krausmann, F., Gaube, V., Bondeau, A., Plutzar, C., ..., & Fischer-Kowalski, M. (2007). Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. *Proceedings of the National Academy of Sciences*, *104*(31), 12942-12947.

Hassan, Z., Shabbir, R., Ahmad, S. S., Malik, A. H., Aziz, N., Butt, A. & Erum, S. (2016). Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *Springer Plus*, *5(*1), 812.

Hermosilla, T., Wulder, M. A., White, J. C., Coops, N. C., & Hobart, G. W. (2015). An integrated Landsat time series protocol for change detection and generation of annual gap-free surface reflectance composites. *Remote Sensing of Environment*, *158*, 220-234.

Houghton, R. A., & Nassikas, A. A. (2017). Global and regional fluxes of carbon from land use and land cover change 1850–2015. *Global Biogeochemical Cycles*, *31*(3), 456-472.

Huber, A. (2019). Hydropower in the Himalayan hazardscape: Strategic ignorance and the production of unequal risk. *Water*, *11*(3), 414.

Immerzeel, W. W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science, 328*(5984), 1382-1385.

Ishtiaque, A., Shrestha, M., & Chhetri, N. (2017). Rapid urban growth in the Kathmandu Valley, Nepal: Monitoring land use land cover dynamics of a Himalayan city with Landsat imageries. *Environments*, *4*(4), 72.

Ives, J. D., & Messerli, B. 1989. *The Himalayan Dilemma: Reconciling Development and Conservation*. Routledge: NY.

Jin, S., Yang, L., Zhu, Z., & Homer, C. (2017). A land cover change detection and classification protocol for updating Alaska NLCD 2001 to 2011. *Remote Sensing of Environment*, *195*, 44-55.

Jodha, N. S. (2005). Adaptation strategies against growing environmental and social vulnerabilities in mountain areas. *Himalayan Journal of Sciences*, 3(5): 33 – 42.

Khawas, V. (2009). Environmental Challenges and Human Security in the Himalaya. *Environmental Concerns and Sustainable Development: some perspectives from India*, 1-36.

Kleemann, J., Baysal, G., Bulley, H. N., & Fürst, C. (2017). Assessing driving forces of land use and land cover change by a mixed-method approach in north-eastern Ghana, West Africa. *Journal of Environmental Management*, *196,* 411-442.

Krausmann, F., Erb, K. H., Gingrich, S., Haberl, H., Bondeau, A., Gaube, V., …, & Searchinger, T. D. (2013). Global human appropriation of net primary production doubled in the 20th century. *Proceedings of the national academy of sciences*, *110*(25), 10324-10329.

Krylov, A., Steininger, M. K., Hansen, M. C., Potapov, P. V., Stehman, S. V., Gost A., ..., & Ellis, E. A. (2019). Contrasting tree-cover loss and subsequent land cover in two neotropical forest regions: sample-based assessment of the Mexican Yucatán and Argentine Chaco. *Journal of Land Use Science*, *13*(6), 549-564.

Lambin, E. F., & Geist, H. (2006). Land-Use and Land-Cover Change: Local Processes and Global Impacts. *Global Change-The IGBP Series.*

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, *108*(9), 3465-3472.

Lemke, P., Ren, J., Alley, R. B., Allison, I., Carrasco, J., Flato, G, …, Zhang, T. (2007). Observations: Changes in snow, ice and frozen ground. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, & H.L. Miller (Eds.), Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change (pp. 337–383). Cambridge: Cambridge University Press.

Lepcha, (2015). Changing Patterns of Population Density And Spatial Distribution In Kurseong Municipality: An Empirical Study. *International Journal of Informative & Futuristic Research,* 2(12): 2347-1697.

Li, X., Chen, G., Liu, X., Liang, X., Wang, S., Chen, Y., ..., & Xu, X. (2017). A new global land-use and land-cover change product at a 1-km resolution for 2010 to 2100 based on human–environment interactions. *Annals of the American Association of Geographers*, *107*(5), 1040-1059.

Lillesand, T. M., & Kiefer, R. W. (2004). Chipman, JW (2004). *Remote Sensing and Image Interpretation. John Wiley & Sons, New York, USA*, *31*.

Lim, C. L., Prescott, G. W., De Alban, J. D. T., Ziegler, A. D., & Webb, E. L. (2017). Untangling the proximate causes and underlying drivers of deforestation and forest degradation in Myanmar. *Conservation Biology*, *31*(6), 1362-1372.

Longhurst, R. (2012). Semi-structured interviews and focus groups. In, *Key methods in geography*, eds. N Clifford, S. French and G. Valentine, 103-115. Sage, London.

Ma, L., Li, M., Ma, X., Cheng, L., Du, P., & Liu, Y. (2017). A review of supervised object-based land-cover image classification. *ISPRS Journal of Photogrammetry and Remote Sensing*, *130*, 277-293.

Machado, M. R. (2018). What's going on with land-use in Cuba?: Disparate data sets and the Cuban agricultural transition. *Journal of Land Use Science*, *13(*4), 439-446.

Mathews, A. J. (2019). A practical UAV remote sensing methodology to generate multispectral orthophotos for vineyards: Estimation of spectral reflectance using compact digital cameras. In *Geospatial Intelligence: Concepts, Methodologies, Tools, and Applications*, IGI Global, 298-322.

Meyfroidt, P., Lambin, E. F., Erb, K. H., & Hertel, T. W. (2013). Globalization Of Land Use: Distant Drivers Of Land Change And Geographic Displacement Of Land Use. *Current Opinion in Environmental Sustainability*, 5(5), 438-444.

Meyfroidt, P., Roy Chowdhury, R., de Bremond, A., Ellis, E. C., Erb, K. H., Filatova, T., ..., & Kull, C. A. (2018). Middle-range theories of land system change. *Global Environmental Change*, 53: 52-67.

Mishra, P. K. (2017). Assessment of Run-off and Soil Loss under different Land-use Practices in a Himalayan Watershed, India. *American Research Journal of Humanities and Social Sciences*, *3*, 1-10.

Müller, D., Kuemmerle, T., Rusu, M., & Griffiths, P. (2009). Lost in transition: determinants of post-socialist cropland abandonment in Romania. *Journal of Land Use Science*, 4(1-2): 109-129.

Nathan, F. (2008). Risk perception, risk management and vulnerability to landslides in the hill slopes in the city of La Paz, Bolivia: A Preliminary Statement. *Disasters*, 32(3): 337-357.

Newswire, The. (July 2015). 'Darjeeling: 600 in Relief Camps in Tingling'.

Nyberg, G., Mureithi, S. M., Muricho, D. N., & Ostwald, M. (2019). Enclosures as a land management tool for food security in African drylands. *Journal of Land Use Science*, *14*(1), 110-121.

Ostwald, M., Wibeck, V., & Stridbeck, P. (2009). Proximate causes and underlying driving forces of land-use change among small-scale farmers–illustrations from the Loess Plateau, China. *Journal of Land Use Science*, *4*(3), 157-171.

Pal, R., Biswas, S. S., Mondal, B., & Pramanik, M. K. (2016). Landslides and floods in the Tista Basin (Darjeeling and Jalpaiguri Districts): Historical evidence, causes and consequences. *J. Ind. Geophys. Union*, *20*(2), 66-72.

Pant, B. R. (2003). Degrading environment and growing population of the Indian Himalaya. *Envis Bull Himal Ecol Dev*, 11(1), 23-34.

Pelling, M., & Dill, K. (2006). 'Natural' disasters as catalysts of political action. *Media Development*, *53*(4), 7.

Petley, D. (2012). Global patterns of loss of life from landslides. *Geology*, *40*(10), 927-930.

Reenberg, A. (2009). Land system science: handling complex series of natural and socio-economic issues. *Journal of Land Use Science*, *4*(1-2), 1-4.

Rounsevell, M. D., Pedroli, B., Erb, K. H., Gramberger, M., Busck, A. G., Haberl, H., ..., & Lotze-Campen, H. (2012). Challenges for land system science. *Land use policy*, *29*(4), 899-910.

Roy, S. (2010). *A Cultural Politics of Mobilities and Post-Colonial Heritage: A Critical Analysis of the Darjeeling Himalayan Railway (DHR)* (Doctoral dissertation, University of Sunderland).

Rueda, X., Velez, M. A., Moros, L., & Rodriguez, L. (2019). Beyond proximate and distal causes of land-use change: linking Individual motivations to deforestation in rural contexts. *Ecology and Society*, *24*(1), 4.

Rumbach, A. (2016). Disaster Governance in Small Urban Places: Issues, Trends, and Concerns. In, *Disaster Governance in Urbanising Asia*, 109-125 Springer Singapore.

Rwanga, S. S., & Ndambuki, J. M. (2017). Accuracy assessment of land use/land cover classification using remote sensing and GIS. *International Journal of Geosciences*, *8*(04), 611.

Shrestha, U. B., Gautam, S., & Bawa, K. S. (2012). Widespread climate change in the Himalayas and associated changes in local ecosystems. *PloS one*, *7*(5).

Srivastava, P. K., Han, D., Rico-Ramirez, M. A., Bray, M., & Islam, T. (2012). Selection of classification techniques for land use/land cover change investigation. Advances in Space Research, *50*(9): 1250-1265.

Starkel, L., & Basu, S. 2000. *Rains, landslides, and floods in the Darjeeling Himalaya.* Indian National Science Academy: New Delhi.

Starkel, L. 2010. Ambootia Landslide Valley—Evolution, Relaxation, and Prediction (Darjeeling Himalaya). *Landform Evolution in the mountain areas*, 113-133.

Tierney, K. (2012). A bridge to somewhere: William Freudenburg, environmental sociology, and disaster research. *Journal of Environmental Studies and Sciences*, *2*(1), 58-68.

Turner, B. L., Lambin, E. F., & Reenberg, A. (2007). The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences*, *104*(52), 20666-20671.

Turner, B., Clark, W. C., Kates, R. W., Richards, J. F., Mathews, J. T., & Meyer, W. B. (1990). The Earth as transformed by human action: global change and regional changes in the biosphere over the past 300 years. In *The Earth as transformed by human action: global change and regional changes in the biosphere over the past 300 years*. Cambridge University Press, with Clark University.

Vadjunec, J.M., Frazier, A, Kendron, P., & Zhao, Y. (2018). A Land Systems Science Framework for Bridging Land System Architecture and Landscape Ecology: A Case Study from the Southern High Plains. *Land, 7, 27.*

van Westen, C. J., Jaiswal, P., Ghosh S., Martha, T. R., & Kuriakose, S. L. (2012). Landslide Inventory, Hazard and Risk Assessment in India. *In, Terrigenous Mass Movements,* 239-282. Springer: Berlin Heidelberg.

Veldkamp, A. (2009). Investigating land dynamics: future research perspectives. *Journal of Land Use Science*, *4(*1-2), 5-14.

Verburg, P. H., Erb, K. H., Mertz, O., & Espindola, G. (2013). Land System Science: between global challenges and local realities.

Wisner, B., Blaikie P., Cannon T., …, & Davis I. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters.* London: Routledge.

Yao, T., Thompson, L., Yang, W., Yu, W., Gao, Y., Guo, X., …, & Joswiak, D. (2012). Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. Nature Climate Change. doi:10.1038/NCLIMATE1580

Ye, S., Pontius Jr, R. G., & Rakshit, R. (2018). A review of accuracy assessment for object-based image analysis: From per-pixel to per-polygon approaches. *ISPRS Journal of Photogrammetry and Remote Sensing*, *141*, 137-147.

Yeh, E. T., Nyima Y., Hopping K. A., & Klein, J. A. (2014). Tibetan Pastoralists' Vulnerability To Climate Change: A Political Ecology Analysis Of Snowstorm Coping Capacity. *Human Ecology,* 42(1), 61-74.

CHAPTER III

THE POLITICAL ECOLOGY OF MULTIDIMENSIONAL DISASTER VULNERABILITY: A CASE STUDY IN KURSEONG, INDIA

Samayita Bandyopadhyay

Abstract: *This article assesses multiple dimensions of social vulnerability to natural disasters by integrating a vulnerability framework and a political ecology (PE) analytical framework. The study is based in a landslide-prone Himalayan Mountain region called Kurseong, in eastern India. First, this paper identifies the various indicators in which a household becomes vulnerable to landslides, using the Multidimensional Livelihood Vulnerability Index Framework (MLVI). Then, a critical PE focus analyzes the processes that make households vulnerable, based on the identified indicators. Five field sites were selected in Kurseong, and 24 indicators of vulnerability were identified within households. The indicators were first categorized under various socio-economic components, which were further nested under the three dimensions of vulnerability, namely, exposure, sensitivity, and adaptive capacity. Primary data, obtained through household surveys, were used to identify the indicators, and calculate the degree of vulnerability within each of the five communities, using the MLVI framework. Results show the five field sites having varying intensities of vulnerability depending on land management for disaster recovery. However, commonly, in some aspects all field sites are vulnerable in terms of sensitivity and adaptive capacity. Through key-informant interviews, community meetings and field observations, the political process behind control and distribution of resources and amenities, as well as ecological constraints of accessing resources in a mountain environment, were analyzed to be major factors behind vulnerability.*

Keywords: indicators, multidimensional livelihood vulnerability index, political ecology

1. Introduction

Vulnerability is a key concept in risk-hazards/disaster research that explores a society's inability to cope with natural or man-made hazards at every spatial scale (Wisner et al., 2004). Vulnerability is socially produced and socially experienced (Cutter, 2003; Wisner et al., 2004; Adger, 2006; Birkmann, 2006; Robbins et al., 2015; Watts, 2016; Elmhirst et al., 2017), hence, the terms vulnerability, social vulnerability, and/or people's vulnerability will be used interchangeably in this article. One of the major foci of research on disaster vulnerability involves developing frameworks to understand the factors that make a society, community, or an individual vulnerable to adverse environmental conditions (O' Keefee et al., 1976; Turner et al., 2003a; Adger, 2006). One of the methodologies adopted by research communities to assess vulnerability is creating indices through which, social and biophysical parameters of vulnerability are analyzed through modeling (e.g., Cutter, 2003; Hahn et al., 2009; Antwi et al., 2015; Gerlitz et al., 2017). These indices have been immensely useful to quantify the extent and degree of social vulnerability at a given space and time.

Although vulnerability indices have contributed largely in the present knowledge base on social vulnerability, often these parameters stand alone as observed and researched variables. They lack an explanation of the interconnected processes through which a vulnerability situation comes to function. Other models of disaster risk and vulnerability, such as the Pressure and Release (PAR), and Access models strive to incorporate the nature-society interactions to understand better, the "chain of explanation" and the "chain of causation" that drives the "progression of vulnerability" (Wisner et al. 2004, 87, 94). The Access model, for example, acknowledges the role of political economy, i.e., 'social relations' and 'political domination' that produces coping inequalities (Wisner et al., 2004; Griffin, 2019). The disparate but related research field of Political Ecology critically analyzes such chains of explanation between social and environmental actors leading to vulnerability, e.g., marginality of environment and certain communities, environmental outcomes (degradation and disasters), etc. (Blaikie, & Brookfield, 1987; Robbins, 2012). Hence, this research aims to incorporate a Political Ecology (PE) analytical framework to an adopted model called the Multidimensional Livelihood Vulnerability Index (MLVI) (Gerlitz et al., 2017) to understand the interactive processes that make households and communities vulnerable, and the degree and extent to which they continue to be vulnerable.

The following section of this article will involve describing the conceptual frameworks of vulnerability that this study draws upon; elaborate on the MLVI framework; and finally explain the PE frameworks of political and economic marginalization, and ecological degradation that is used in this study to identify the processes impacting local vulnerability. The next section will describe the context or background of the case study area. Following this, methodologies of constructing MLVI and establishing a PE analysis will be discussed. Next, results will be explained, followed by analysis and discussion of the usefulness in the integration of two separate concepts and methodologies.

2. Conceptual Frameworks of Vulnerability, MLVI and PE

2.1. The concept of Vulnerability in Human-Environment Research

A number of disciplines study vulnerability and define the term according to the focus and approach of their study. W. Neil Adger (2006) defined vulnerability as “the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt” (268). Previously, Turner and colleagues had established the components of vulnerability, namely exposure, sensitivity and adaptive capacity in their framework of vulnerability within the field of sustainability science (Turner et al., 2003 a, b). The Intergovernmental Panel on Climate Change defined vulnerability simply as the “propensity and predisposition to be affected” (IPCC 2012, p.32, cited in Gerlitz et al., 2017). Gerlitz and colleagues

(2017) opine IPCC's broad and somewhat "vague" definition of vulnerability is to recognize and accommodate various ways of defining and approaching vulnerability within climate change research. Nonetheless, most vulnerability analyses agree on the fact that vulnerability is socially produced, and can be linked with human adaptations to the environment (Wisner et al., 2004; Adger, 2006; Watts, 2016; Elmhirst et al., 2017).

With the conceptualization of vulnerability among a large academic realm of disaster studies, some risk hazard scholars focused on devising a heuristic to identify and measure the factors that tend to make certain groups of people more vulnerable than others. For example, Birkmann mentioned that "the ability to measure vulnerability is increasingly being seen as a key step towards effective risk reduction and promotion of a culture of disaster resilience" (2006, p. 9). With rising concerns about climate crisis, global environmental change – growing incidences of both long-term environmental degradation and sudden cataclysms, it has become more important, now than ever, to effectively assess the complexities of human vulnerabilities that continue to hinder human ability to combat environmental disasters.

Susan Cutter's (2003) quantitative assessment of social vulnerability index (SoVI) was widely cited and replicated (e.g., Fekete et al., 2009; Kok's et al., 2015) as the author created a metric to identify a vast range of social parameters at a regional level that make people vulnerable. She accounted for factors like inaccessibility to resources, political capitals as indicators of vulnerability along with socio-demographic status, and economic conditions (Cutter 2003, p. 245-9). Cutter's research also provided a working methodology of statistical modeling of vulnerability with census data. Her case study consisted of all counties in the United States. Cutter's SoVI focused more on macro-level indices of vulnerability, while largely ignoring more micro levels such as individuals and households. Hahn and colleagues (2009) expanded from Cutter's SoVI to create a Livelihood Vulnerability Index (LVI) that includes household assets to understand vulnerabilities at a micro-level. In the current decade these vulnerability indices have been used extensively in disaster research with the purposes of informing policies for disaster risk management (Hahn et al., 2009; Adepoju et al., 2011; Gerlitz et al., 2017; de Loyola Hummell et al., 2016; Kok's et al., 2015; Mavhura et al., 2017; Papathoma-Köhle et al., 2019).

Although these heuristics are generalized and reproducible to assess vulnerabilities in various parts of the world (Rufat, 2015), the pathways in which the social, economic, political, and cultural factors function to create the state of vulnerability is largely omitted in these assessments. In this article, one such vulnerability index framework will be used along with an explanation of the choice of the indicator variables, with a political ecology analysis of resource access and political control of livelihood choices. The next two subsections will first explain the adopted MLVI framework and then, illustrate how a critical political ecology of vulnerability analysis can help assess the indicator variables and analyze the findings.

2.2. Adoption of the MLVI Framework

The MLVI framework expanded Hahn's (2009) Livelihood Vulnerability Index (LVI), and combined it with the concept of Alkire and Foster's (2011) multidimensional poverty index (MPI) to obtain and assess data on variables that impact vulnerability at a small scale (individual and household) (Gerlitz et al., 2017). Both LVI and MLVI frameworks acknowledge vulnerability to be a function of: *i) Exposure*, or the proximity of an individual or a household to environmental or social stressors; ii) *Sensitivity*, or the extent in which an individual or a household is affected by a disaster that can be assessed by the entitlements and amenities they have, or do not have; and iii) *Adaptive or Coping Capacity*, that reflects the collective status and capitals of an individual or a household that help or do not help to minimize the negative impacts of an external disaster to return to normal life conditions (Turner et al., 2003a, b; Annan, 2003; Hahn et al., 2009; Gerlitz et al., 2017). The MLVI framework was postulated as part of a project called the Vulnerability and

Adaptive Capacity (VACA), a venture carried out by the *International Center for Integrated Mountain Development (ICIMOD)* and their local partners, under the umbrella project called the *Himalaya Climate Change Adaptation Program (HICAP)* (Gerlitz et al. 2017, p. 124, 127).

The MLVI designed a heuristic device to incorporate household level data that was largely missing in IPCC national and global scale assessments of climate change vulnerability. To understand the extent to which individuals and households are affected by environmental hazards, the MLVI adopted Alkire and Foster's (2011) methodology of MPI. Using this idea, Gerlitz and colleagues (2017) conducted thorough literature reviews and field interviews to identify indicators of vulnerability based on social components that make up the dimensions of vulnerability, i.e., exposure, sensitivity and adaptive capacity. Although the dimensions of vulnerability can be universally used, the purpose of dividing them into components and indicators were "context specific" aimed to inform policies at a regional level (Gerlitz et al. 2017, p. 127).

Gerlitz and colleagues (2017) used components based on the "mountain specificities" including two components, namely environmental shocks and socio-economic shocks under the dimension of exposure. They entailed environmental damage and socio-economic damage per household faced in the last 12 months. The dimension sensitivity included components that embody general wellbeing of households, health and sanitation, food security, water security and environmental stability. Adaptive capacity is divided under components as socio-demographic status, resource and energy, livelihood strategies, social networks, and physical accessibility. Ultimately 25 indicators under 12 components, and each component under one of the three dimensions of vulnerability were shortlisted for measuring vulnerability. The MLVI indicators as well as Hahn's (2009) LVI was influenced by Cutter's (2003) social vulnerability index.

In the MLVI framework, in addition to objective indicators such as consumption, access to markets, etc., subjective indicators that depend on perceptions were included (Gerlitz et al., 2017).

Perceptions of risk has long been considered as an indicator of adaptation in disaster research. Aguilar and Rivera (2016) used Bourdieu's concept (1990) *risk habitus* to study landslide vulnerability in Teziutlán, Mexico. This concept assumes individual perceptions of risk and social capitals are indicators of vulnerability that help households to access resources or other forms of capitals, such as political and economic capitals to cope with disasters. Decision-making plays an important role in people's responses to a disaster, thereby having a bearing on vulnerability (Murakami et al., 2020). The MLVI framework by Gerlitz et al. (2017) conceptualizes these subjective indicators within a measurable framework.

The MLVI framework is used in this study, firstly, because it can identify the indicators of vulnerability at a household level. Secondly, under MLVI, these factors can be analyzed separately. Additionally, the study area for this research is geographically closer to the study area of Gerlitz et al. (2017), both being situated in different parts of the Himalayas. Hence, the regional overlap and close connection of human-environment interactions allowed the adoption of several indicators used in the MLVI framework. In this research, further indicators, e.g., governmental, political and institutional relations with local households are measured and analyzed. The PE analytical framework appended with the MLVI, helped critically analyze the processes through which these indices construct vulnerability in the study area.

2.3. Political Ecology and Integration with the MLVI Framework

Political Ecologists approach vulnerability through critical analyses of the processes and impacts of environmental degradation on society (Blaikie, & Brookfield, 1987; Wisner et al., 2004). PE provides a plurality of approach: analyzing vulnerability through a) the dialectics of human-environment interactions through a broadly defined political economy (Blaikie, & Brookfield, 1987); b) marginalization of groups of people through political control over and access to environmental resources (Watts, & Peet, 2004; Ranganathan, 2015; Huber, 2019); c) political constitution of hazards and environmental degradation (Pelling, & Dill, 2006; Donner, 2007; Sovacool, 2018); d) vulnerability as outcomes of differential narratives of environmental degradation (Robbins, 2012). Political Ecology has distal antecedent roots in Risk-Hazards/Disaster research (Brannstrom, & Vadjunec, 2013), and to date much new PE research has focused on exploring pathways of vulnerability (e.g., Pelling, 1999; Ranganathan, 2015; Elmhirst et al., 2017; Griffin, 2019; Watts, 2016; Huber et al., 2017; Huber, 2019).

Epistemologically and theoretically, a Political Ecology research approach is different from a modernist approach of constructing vulnerability indices (often tied to economic theories, e.g., Capability Theory used by Alkire, & Foster, 2011), and assigning numerical weights of such indices (Cutter, 2003; Gerlitz et al., 2017; Alcantara-Ayala et al., 2017; Papathoma-Köhle et al., 2019). Political Ecology largely takes a middle ground between hardcore constructivism (see Smith, & O'Keefee, 1980) and hardcore realism by acknowledging that the human idea of nature depends on one's social idea of the world at any given point of time, at the same time recognizing that a problem will inevitably be seen differently with time (Robbins 2012, p. 125). From a Political Ecology perspective, vulnerability is "a complex social space constituted through geographically and historically specific networks of entitlement and power relation… [and the] dialectical relation between social theory and political economy…" (Watts 2016, p. 262). PE assumes that "any tug on the strands of the global web of human-environment linkages reverberates throughout the system as a whole" (Robbins 2012, p. 13). Integrating a PE lens with quantitative analysis is thus useful in situating vulnerability within a specific geographical context of human-environment relationships.

Using a PE framework, Ranganathan (2015) explored flood vulnerability in post-colonial Bangalore, India, by analyzing the changing dialectics of 'flow' and 'fixity' from the colonial to the neoliberal era. She approached the heightened risk of flood by analyzing the "sociomaterialistic" flow and fixity of capitalism that have impacted storm drains in Bangalore. Both Ranganathan (2015) and Pelling (1999) historicized the roots of flood vulnerability to colonial politics that translated to the redistributions of power and vulnerability by political elites. Andersson et al. (2011) discussed smallholder farmer's vulnerability in the African Sahel through chains of explanations of drivers as a function of environmental pressure, the role of state, their impacts and response. Elmhirst et al. (2017) assigned poor governance to be a common factor that affect disaster vulnerabilities. Human adaptations play a critical role in defining human agency in PE research. A recent study of involving the Bangladeshi vulnerability to climate change investigated that national adaptation programs have enabled elites to capture land forcefully and marginalize local farmers, with direct impact on vulnerability through changed land-use decisions (Sovacool, 2018).

PE uses a bottom-up approach where an individual's vulnerability is linked with broader social and ecological processes of resource use, access and control, responses to disasters and socio-economic and political capitals (Turner, & Robbins, 2008; Robbins, 2012; Brannstrom, & Vadjunec, 2013; Huber et al., 2017; Griffin, 2019; Yeh et al., 2014, Elmhirst et al., 2017). This bottom-up approach ties directly with the MLVI framework adopted in this research, that takes an individual or a household as the unit of study, which integrated together, derives a community's or a region's vulnerability (Alkire, & Santos, 2010; Alkire, & Foster, 2011; Gerlitz et al., 2017).

In the following section, the study area is discussed based on which the vulnerability index and political ecology chain of explanation will be analyzed.

3. Study Area Background

The study area for this research is based in Kurseong, a subdivision of the Darjeeling district of West Bengal in the eastern Himalayan mountain ranges of India (Fig 3.1). According to the latest census, 77% of the workforce in Kurseong were engaged with plantation or smallholder agriculture (Census of India, 2011). To this date, Kurseong is mostly rural, where people's livelihoods largely depend on agriculture (based on the most recent field visit on January 2018). At the same time, this region, being situated in a tectonically active thrust-fold mountain belt, faces a constant threat of earthquakes and landslides that have historically claimed lives, belongings and land (Basu, & De, 2003; Basu Roy, & Saha, 2011; Ghosh et al., a, b). The majority of the present-day population of Kurseong consists of descendants of immigrant laborers from Nepal, and Indian states of Bihar, Assam, Bengal, among others who settled during the British regime's establishment of tea plantations in the 1850s (O Malley, 1999 [1907]; Khawas, 2005; Besky, 2008). Kurseong, previously a densely forested mountain ecosystem was subjected to massive transformation with roads and railway networks, rural and semi-urban settlements, as tea became an important cash crop and a major revenue earner in the region in the late nineteenth and early twentieth century (Das et al., 2011; Biswas et al., 2013). Tea being a labor-intensive industry, a large number of workers were required to stay within plantations. So, they were given housing, health insurance and subsidized schooling for children by the British government (Khawas, 2005).

During the postcolonial era, the economic conditions of plantation workers have not improved. The Indian Labor Act of 1951 still protects the workers with free and sometimes subsidized accommodation, however, as of 2018, the wage of the plantation worker was less than an equivalent of $2/day (Besky, 2008, 2017; Field notes, 2018). In most of the families, not everyone is an earning member. Additionally, living amenities do not always have adequate sewerage, drains, sanitation, water supply and protection from landslide disasters, common in the region.

The smallholder regions in Kurseong, as studied for this research, are either in more inaccessible and hilly regions in the north, or towards the foothill region in the south, most of which have been affected by landslides. Although the regions differ in accessibility to amenities and facilities such as transportation, access to markets, roads, healthcare centers and schools, the residents live in constant threat of landslides and feel vulnerable. In this context, vulnerability of farming households is analyzed across multiple dimensions. The variables identified through field investigations (e.g., key-informant interviews), were used to collect primary household data that were incorporated in the MLVI framework, as well as analyzed through PE chain of explanation. Focus are given on resource availability as it influences local adaptive capacities, an important dimension of vulnerability; land-use choices and constraints that impact local exposure to landslide hazards, and structural (institutional and government) aids that impact sensitivity and adaptive capacity of the households to natural disasters.

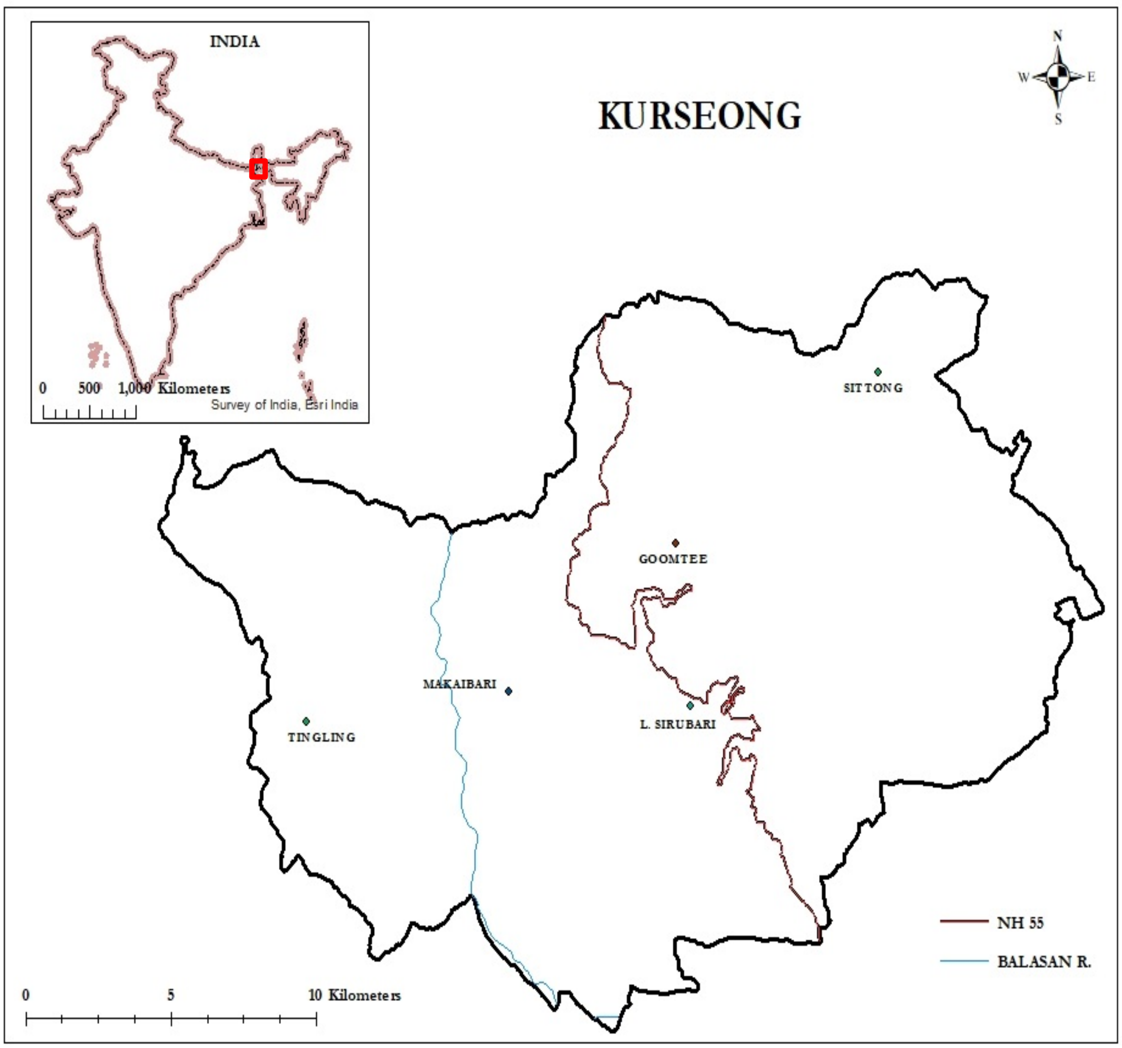

Fig 3.1. Location of Kurseong and Study Areas

4. Materials and Methods

This research combines the MLVI framework by Gerlitz and colleagues (2017) with a PE analytical framework in a) identifying appropriate indicators of vulnerability in five villages (field sites) of Kurseong, each with varied experiences of and adaptation to landslide disasters; b) explaining the interactions among the various indicators in the social construction of vulnerability. This study is part of a larger study with a bigger goal to understand the role of human-environment interactions on vulnerability in a disaster-prone region. As part of the field methods, primary data were collected via key-informant (K-I) interviews and Household (HH) surveys on five selected study sites. The following subsections of the methodology will explain the objectives behind the primary data collection and how the data have been integrated within the MLVI framework and vulnerability analysis.

4.1. Key- Informant Interviews

30 K-I interviews were conducted with local tea plantation managers/owners, smallholders, and government and local administrators who have experience and expertise on topics such as farmer livelihoods, disaster response, vulnerabilities and infrastructures for sustainability and disaster mitigation. Purposive and snowball (respondent-driven) sampling methods were used to select key informants where a few were chosen initially. The participants then referred to other potential interviewees having expertise in their respective fields (Longhurst 2012). Semi-structured questionnaires were used to obtain these information and informed perceptions on one of the aforementioned themes. K-I interviews provided a) selecting field sites to conduct HH surveys, b) set up a questionnaire for the surveys to cover the maximum information on livelihoods, adaptation, environment and vulnerabilities, and c) provided relevant information to understand the chain of causation that result in the nature and type of vulnerability in Kurseong.

Selection of Field Sites

Tea plantations cover more than 90% of the agricultural area in Kurseong. Three tea plantations (Tingling, Makaibari and Goomtee) were selected spreading from the western through the eastern side of Kurseong where tea is optimally grown. Two rural areas (Sittong and Lower Sirubari), predominantly and traditionally practicing smallholder agriculture were chosen, one each from the northern and southern parts of the subdivision. Another criterion of selecting these five villages was that they have had different landslide histories and land managers. For example, the Makaibari plantation is known to be relatively stable compared to the other villages. Tingling suffered losses from landslides in 2015 after the Nepal earthquake and is most vulnerable currently. Goomtee is an example of a plantation community that experienced great loss of property and life 20 years ago and stabilized with local mitigation measures. One of the two smallholder regions, Sittong, also have a 30-year-old landslide but have continued to be vulnerable as mitigation measures have not been satisfactory. In Sirubari, the local landslide is more recent (reportedly started in 2011). It did not affect the households directly, albeit some households losing agricultural land, it did impact transport and mobility by blocking the roads to the towns and schools. The differences in landslide exposures and land management within the five study areas were preferred to identify possible differences in adaptation processes as well as underlying commonalities that influence local vulnerability to landslides.

4.2. Household Surveys

The household survey questionnaire consisted of 150 structured questions related to social, demographic, economic data; lifestyles, amenities, consumption patterns; exposure to disasters, perceptions of vulnerability; and governmental/political aids before and after a disaster event. A total of 146 households were surveyed, with a minimum of 25 and a maximum of 31 HHs from each of the 5 field sites. A purposive sampling method was followed to select the HHs that were representative of the maximum HHs within a village. These HHs according to K-Is having regional expertise, represent the minimum outliers in terms of livelihood, consumption patterns, exposure to landslides, among others. For the purpose of this article, data from the HH surveys were incorporated in the MLVI framework where 24 indicators of vulnerability were identified.

4.3. MLVI Methodology

The overarching purpose of the MLVI framework is to identify and evaluate the potential of an individual or household to be adversely affected by environmental stressors (Gerlitz et al., 2017). Apart from field investigation, the data collected through household surveys and incorporated in this framework, are also based on thorough literature reviews on risk – hazards research (Jodha, 1992, 2001, 2005; Kasperson, & Kasperson, 2001; Turner et al., 2003a, b; Wisner, et al., 2004; Rufat et al., 2015; Gerlitz et al., 2017); United Nations discussions on Human Development and Adaptation to Natural Hazards (UNDRR, 2009, 2015, 2019); research on economics related to poverty and human wellbeing, specially Capability Theory (Sen, 1993, 1996, 2004; Alkire, & Santos, 2010; Alkire, & Foster, 2011); and studying reports on India's average acceptable levels of consumption and living standards in rural and urban areas (NSSO, 2017; Census of India 2011; World Bank, 2020).

The MLVI framework divides 24 indicators of vulnerability under 12 components that include social, environmental, perceptional, and adaptive aspects of vulnerability (Table 3.1). These components were further nested under the three dimensions of vulnerability, namely *exposure, sensitivity* and *adaptive capacity.* Each component is weighted equally because they are perceived as mutually independent (Alkire, & Santos, 2010; Gerlitz et al., 2017). The MLVI is a product of the proportion of households that are multidimensionally vulnerable, known as the headcount ratio (H) and the average intensity or the average of the weighted sums of all the indicators of each multidimensionally vulnerable household (A). So, $MLVI = H \times A,$ or the overall vulnerability index for a region. The next sub-sections will discuss in detail the choice of indicators, the weighting system and the implementation of the MLVI framework.

Table 3.1. Dimensions, Components, Indicators, Weights and Initial Cut-Off for the MLVI (adopted from Gerlitz et al., 2017)

Dimension	Component	Indicator	Weight	Vulnerable If…
Exposure	Environmental Shocks	Environmental impacts from Landslides	.083	The HH suffered landslides in the past or at present/lost agricultural land/moved to a different place because of landslides.
	Socio-Economic Shocks	Socio-Economic Impacts from Landslides	.083	The HH has lost money/property/lost someone from landslides. Suffered physical harm.
Sensitivity	Food and Drinking Water	Consumption	.042	The monthly HH earnings – rent < the national (rural) average expenditure for per-head food consumption, which is Rs. 659.1 (NSSO, 2017)
		Adequate Water Supply	.042	The HH does not get adequate water supply at any time of the year/have to buy water at a hefty price for the period of water unavailability. And/or HH members travel for a distance of >1 Km and/or >30 minutes for drinking, cooking and other HH purposes.
	Shelter	Shelter	.042	HH does not currently have a shelter and lives in makeshift place/refugee shelter/neighbor's HH for a minimum of 6 months (it is a reasonable time required to build a house with brick walls and asbestos roof). This makes HH deprived of the basic means of living.
		Land Holding/Tenure	.042	HH lives in plantation or government housing and although they are not forced to vacate, they feel vulnerable for not having a land ownership.
	Health Care	Health Care Facilities	.042	HH does not have free or subsidized general healthcare near home, and affordable healthcare facilities for serious illness.
		Health Care Distance	.042	HH does not have access to networked healthcare facilities within a 5-kilometer radius distance. This increases vulnerability of a sick person or a disaster victim to access immediate health care (Kadobera et al., 2012).
	HH Infrastructure and Amenities	Toilet, Bath, Sanitation	.028	HH does not have proper toilet at home/ has kuccha toilets/open space for bath and toilet/ visits neighbor's house/jhoras/slopes for sanitation, ablution or washing purposes. This adversely impacts HH sensitivity to landslides.
		Sewerage & Waste Disposal	.028	HH does not have proper closed drains to carry wastes/ HH dumps kitchen/toilet/other wastes in slopes. This makes HH prone to air and water borne diseases. Also, untreated wastes along slopes pollute soil and agricultural crops that they grow within HH premises, as well as destabilize the slope soil.
		Burning non-biodegradable materials	.028	Burning plastics or other non-biodegradable wastes in slopes within HH premise makes HHs vulnerable to air pollution and create health problems.
	Environmental Impacts	Proximity to landslide or sinking area	.042	HH lies within 100 feet of a landslide area/lies within a sinking area. This increases a chance of the HH to be affected by a future landslide event manifold.
		Dwelling Condition	.042	Cracks seen in walls/roof/floor, which have not been/will not be repaired soon/ house is in a steeper slope than 26 degrees or the critical angle of repose for clay, earth or gravel to slide or topple.

Dimension	Component	Indicator	Weight	Vulnerable If…
Adaptive Capacity	Socio-demographic Status	Dependency Ratio	.042	HH dependency ratio > 1.5 meaning if a HH member belongs to the work force and has to take care of more than 1 person in the HH (Gerlitz et al., 2017).
		Education	.042	HH head does not have primary education – this makes HH decision-making poorly informed especially during stress (Gerlitz et al., 2017)
	Livelihood Strategies	Agricultural job status	.042	HH either does not have at least 1 member working as a permanent worker within tea plantation/or has < .07 hectares of per head arable land for agricultural production, which is regarded as the bare minimum for sustenance (Myers 1999, mentioned in Gerlitz et al., 2017).
		Non-Agricultural Job Diversity	.042	There are no alternative non-agricultural jobs if the minimum requirements are not met by the agricultural livelihood strategies.
	Resources & Aids	Government Aids	.042	HH is a victim of landslide and have been denied adequate compensation of housing, money and other basic amenities such as food and clothing for more than 6 months.
		Employer and Community Aids	.042	HH has no provision for housing, food and clothing from employer or community in case of a disaster.
	Physical Accessibility	Access to road	.028	HH does not have access to proper road within 1 kilometer, to reach a destination, carry goods.
		Access to public transport	.028	HH does not have access to public transport within 1 kilometer; adult walks more than 1-kilometer daily to work, market or to healthcare institutes, and kids to school. This increases vulnerability during illness, trauma or disasters.
		Access to market	.028	HH does not have access to markets within <10 kilometers. If the nearest market place is 10 kilometers and more, it takes >2 hours round-trip to collect necessary items for the HH.
	Perceptions	Environmental Stability	.042	HH lives in constant threat of landslides. Fear risks adaptive or coping capacities during disaster and increases sense of inadequacy to cope with a disaster impact.
		Socio-economic Stability	.042	HH is aware that they will not be able to withstand a disaster economically even if there is no death in the family.

Selection of Indicators, Choice of Weights and Cut-Offs

To understand the utility of the MLVI and implement it to other research it is important to explain the reasonings behind the choice of indicators, weightage and two cut-off points. Table 3.1. explains the dimensions, components, indicators and their weights and what constitute to be the first cut-off point to be considered vulnerable for each indicator. The choice of indicators and components are a mix of those used in the Gerlitz et al. (2017) study, as well as several indicators that are specific to this current research. The latter were included using primary data from field study and household surveys conducted in the region. The utility of the MLVI framework lies not only in identifying and aggregating multidimensional aspects of vulnerability but also in its ability to decompose into the share of vulnerability for each indicator, component and dimension (Gerlitz et al., 2017). This helps in practical interventions for each deprivation the household unit faces.

A. Selection of Indicators

In this study, the MLVI framework has 3 dimensions, 12 components and 24 indicators of vulnerability. All components are weighted equally that determined the aggregate weights of each dimension and individual weights of indicators. While *Exposure* has two components and one indicator for each component, components under *Sensitivity* and *Adaptive Capacity* has multiple indicators. For example, consumption is considered as a better indicator than income (Sen, 1993; Alkire, & Santos, 2010; Alkire, & Foster, 2011; Gerlitz et al., 2017), because it indicates the how well needs of each member of household is met after paying off rents and debts. Water supply is considered as a separate indicator because procurement of water is different from consuming other food and essential items. Hence consumption and water supply are aggregated under the component of food and water supply. Availability of healthcare facilities are widely considered to be an important indicator to tend to victims of environmental shocks. Combined with the physical inaccessibility of mountains (Ives, & Messerli, 1989; Jodha, 2005; Pant, 2003), the distance to health care facilities also prove to be an important indicator, both combined under the component of health care. The fragility of mountains involves difficulties in establishing infrastructure for proper waste management, more so to keep up with a growing population. The aspects of vulnerability observed in the study area regarding household infrastructure and amenities include three indicators, viz. sanitation, waste disposal and sewerage and destroying non-degradable wastes such as plastics. Lastly, the proximity of the household to a sinking area makes it sensitive to present and future landslide impacts. These impacts are specifically reflected in the dwelling condition if cracks or sinking floors are visible in the household.

The components and indicators representing adaptive capacity include the dependency ratio of each earning member of household, i.e., the ratio between the employed and unemployed people in the household. The higher the value the more vulnerable is the household. Education is also considered an important factor to reduce vulnerability as it provides adequate knowledge to cope with adverse situations (Gerlitz et al., 2017; Alkire, & Foster, 2011). Both agricultural and non-agricultural livelihood opportunities available in a region also influence the adaptive capacity of a household. Access to resources and institutional aids e.g., governments and employer institution help coping capacities in a household that was observed to be an important indicator of vulnerability in the study area. Moreover, physical accessibility to roads, transports and market at times of crisis are important indicators influencing adaptive capacity. Lastly, perceptions of environmental and social vulnerabilities are included to sum up most of the drivers of vulnerability observed in the study area.

B. Choice of Weights and Cut-Offs

Assigning weights is a crucial part of the MLVI calculation. If the aggregate vulnerability is considered to be 1, then the 12 components are equally weighted as $\frac{1}{12}, or\ 8.3\%$. Having 2 components, the individual weight of dimension exposure is $\frac{1}{6}, or\ 16.7\%$, and the dimensions sensitivity and adaptive capacity have $\frac{5}{12}, or\ 41.7\%$ share of total vulnerability each. If there are 1 indicator in a component, they carry an 8.3% weight. For a component having 2 indicators, the individual weights of each is at 4.2%; similarly, for a component having 3 indicators, the individual weight of each is at 2.8%. So, if a household has a vulnerability of 1 then it is vulnerable with respect to all indicators.

The MLVI framework uses a two-step cut-off, first, to identify if the household is vulnerable with respect to each indicator, then if the household is multidimensionally vulnerable to ultimately be included in consideration for the MLVI calculation. The second cut-off to determine if the household is multidimensionally vulnerable is unanimously decided both in the MPI and MLVI development to be 30% (Alkire, & Santos, 2010; Gerlitz et al., 2017). That means, each household should be vulnerable to at least 30% of the indicators to be considered multidimensionally vulnerable. The first cut-off of vulnerability is the cut-off for individual indicators defined in Table 3.1. For example, a household is vulnerable with regard to the indicator "consumption", if the per-head food consumption per month for each member of the household is less than Rs. 659.1 (NSSO, 2017). If the household is not vulnerable a zero is assigned to the weighted value for that indicator, if not, the weight of 4.2% is added against the indicator. This method is performed for each indicator and then their aggregate weighted sum is calculated.

The second cut-off is decided to be 30% or total value of 0.33 for a household to be considered to be multidimensionally vulnerable used in both MPI and MLVI framework (Alkire, & Foster, 2011; Gerlitz et al., 2017). If the aggregate vulnerability value is < 0.33 then the household will not be included in further MLVI computation. For example, a household may choose to live in a remote region, might be considered vulnerable with respect to the component "physical inaccessibility" but is otherwise not vulnerable. Commonly, an actually vulnerable household is seen to be vulnerable to multiple indicators thereby satisfying the second cut-off.

4.4. PE Chain of Explanation of Multidimensional Livelihood Vulnerability in Kurseong

From a detailed field investigation and results derived from the MLVI framework, all the indicator variables are synthesized and analyzed together to understand the big picture of vulnerability in the study area. The indicators, components and dimensions of vulnerability are part of a system of human-environment interactions and adaptation that is influenced by environmental and social structure of the region. The significance of political control over environmental resources and impacts on societies has also been recognized in risk-hazards literature (Wisner et al., 2004; Pelling, & Dill, 2006; Watts, 2016). Pelling, & Dill (2006) defined disasters as a political process as well as an influencer of further political processes ensuing from the disaster. Citing examples of disasters from all over the world he established governmental and institutional manipulation hitting marginal lands and marginal groups of people, political unrests ensuing from such repeated political neglect, political manipulation of local land-users to relocate at similar or more hazardous regions, among others (also Wisner et al., 2004). The results will be analyzed along these issues of political ecology to understand the progression of vulnerability in these apparently different field sites, studied for this research.

4.5. Analysis and Synthesis

The MLVI framework provides a normative assessment of individual indicators, components and dimensions at multiple levels. The aggregate vulnerability index identifies the share of vulnerable households in a community, and the degree to which households are vulnerable. The framework also allows decomposition of individual indicators, components and dimensions that helps in individual analysis of various aspects of vulnerability for sustainability policies, planning and further research. In this study, such decomposition is presented in the form of graphical representation. This gives a detailed and comprehensive picture of indicators that make local people vulnerable in the study area. This normative computation is further integrated with a non-normative political ecology analysis that interprets the broad functioning of a system in which the factors of vulnerability exist from a soft-constructivist point of view. For example, why certain households have not yet been relocated from refugee shelters long after a landslide event; or why do people have to travel long distances to collect water, among others are situated within the socio-economic and political context within the study area, and synthesized. The political ecology analysis is represented as a "chain of explanation" in which all indicators of vulnerability interact together.

5. Results

5.1. MLVI of the Five Selected Field Sites

Figure 3.2. shows the *headcount ratio (H), average intensity (A) and MLVI* for each of the five villages in Kurseong.

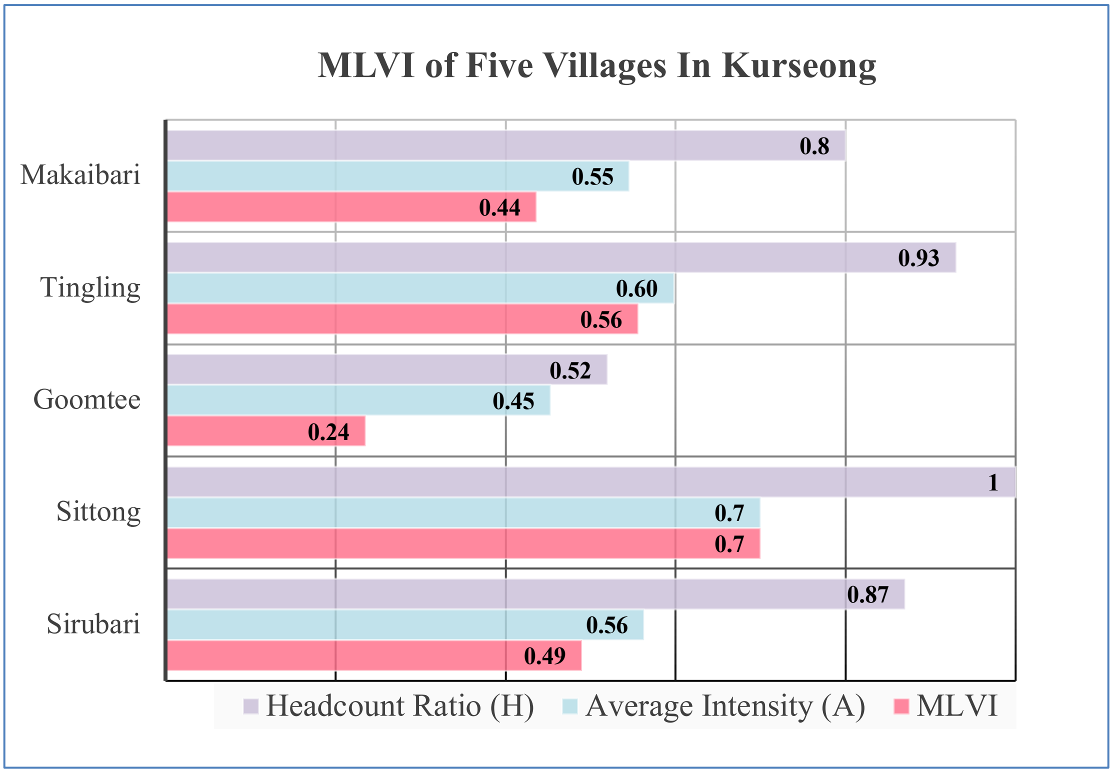

Figure 3.2. Headcount Ratio (H), Vulnerability Intensity (A) and MLVI In Five Villages of Kurseong

The headcount ratio of field site Makaibari is 0.8 and the average intensity of vulnerability is 0.55, meaning 80% of the households were multidimensionally vulnerable with respect to 55% of the indicators. Hence overall MLVI in Makaibari was H × A = 0.44. Tingling plantation have expectedly a higher headcount ratio where 93% of the households surveyed were multidimensionally vulnerable in terms of 60% of the total number of vulnerability indicators. Their MLVI is 0.55. Goomtee plantation village was the most stable among all the study areas. With a headcount ratio of 0.52 and average intensity of 0.45, the MLVI was lower at 0.24. The

MLVI however was low because of the lower headcount ratio. The multidimensionally vulnerable population still have a high average intensity of 0.45. Sittong smallholder rural area is the most vulnerable with a headcount ratio of 1 and the average intensity of 0.7 meaning all households were vulnerable to an average of 70% of all the indicators chosen for this vulnerability analysis. In Sirubari, the headcount ratio is also high (0.87) and the average intensity is 0.56 thereby having the MLVI value of 0.49. Next, the contribution of each dimension, component and indicator within the MLVI framework is explained.

5.2. Decomposition of the MLVI into Dimensions, Components and Indicators

Figures 3.3, 3.4, and 3.5 illustrate the individual shares or contributions of each dimension, component and indicator to the vulnerability index. A major advantage in the computation of MLVI framework lies in its decomposability (Gerlitz et al., 2017). In figure 3.3, the total value of the MLVI is divided into the three dimensions. Results show that *Exposure* to 'external' shocks has the least contribution to vulnerability in all five field sites. *Sensitivity* and *Adaptive Capacity* have the most (together contribute 80% of the vulnerability) and equally impactful shares. In other words, the environmentally extreme events create a ripple effect in the society and its infrastructures compounding people's vulnerabilities manifold.

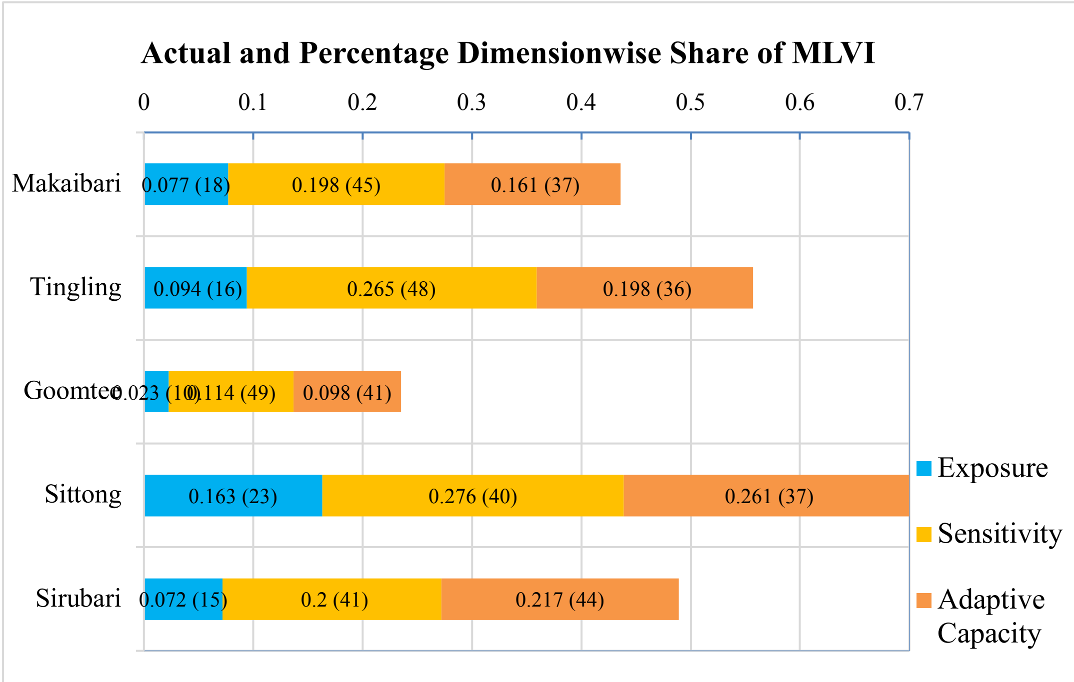

Figure 3.3. Individual Dimension-wise Shares of Vulnerability in Actual Values and Percentage (in bracket) in Five Villages of Kurseong

Of the total share of vulnerability in Makaibari, 18% was due to environmental and socio-economic shocks from landslides. Tingling had a 16% share of exposure, while Goomtee and Sittong were tied at 23%. Lastly, Sirubari had an exposure of 15% contributing to their total share of vulnerability. The relative share of exposure in Makaibari is more than that of Tingling and Sirubari because the degree of social deprivations is less than the other two, the latter being subjected to more recent and devastating landslide events. Interestingly, the relative share of sensitivity is highest in Goomtee because of the limited amenities and household infrastructure available there. Their exposure to extreme events has been less due to a good management system of the tea estate that had worked hard with the government in stabilizing the landslide affected areas with tangible results. Overall the percentage share of all five study villages are comparable and thus can be considered representative for the bigger subdivision region.

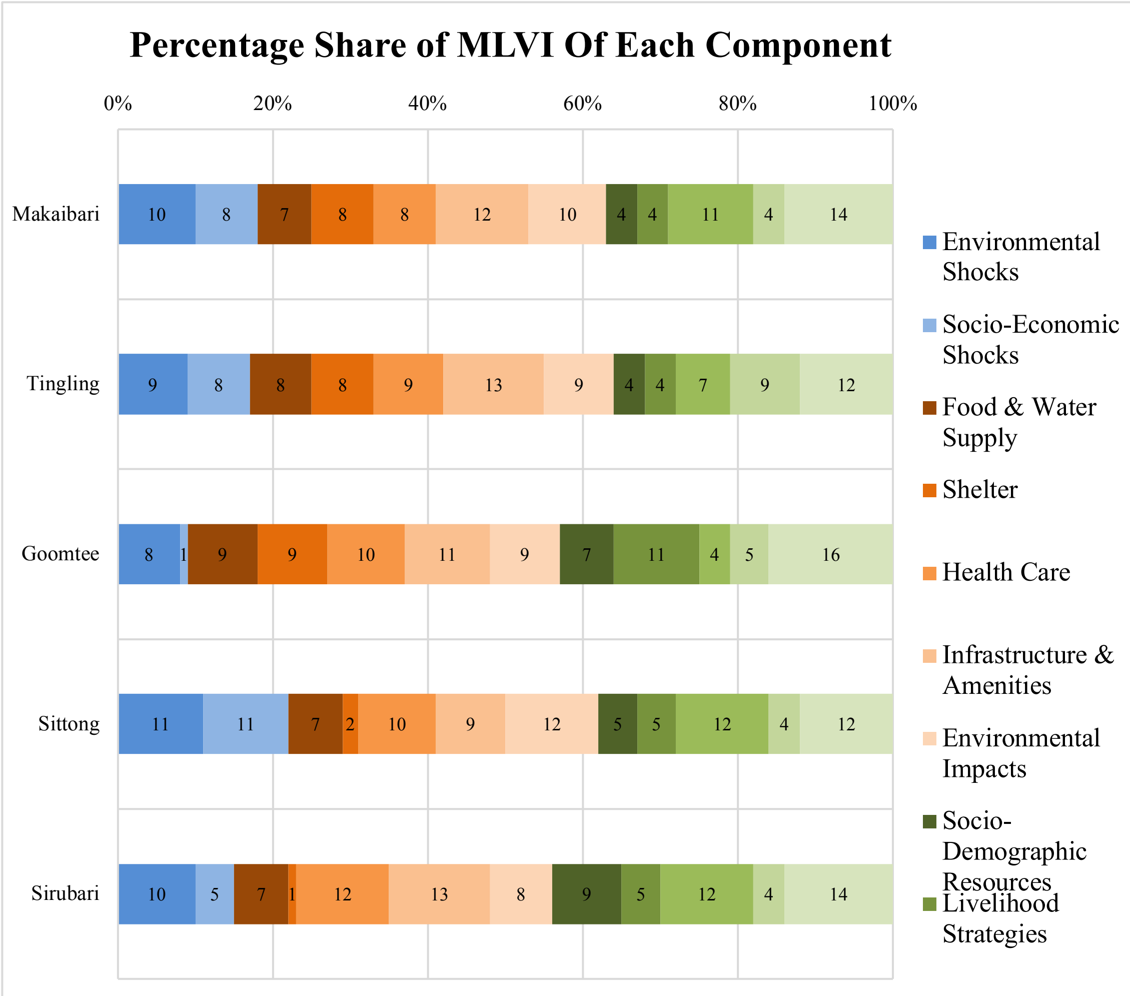

Figure 3.4: Relative Shares of Vulnerability (percent) for each Component in Five Villages of Kurseong

Figure 3.4 illustrates the individual shares of each component in the MLVI. The highest share of vulnerabilities is seen with respect to environmental and socio-economic shocks (except for Goomtee), deprivations in terms of household infrastructures and amenities, disaster victims receiving aids and compensation from employers and the government, and fear of environmental and social calamities. Similar vulnerability shares of components among the five study sites justifies an expectation of similar outcomes for the larger Kurseong region.

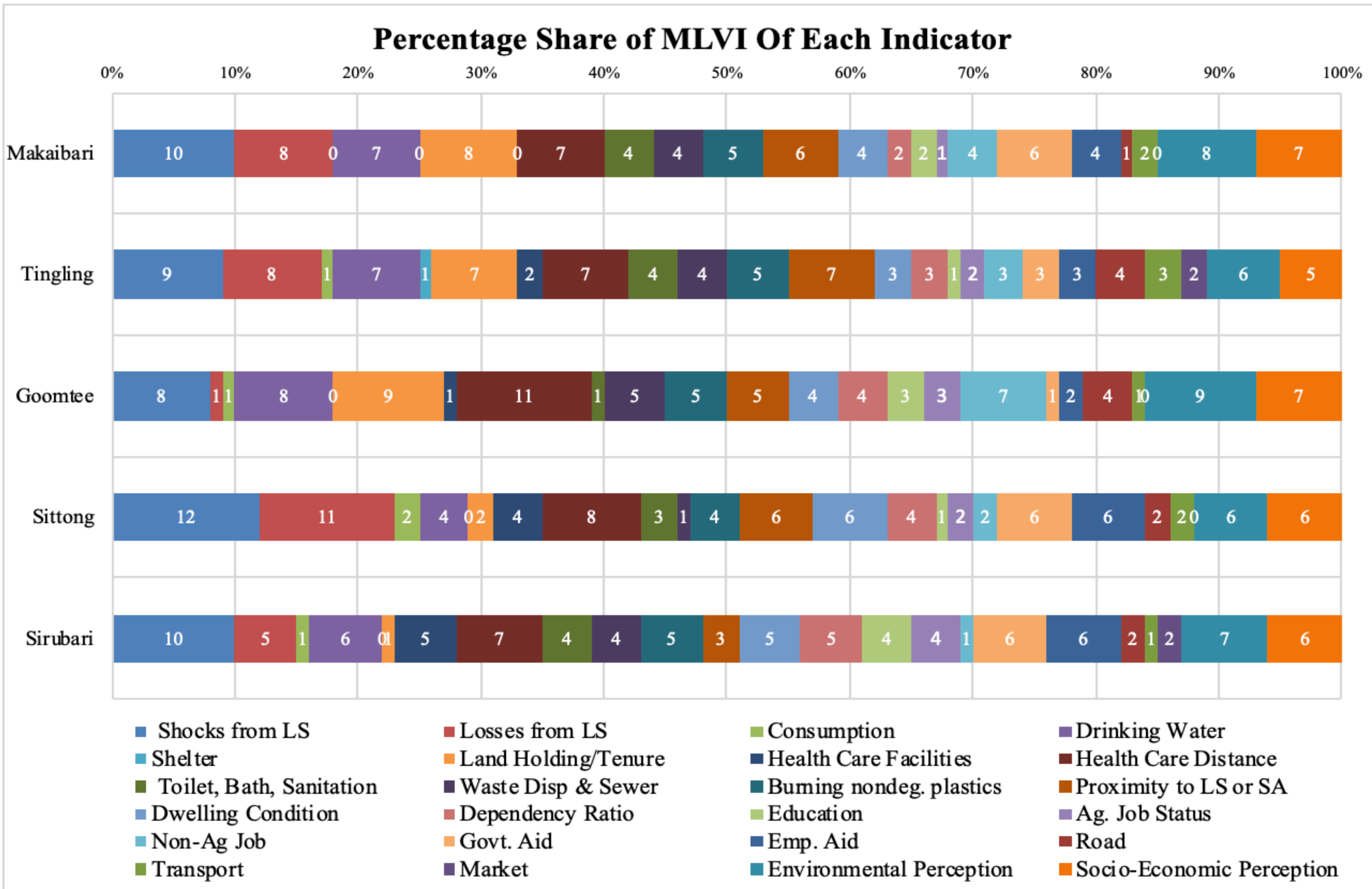

Figure 3.5: Relative Shares of Vulnerability (percent) for each Indicator in 5 villages of Kurseong

Figure 3.5 decomposes the vulnerability share for each indicator that identifies how a specific indicator contributed to the overall vulnerability. Any number of these indicators can be acknowledged during specific policy upgradations for sustainable development. For example, lack of land tenure makes tea plantation workers more vulnerable after a disaster event, due to lack of compensation should they lose their dwelling, as seen in Tingling. Similarly, indicators such as distance to healthcare, lack of infrastructure and proper amenities, government aids to individual households confirm the lack of resources among the local people of the five villages studied. These indicators reinstate that people having less access to resources and less capitals are more vulnerable to negative environmental changes (Cutter, 2003; Wisner et al., 2004; Adger, 2006; Birkmann, 2006).

5.3. PE Analysis of Multidimensional Livelihood Vulnerability

From the MLV results, some salient conditions of vulnerability in Kurseong can be confirmed. As previously mentioned, the field sites chosen for the study apparently had varying degrees of stability and exposure to landslides. After rigorous modeling and measurement however, many cracks were identified in the stable region, Makaibari. Key informants revealed Makaibari to be the pioneer in adopting sustainable plantation practices, high profits, and better farmer conditions. Yet, the region came out to have a high vulnerability index. Observations during HH surveys corroborates the fact that people in Makaibari are similarly vulnerable as in other plantations, in terms of dwelling conditions (cracks in floors and walls of houses), inadequate infrastructure for waste disposal (environmentally harmful), severe problems with water availability, and a colonial cash-crop agricultural system that provides continued low wage labor to plantation workers.

Existing System of Plantation Agriculture and Conflicts

The first salient factor for farmer vulnerability in plantations is the existing system of plantation agriculture itself. Although individual management systems in different estates here and there, may stabilize a landslide area and relocate landslide victims, the infrastructure to allocate proper living conditions and standards to the workers is missing. For example, Goomtee tea plantation has the lowest vulnerability index because of an efficient management system, still, 45% of the households surveyed were vulnerable in terms of land tenure, living conditions, consumption, water supply, lack of sanitation and drainage systems. The reason why such vulnerability pattern in consistent in plantations has roots in a colonial exploitative system of plantation agriculture that has somehow been carried to the existing system of tea plantations in eastern India. The study area is part of the Darjeeling tea plantations controlled by the Tea Board of India that record the lowest farmer wage in India (Sarkar, & Reji, 2019). By the mandates of the tea board, each plantation complies with the regulations of the tea board, so, for example, wages and housing of workers among all plantations in Darjeeling have to be equal (see also, Sivanesan, 2013 for functions of the Tea Board). A raise in wages only happens when all plantations agree to it (K-I). Hence, farmer conditions within individual plantations do not improve with profit within that same plantation. This explains why some indicators of vulnerability are consistent among plantations having managements with varying capacity.

In Tingling plantation, more than 40 people went missing, 19 people were killed, and 150 HHs had to be relocated after the 2015 July landslide, because of plantation workers living in less than safe conditions (Telegraph India, Feb 2016). Key-informant interviews with local experts and participant observations revealed that until 2018, their relocation was not complete. Farmers without land holding/tenure do not need to be compensated as they are provided subsidized housing within a plantation land. So, plantation workers who lost their homes lived in refugee shelters (e.g., schools, neighbors' house) but worked for their daily wage earnings.

Protests and political strikes have ensued against the State Government as they control the Tea Board Regulations (previous such issues are documented in Khawas, 2005; Besky, 2008). Cries for better wage (Besky, 2017; Robbins et al., 2020), amenities and land tenure has given shape to a bigger political agenda and further exacerbated worker conditions e.g., through stalling wages during strikes. The lack of support, or rather, conflict with more powerful groups, here, government and plantation administrations that have control over land resources as well as local livelihoods, have repeatedly and cumulatively impacted adaptive capacities of farmer households.

Environmental Inaccessibility

Secondly, inaccessibility plays an important role in thwarting developmental policies in the hills of West Bengal (Rumbach, 2016). The smallholder region, Sittong, has been most vulnerable among all the five study areas because of its rugged terrain. A massive landslide in Sittong started in 1982 and have relapsed several times since then. At least 11 households surveyed in this region were displaced and lost fertile agricultural lands. Every household surveyed in this region have been vulnerable for more than 70% of the indicators. In Sittong, every household is vulnerable to environmental shocks, proximity to landslide or sinking area, amenities to dispose non-degradable waste, government or other institutional aids and their perceptions of environmental vulnerability. 97% of the households are vulnerable to socio-economic stressors, having high dependency ratio and unemployment in the area. Most traditionally smallholders who lost land or access to agricultural lands due to the disaster has been compensated inadequately. As a result, their primary livelihood strategies have dwindled considerably. The alternate jobs include those of semi-skilled temporary construction labor jobs that have a high work load with low wage.

The landslide near Sirubari blocks roads during monsoons and prevents workers and children from being able to commute back and forth between home, work, and school. Job opportunities are marginally better in Sirubari than in Sittong because it is closer to the Kurseong township. Still 81% of all vulnerable households have not received help from the government in terms of stabilizing roads, compensating for cracks in houses among others. 96% of the vulnerable households in Sirubari have to burn plastics near their homes, as is the case for all other villages data was collected on, resulting in atmospheric pollution and other unassessed climate change issues. Drinking water problem is prevalent in 77% of the vulnerable population whereas access to proper sanitation and waste disposal system is absent among more than 80% of the vulnerable household.

The Political Ecology of Adaptation of the Grassroot Population

Finally, a third factor that contributes to the continued production of vulnerability, and widely recognized in political ecology studies (Pelling, & Dill 2006; Robbins et al., 2020) is local land-users' adaptation amidst the infrastructural constraints posed by government, employer institutions, and environmental conditions. Earlier parts of this bigger research showed landslide vulnerability is the highest near settlements and rivers because of unsustainable drainage and disposal. People having inadequate job opportunities restore to the drudgery of low paying labor job, with no land of their own to farm, no house under their name. Hence, repair of housing damaged after a disaster event is impossible to afford. These factors function together and cumulatively exacerbate vulnerabilities of local farmers. The highest number of respondents perceive that vulnerabilities are caused by systemic marginalization of hard-working farmers that have historically constrained their access to basic resources but benefitted from their labor.

6. Discussion and Conclusion

This paper analyzed disaster vulnerability by integrating two paradigmatically different, yet, related fields of human-environment research. While disaster-risk/vulnerability research has a normative goal to quantify and measure a subjective social characteristic, i.e., vulnerability, political ecology provides an explanation to how such drivers of vulnerability function together in an interactive way. As Birkmann (2006) mentioned the goal of any scientific community involved in disaster research according to the United Nations expectations, lies in "[developing] systems of indicators of disaster risk and vulnerability … that will enable decision-makers to assess the impact of disasters on social, economic and environmental conditions and disseminate the results to decision makers, the public and populations at risk" (Birkmann, 2006, p. 10), both positivist Hazards – Risk/vulnerability research and pluralist/constructivist PE research assimilates there. This research has a similar aim to disseminate the results to help policy modifications.

Five field sites, used to identify multidimensional livelihood vulnerability in Kurseong, have some variations in terms of number of households vulnerable and the average intensity of vulnerability. Yet, an underlying commonality lies in the fact that many indicators of vulnerability e.g., infrastructure, amenities, etc. are similar, spanning all field sites. From a political ecology perspective, the production and prevalence of vulnerability in Kurseong functions from a plurality of approaches. The structural control over livelihoods and land resources in a region established primarily as a plantation agricultural region, have historically focused on enhancing profits for the government and endowed plantation managers. The human laborers, consisting of the major work-force in the study area, are cheap in terms of wages, but have been an indispensable part of the production process. The plantation systemically minimizes farmer entitlements. In other words, farmer marginalization does not depend on individual plantation managers, rather it depends on the plantation system as a whole.

Smallholder regions, although outside tea plantations, have similar entitlements, as they are geographically situated within a social-ecological system that was primarily established for plantations. Smallholder regions have less institutional help, without the plantation management, and with inadequate government funds to help in times of disasters. Local conflicts that erupt from disdain, cumulatively impact wages and livelihoods, exacerbating vulnerabilities. Social vulnerability in Kurseong thus, have a commonality particularly in indicators of sensitivity and adaptive capacity. Exposure to natural hazards have the lowest impacts in the determination of vulnerability.

This research, in spite having a strong foundation and findings, have some practical limitations. The field method of household surveys could not be randomly selected for the study. The difficulties of accessibility and availability of respondents made household selection based on purposive sampling. Although it is expected that the results have been most representative of the maximum number of HHs in the region, yet it might fail to cover any different stories that are present in reality. Moreover, vulnerabilities are specific to plantation and smallholder farming households. The rest of the livelihoods are left out to avoid complexity and due to the fact that such livelihoods are sporadic. Despite of these shortcomings, the integrated methodology is robust in providing a deeper understanding of the relationships between vulnerability, marginalization and environmental degradation.

The scope of an integrated MLVI and political ecology approach far exceeds the regional limitations. The MLVI approach stress on the significance of the method of vulnerability calculation in its replicability in other research (Gerlitz et al., 2017). The original methodology acknowledged the identification process of indicators and components within the MLVI framework to be based on "normative decisions" (Gerlitz et al., 2017, p. 135), and hence there is room for adding and removing components based on contextual studies of the empirical work. While reproducibility is an advantage of such frameworks, PE themes of marginalization, lack of access to resources, among others define the complex co-production of vulnerability as a case study. This research adopted several indicators used in the original MLVI study (from Gerlitz and colleague's work), at the same time found room to incorporate in field indicators as observed specific to the study area. Thus, while broad dimensions, and some components define universality of social parameters of vulnerability, a combination of unique variables stress the importance of empirical analysis for specific geographical variations. Scientifically, a transdisciplinary study of vulnerability opens up the possibility of integration of ideas to approach real world problems. The integration of these two disparate methodologies bolster the understanding of the complex processes that increase vulnerability as well as measure individual and collective contribution of several indicators towards the same.

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References:

Adger, W. N. (2006). Vulnerability. *Global environmental change*, 16(3), 268-281.

Adepoju, A. O., Yusuf, S. A., Omonona, B. T., & Okunmadewa, F. Y. (2011). Vulnerability profile of rural households in South West Nigeria. *Journal of Agricultural Science*, 3(1), 128.

Aguilar, B. H., & Rivera, N. R. (2016). The production of vulnerability to landslides: the risk habitus in two landslide-prone neighborhoods in Teziutlán, Mexico. *Investigaciones Geográficas, Boletín del Instituto de Geografía*, 2016 (90), 7-27.

Alcántara-Ayala, I., Sassa, K., Mikoš, M., Han, Q., Rhyner, J., Takara, K., ..., & Briceño, S. (2017). The 4th world landslide forum: landslide research and risk reduction for advancing the culture of living with natural hazards. *International Journal of Disaster Risk Science*, 8(4): 498-502.

Alkire, S. & Foster, J. (2011). Counting and multidimensional poverty measurement. Journal of Public Economics, 95(7), 476–487.

Alkire, S. & Santos, M. E. (2010). Acute multidimensional poverty: A new index for developing countries. UNDP Human Development Research Paper 2010/11, New York, USA.

Andersson, E., Brogaard, S., & Olsson, L. (2011). The political ecology of land degradation. *Annual review of environment and resources,* 36, 295-319.

Annan, K., (2003). Message for the international day for disaster reduction 8 October 2003. *Source: http://www. unisdr. org/eng/public_aware/world_camp/2003/pa-camp03-sg-eng. htm. Last assessed*, *15*(11), p.2005.

Antwi, E. K., Boakye-Danquah, J., Owusu, A. B., Loh, S. K., Mensah, R., Boafo, Y. A., & Apronti, P. T. (2015). Community vulnerability assessment index for flood prone savannah agro-ecological zone: A case study of Wa West District, Ghana. *Weather and Climate Extremes*, *10*, 56-69.

Basu Roy, T., & Saha, S. (2011). Article: Study on Landslide Incidents of Paglajhora and Adjacent Areas–An Overview; Kurseong Block, Darjeeling, India.

Basu, S. R. & De, S. K. (2003). Causes and consequences of landslides in the Darjiling-Sikkim Himalayas, India. *Geographia Polonica*, 76(2): 37-52.

Besky, S. (2008). Can a plantation be fair? Paradoxes and possibilities in fair trade Darjeeling tea certification. *Anthropology of Work Review*, 29(1), 1-9.

Besky, S. (2017). Fixity: On the inheritance and maintenance of tea plantation houses in Darjeeling, India. *American Ethnologist*, 44(4), 617-631.

Birkmann, J., (2006). Measuring vulnerability to promote disaster-resilient societies: Conceptual frameworks and definitions. *Measuring vulnerability to natural hazards: Towards disaster resilient societies*, *1*, pp.9-54.

Biswas, S. (2013). Urban Growth Centers In Darjeeling Hills Of West Bengal: A Geographical Analysis. *The Journal of Bengal Geographer,* 2(1), 30 – 48.

Blaikie, P., & Brookfield, H.C. (1987). Defining and debating the problem. In, *Land Degradation and Society.* London: Methuen.

Brannstrom, C., & Vadjunec, J. M. (2013). Notes for avoiding a missed opportunity in Sustainability Science. In, *Land Change Science, Political Ecology, and Sustainability: Synergies and Divergences*, 1- 23. Routledge.

Census of India, 2011. District Census Handbook – Darjeeling, India.

Chhetri, V. (February 3, 2016). Landslide victims call strike in Mirik. *The Telegraph, India.* E-paper.

Cutter, S.L., Boruff, B.J., & Shirley, W.L., (2003). Social vulnerability to environmental hazards. *Social science quarterly*, *84*(2), pp.242-261.

Das, N., Chatterjee, S., & Roy, U. (2011). An assessment of anthropogenic impact on natural landscape–The case of Kurseong Town, Darjeeling, West Bengal. *Indian Journal of Geography & Environment*, 12, 40-50.

de Loyola Hummell, B. M., Cutter, S. L., & Emrich, C. T. (2016). Social vulnerability to natural hazards in Brazil. *International Journal of Disaster Risk Science*, *7*(2), 111-122.

Donner, W. R. (2007). The political ecology of disaster: An analysis of factors influencing US tornado fatalities and injuries, 1998–2000. *Demography*, *44*(3), 669-685.

Elmhirst, R., Middleton, C., & Resurreccion, B. (2017). Migration and Floods in Southeast Asia: a mobile political ecology of vulnerability, capability, resilience and social justice. In, *Living with Floods in a Mobile Southeast Asia: A Political Ecology of Vulnerability, Migration and Environmental Change, Abingdon UK: Earthscan*, 1-21.

Fekete, A. (2009). Validation of a social vulnerability index in context to river-floods in Germany. *Natural Hazards & Earth System Sciences*, 9(2), 393-403.

Gerlitz, J.Y., Macchi, M., Brooks, N., Pandey, R., Banerjee, S., & Jha, S.K., (2017). The multidimensional livelihood vulnerability index–an instrument to measure livelihood vulnerability to change in the Hindu Kush Himalayas. *Climate and Development*, *9*(2): 124-140.

Ghosh, S., van Westen, C. J., Carranza, E. J. M., Jetten, V. G., Cardinali, M., Rossi, M., & Guzzetti, F. (2012a). Generating event-based landslide maps in a data-scarce Himalayan environment for estimating temporal and magnitude probabilities. *Engineering Geology*, 128, 49-62.

Ghosh, S., van Westen, C. J., Carranza, E. J. M., & Jetten, V. G. (2012b). Integrating spatial, temporal, and magnitude probabilities for medium-scale landslide risk analysis in Darjeeling Himalayas, India. *Landslides*, 9(3), 371-384.

Griffin, C. (2019). The Dieng 'hazardscape': a political ecology of vulnerability to natural hazards in Java's highlands. *Environmental Hazards*, 18(1), 26-42.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global environmental change*, 19(1), 74-88.

Huber, A., Gorostiza, S., Kotsila, P., Beltrán, M. J., & Armiero, M. (2017). Beyond "socially constructed" disasters: Re-politicizing the debate on large dams through a political ecology of risk. *Capitalism Nature Socialism*, *28*(3), 48-68.

Huber, A. (2019). Hydropower in the Himalayan hazardscape: Strategic ignorance and the production of unequal risk. *Water*, *11*(3), 414.

IPCC, (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. Special report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Ives, J. D., & Messerli, B. (1989). *The Himalayan Dilemma: Reconciling Development and Conservation*. Routledge: NY.

Jodha, N. S. (1992). Mountain perspective and sustainability: A framework for development strategies. In, *Sustainable mountain agriculture, Volume 1: Perspectives and issues,,* (eds.) N. S. Jodha, M. Banskota, & T. Partap (Eds.), New Delhi: Oxford and IBH. 41 – 82.

Jodha, N. S. (2001). Global change and environmental risks in mountain ecosystems. In, *Global environmental risks,* (eds.) J. X. Kasperson & R. Kasperson, Tokyo: Earth Scan, United Nations University and London, 306–342.

Jodha, N. S. (2005). Adaptation strategies against growing environmental and social vulnerabilities in mountain areas. *Himalayan Journal of Sciences*, 3(5), 33 – 42.

Kadobera, D., Sartorius, B., Masanja, H., Mathew, A., & Waiswa, P. (2012). The effect of distance to formal health facility on childhood mortality in rural Tanzania, 2005–2007. *Global health action*, *5*(1), 19099.

Kasperson, R. E., & Kasperson, J. X. (2001). *Climate change, vulnerability, and social justice* (pp. 1-18). Stockholm: Stockholm Environment Institute.

Khawas, V. (2005). Status of tea garden labourers in eastern Himalaya: a case of Darjeeling tea industry. *Socio-Economic Conditions of Resident Tea Garden Labourers in Darjeeling Hills-A Pilot Study*.

Koks, E. E., Jongman B., Husby T. G., & Botzen, W. J. (2015). Combining hazard, exposure and social vulnerability to provide lessons for flood risk management. *Environmental science & policy*, 47, 42-52.

Longhurst, R. (2012). Semi-structured interviews and focus groups. In, *Key methods in geography*, eds. N Clifford, S. French and G. Valentine, 103-115. Sage, London.

Malley, L. O. (1999) [1907]. *Bengal district gazetteer: Darjeeling*. Concept Publishing Company.

Mavhura, E., Manyena, B., & Collins, A. E. (2017). An approach for measuring social vulnerability in context: The case of flood hazards in Muzarabani district, Zimbabwe. *Geoforum*, *86*, 103-117.

Murakami, M., Takebayashi, Y., Ono, K., Kubota, A., & Tsubokura, M. (2020). The decision to return home and wellbeing after the Fukushima disaster. *International Journal of Disaster Risk Reduction*, *47*, 101538.

Myers, N. (1999). The next green revolution: its environmental underpinnings. *Current Science*, 76(4), 507-513.

National Sample Survey Office, India (2017). Household Consumer Expenditure Survey Results. https://data.gov.in/catalog/household-consumer-expenditure-national-sample-survey

O'Keefe, P., Westgate, K., & Wisner, B., (1976). Taking the naturalness out of natural disasters. *Nature*, *260*, pp.566-567.

Pant, B. R. (2003). Degrading environment and growing population of the Indian Himalaya. *Envis Bull Himal Ecol Dev*, 11(1), 23-34.

Papathoma-Köhle, M., Cristofari, G., Wenk, M., & Fuchs, S. (2019). The importance of indicator weights for vulnerability indices and implications for decision making in disaster management. *International journal of disaster risk reduction*, *36*, 101103.

Pelling, M. (1999). The political ecology of flood hazard in urban Guyana. *Geoforum*, *30*(3), 249-261.

Pelling, M., & Dill, K. (2006). Natural Disasters as Catalysts of Political Action. *Media Development*, *53*(4), 7.

Ranganathan, M. (2015). Storm drains as assemblages: The political ecology of flood risk in post-colonial Bangalore. *Antipode*, 47(5), 1300-1320.

Robbins, P. (2012). *Political ecology: A critical introduction* (Vol. 16). John Wiley & Sons.

Robbins, P., Chhatre, A., & Karanth, K. (2015). Political ecology of commodity agroforests and tropical biodiversity. *Conservation Letters*, 8(2), 77-85.

Robbins P., Tripuraneni V., Karanth, K. K., & Chhatre, A. (2020). Coffee, Trees, and Labor: Political Economy of Biodiversity in Commodity Agroforests. *Annals of the American Association of Geographers*, 1-16.

Rufat, S., Tate, E., Burton, C. G., & Maroof, A. S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International Journal of Disaster Risk Reduction*, *14*, 470-486.

Rumbach, A. (2016). Disaster Governance in Small Urban Places: Issues, Trends, and Concerns. In, *Disaster Governance in Urbanising Asia* (p. 109-125). Springer Singapore.

Sen, A. (1993). ‘Capability and Well-being’, In M. Nussbaum & A. Sen (Eds.), The Quality of Life. Oxford: Clarendon Press, 30-53.

Sen, A. (1996). ‘On the foundations of welfare economics: utility, capability and practical reason’, In F. Farina, F. Hahn & S. Vannucci (Eds.), Ethics, Rationality, and Economic Behaviour. Oxford: Clarendon Press, 50-65.

Sen, A. (2004). ‘Capabilities, Lists, and Public Reason: Continuing the Conversation’, Feminist Economics, 10(3), 77-80.

Smith, N., & O'Keefe, P. (1980). Geography, Marx and the concept of nature. *Antipode*, 12(2), 30-39.

Sivanesan, R. (2013). Functions of Tea Board in India: A Study. *Int J Mgmt Res & Bus Strat*, *2*(4), 41-51.

Sovacool, B. K. (2018). Bamboo beating bandits: Conflict, inequality, and vulnerability in the political ecology of climate change adaptation in Bangladesh. *World Development*, 102, 183-194.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen L., ..., & Polsky C. (2003a). A framework for vulnerability analysis in sustainability science. *Proceedings of the national academy of sciences*, 100(14): 8074-8079.

Turner, B. L., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., ..., & Martello, M. L. (2003b). Illustrating the coupled human–environment system for vulnerability analysis: three case studies. *Proceedings of the National Academy of Sciences*, 100(14): 8080-8085.

UNDRR (2009). Global Assessment Report on Disaster Risk Reduction. ISBN/ISSN: 9789211320282

UNDRR (2015). Global Assessment Report on Disaster Risk Reduction. ISBN/ISSN/DOI 9789211320428

UNDRR (2019). Global Assessment Report on Disaster Risk Reduction. ISBN/ISSN/DOI 978-92-1-004180-5

Watts, M., & Peet, R. 2004. Liberating political ecology. *Liberation ecologies: Environment, development, social movements*, 2, 3-43.

Watts, M. J. (2016). From vulnerability to resilience: Hans-Georg Bohle's scholarship and contemporary political ecology. *DIE ERDE–Journal of the Geographical Society of Berlin*, 147(4), 252-265.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At Risk: Natural Hazards, People’s Vulnerability and Disasters.* London: Routledge.

World Bank (2020). Global Consumption Database: India. http://datatopics.worldbank.org/consumption/country/India

Yeh, E. T., Nyima, Y., Hopping, K. A., & Klein, J. A. (2014). Tibetan Pastoralists' Vulnerability To Climate Change: A Political Ecology Analysis Of Snowstorm Coping Capacity. *Human Ecology*, 42(1), 61-74.

CHAPTER IV

THE POLITICAL ECOLOGY OF ADAPTATION IN A HIMALAYAN PLANTATION LANDSCAPE – A CASE STUDY IN KURSEONG, INDIA

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Abstract: *This article explores farmer adaptations and vulnerabilities in a postcolonial plantation system in Kurseong, located in the Indian Himalayas. This study reviews the historical roots of plantation agricultural systems, and collects qualitative data on land management, vulnerabilities, livelihoods and adaptations of farmers in the study area. Using a decolonized political ecology approach, the study finds that the remnants of a colonial system of exploitation has translated within the existing plantation agriculture system, and profoundly in the society in the form of poor governance towards livelihood generation, infrastructural development, disaster management and political conflicts in the post-colonial period. The combined effect of such socio-ecological systems poses a "wicked problem" to local land users. Local adaptations to such problems are explored. Archival research on the colonial establishment of the plantation agricultural system in Kurseong, and information from key-informant interviews, community meetings and household surveys reveal that in spite of past colonial histories, local farmers adapt, and even build resilience, using rudimentary sustainable practices, such as vegetable farming and afforestation programs. The socio-ecological outcomes have resulted in the sustenance of households living below the poverty line, as well as an increase in forest cover. Maladaptations such as inabilities to relocate, burning or dumping non-degradable wastes, contribute to the prevailing vulnerabilities. Such land-use decisions are constrained by infrastructural obstacles such as lack of drainage, waste disposal, and water supply systems. Hence, together, the assemblage of adaptations is called "clumsy solutions".*

Keywords: postcolonial agroecosystems, political ecology, wicked problems, clumsy solutions

1. Introduction

Plantations, started by European colonizers in the mid-nineteenth century tropics, are considered “laboratories of modernity” with the introduction of new farming technologies, global markets and abundant low-wage labor (Tiffen, & Mortimore, 1990; Duncan, 2002, p. 317). Although production in plantations ushered in the future for commodity agriculture, scholars extensively explored issues of social injustices such production systems generate in terms of their labor relations (Duncan, 2002; Besky, 2014). Vestiges of colonial establishments of commodity agroecosystems remain in sugar, rubber, cashew nut, cotton, coffee, tea and several other plantations around the world, i.e., in parts of South America, British colonies in Africa, and in parts of South and Southeast Asia even after the end of the colonial era (Duncan, 2002; McKittrick, 2013; Oas, & Hauser, 2017; Davis, & Robbins, 2018; Baofo, & Lyons, 2019). The broad colonial ideas of environment and production system often remain “entrenched in the imagination and structure” within post-colonial societies (Kull, 2002, p. 341). These ideas in turn, reflect in decision and policy-making, involving land and labor relations. In South Asia, e.g., in India and Sri Lanka, the specter of the British colonial system of control over land and labor is nowhere as looming as within the existing plantation agriculture systems (Duncan, 2002; Besky, 2014).

Tea is one such form of prevailing plantation found in a) eastern India – in the districts of Darjeeling and Jalpaiguri in West Bengal, and in the state of Assam; and b) in the south Indian states of Kerala and Tamil Nadu (Panwar, 2017). This study explores farmer adaptation and vulnerabilities in tea plantations and smallholder agricultural regions in a subdivision of the Darjeeling district. Farmer adaptation is defined in this context as adjustments and actions made by farmers at individual, household and community levels to survive in the face of adverse socio-economic and environmental conditions. Their inability to cope with certain aspects of the systemic adversity addresses their vulnerability. This study aims to employ an international and decolonized political ecology (PE) approach to connect local perceptions on farmer vulnerabilities and adaptations to an analysis of how the colonial past has influenced farmer access to economic, social and political resources in present-day Kurseong.

Located in the Indian subcontinent, the study region for this research is the Kurseong subdivision of the Darjeeling district, located in the eastern Himalayas. This research is part of a larger study that explores the role of land use/ cover changes (LULCC) in impacting landslides, a common disaster in Kurseong; and vulnerabilities of tea plantation workers and smallholder farmers from the disaster. Contrary to popular narrative, LULCC mapping reveal afforested land covers and stabilized landslide areas (Bandyopadhyay, n.d.). However, this research also suggests that farmer households are multidimensionally vulnerable, and a myriad of underlying processes related to their survival and livelihoods influence them. Farmer land-use decisions and response to disasters depend on amenities and resources, i.e., entitlements[1] from the government and employer institutions (the latter refer to tea plantations).

The constraints experienced by land managers (e.g., plantation managers and smallholders) and local land users (plantation workers and smallholders) to cope and survive amidst the hills' natural predisposition to environmental hazards pose what Rittel and Webber (1973) termed as 'wicked problems.' Originally coined to describe problems related to social policy, the term "wicked problems" is applied to dichotomies that exist in societies, such as the contrasting pull between sustainability and development, equity or social justice for competitive stakeholders, etc. Resorting to Rittel and Weber's idea (1973, see also Rayner, 2006) that wicked problems cannot have scientific solutions, adaptations of land users can be termed as 'clumsy solutions.' Hence, to explore the complex socio-ecological context in which farmers adapt, cope, survive, fail or thrive, the ideas of wicked problems and clumsy solutions are adopted.

[1] The term, 'entitlement' was used by economist Amartya Sen (1981), and later adopted by Leach, Mearns, & Scoones (1999, p. 233) to describe the "utilities derived from environmental goods and services over which social actors have legitimate effective command and which are instrumental in achieving wellbeing"

This paper attempts to illustrate a political ecology "chain of explanation" (Blaikie, & Brookfield, 1987; Robbins 2012) from farmer adaptations to the environment, the current institutional and political systems, and the historical foundations on which, the present social-ecological system (SES) function. Through such explanation, the paper explores the complexities and constraints faced by local land users for a sustained survival. Specifically, this study answers: i) how colonial legacies of labor relations, within the tea plantations of Kurseong, influence the post-colonial management system ii) within such a system, how farmers constantly adapt and survive; and iii) how such adaptations translate into the existing environmental outcomes.

The structure of this article first involves a discussion of current approaches within political ecology exploring historically colonized agrarian systems, then a description of the study area. Next, the methodology employed to understand farmer adaptation and vulnerabilities, are explained. The following sections illustrate the findings from archival and ethnographic research; discusses the findings, and concludes with a summary of the results, the scopes and limitations of the study, and its contribution to future research.

2. Towards a Decolonized Political Ecology Approach

This study adopts a political ecology framework because as a field of geographical inquiry, it extensively explores the constantly evolving nature-society relationships, and the politics of accessing and controlling earth's resources by different social actors that further influence environmental changes (Robbins, 2012). A major focus of PE research involves peasant studies in the global south (Bassett, 1988; Bryant, 1992; Kull, 2002; Duncan, 2002; Yeh et al., 2014; Oas, & Hauser, 2017; Boafo, & Lyons, 2019). Hence, a political ecology approach helps conceptualize the power dynamics between both economically endowed and marginalized groups, and analyze their consequences on ecological change.

Political ecology research acknowledges that Western industrialization and colonization have largely impacted global environmental changes in the present era (Schulz, 2017). Scholars have long challenged colonial narratives that peasants in the developing regions who have not adopted modern practices have either less-than optimally utilized land resources, or have ushered land degradation (Blaikie, & Brookfield, 1987; Beymar Farris, 2013). Hence, colonialism and postcolonial impacts on the labor class has been explored critically in PE research (Bryant, & Bailey, 1997; Duncan, 2002; Forsyth, 2003; Oas, & Hauser, 2017; Davis, & Robbins, 2018). Political ecology studies recognize pluralistic drivers and impacts of environmental change (Blaikie, & Brookfield, 1987; Kull, 2002). The present study draws upon four concepts of the political ecology "toolkit" (Robbins, 2012), to explore the contexts of farmer adaptations in Kurseong. This includes the colonial legacies of postcolonial hegemonies, peasant resistance and conflicts, "adaptation 2.0" (Watts, 2015), and a goal towards a decolonized political ecology.

2.1. Colonial Legacies of Postcolonial Hegemonies

"Colonial legacy in the Third World is more than one of environmental degradation and economic dependency on natural resource exploitation. Colonial rule also led to political and administrative changes that fundamentally altered the ways in which states went about managing the peoples and environments under their jurisdiction." (Bryant, & Bailey 1997, p. 7).

The rationale behind colonial control over lands and societies developed through dominant western narratives that many indigenous communities either use land resources less optimally or in ways that degrade the environment. Political ecology explores several of these narratives, including environmental degradation in the form of deforestation (Fairhead, & Leach, 1995), desertification (Davis, 2004; Wainwright et al., 2014), slash and burn practices in Madagascar (Kull, 2002), to name a few. Colonizers occupied lands to "help" local societies and the environment with a resource management system to optimize land and resource use.

Political ecology research explores these hegemonic discourses that translate into the postcolonial politics by the State to secure control over land resources and decision-making (Bryant, & Bailey, 1997; D'Alisa, & Khalis, 2016). Research has shown that such hegemonies are simplistic and devoid of a strong scientific basis, nevertheless have been politically mobilized throughout history, to serve the purpose of the dominant groups of the society (Kull, 2002; Davis, 2004), e.g., the colonial State, the postcolonial governance, and other capitalist stakeholders (Huber, 2019). Thus hegemonies, or "received wisdoms" (Kull, 2002) have informed land-use decisions and adaptations of different stakeholders. Historically, PE research notes that hegemonies (mostly created by the State) often aim at expanding the gap between a powerful class of people, who continue to expand control over resources, and a muted "subaltern", or an inferior class whose labor and original entitlement continues to be exploited (Blaikie, & Brookfield, 1987; Spivak, 1988; Gramsci, 1978 also cited in Gandhi, 1998; Loftus, 2018). Ecologically, these findings hold true over a diverse set of environments, among which, important in context is tropical agrarian systems (see studies Duncan, 2002; Beymar Farris, 2013; Bennike, 2017; Robbins et al., 2020).

Colonial legacies and hegemonies form the basis of environmental perceptions in postcolonial societies as well. Huber (2019) explained the hegemonic discourses through which, corporate actors facilitated by the State, established hydropower projects in Nepal and Sikkim by exacerbating environmental susceptibility to natural hazards, and accentuating the vulnerability of a population who live nearby. Gramsci's notion of hegemony often comes up in PE research to understand methods of violence and coercion applied by the State to establish decisions related to environment (Loftus, 2015). For example, D'Alisa and Khallis (2016) used a PE framework to explain the pertinence of the Gramscian theory of State as a relation among political and civil actors in producing hegemonic ideas. The authors used the Gramscian argument on hegemony to investigate how States often drive faulty adaptations, or "maladaptation" for their own economic and capital gains. For example, within flood and landslide prone areas, India and Italy frequently mobilize investments for constructing dams in hazardous environments rather than help disaster victims (Ranganathan, 2015; D'Alisa, & Khalis, 2016; Huber, 2019). Such maladaptive ambitions often arise from objectives to secure the State's legitimacy to power.

2.2. Active and Passive Peasant Resistance and Conflict

Often, poor land users resist hegemonic mandates by actively or passively restricting actions imposed by the State (Le Billon, 2015). Active resistance involves strategies ranging violent conflicts, political mobilization of territorial control, even resistance through non-violent protests and non-cooperation (Holmes, 2014). Where enough local mobility is compromised due extreme exploitation and marginalization, less powerful groups have diminished capabilities for active resistance. Often such situations enable passive or stealthy methods of everyday resistance such as escaping labor work, theft from conserved lands, and so on (Duncan, 2002; Robbins, 2009). Resistance and conflicts are extensively studied by political ecologists in the forms of evasion (Scott 2010), silent, stealthy and passive methods (Duncun, 2002; Kull, 2002) and active, violent conflicts (Bassett, 1988; Escober, 2006; Benedikter, 2009; Wenner, 2013).

Duncan (2002) argues that unlike the portrayal of voiceless subalterns by several scholars, resistance often comes from silent disobedience to violent ethnic conflicts. His work on postcolonial domination and resistance in Sri Lankan coffee plantation showed labor resistances in the form of quiet and passive escapades from labor-work. Kull's (2002) work on the Isle of Fire in Madagascar shows the strict mandates against burning pastoral lands were anonymously resisted through regular practices of burning. Robbins (2009) notes how the Raika herders in Rajasthan, India resisted by disobeying faulty forest conservation efforts by the National and International environmental protection institutions that did not account for the needs of the herders and their animals.

2.3. "Adaptation 2.0"

The concept of adaptation was key to the development of the human-environment research field of Cultural Ecology (CE) (Netting, 1986; Watts, 2015). A similarly rigorous and revolutionary field of research as political ecology, cultural ecology extensively studied "the adaptive processes by which the nature of society and an unpredictable number of features of culture are affected by the basic adjustment through which man utilizes a given environment" (Netting, 1986, p. 6). CE explored the complex adaptive structure within a systems approach where hunter-gatherers, or fishermen, or pastoralists or cultivators adjust with the environment to survive and thrive. Thus within CE, the concept of adaptation meant complex actions and survival strategies within communities to maintain "homoeostasis" or equilibrium amidst short and long-term environmental perturbations (Watts, 2015). CE focused heavily on human agency in bringing change. PE in the beginning, challenged the limitations of adaptation as approached from cultural ecology, on the grounds that powerful political and economic structures impose constraints on such human agency. The concept of adaptation as solely dependent on human agency was hence, initially discarded within PE discourse.

With growing relevance of research related to climate change and global environmental change, the necessity of political ecology scholarship to study adaptation (adaptive capacities, and vulnerability) increased (Bassett, & Fogelman, 2013). In this respect, Robbins (2015) compared PE to the folkloric figure of a "Trickster" who used normative skills to challenge the order of things. Since it eventually assimilated the concepts of adaptation among other things, such as studying subsistence communities, within its realm, the very concept it challenged in the beginning, Robbins called PE a “Trickster Science”.

Michael Watts (2015, p. 21) argued the renewal of the concept of adaptation within PE as “Adaptation 2.0.” Bassett and Fogelman (2013, p. 51) described the inclusion as “deja-vu and then something new”. Roy Chowdhury and Turner (2006) similarly advocated for the considerations of both structure and agency in human-environment research because both simultaneously influence adaptation. With such arguments PE gradually approached the concept of adaptation as the human agency at individual and community levels that transforms constraints posed by the environment and a higher social structure to survive and thrive.

To define the complexities of adaptation within a social-ecological system this research adopts Rittel and Weber’s (1973) coinage of the phrase “wicked problems”. Since adaptation involves conscious and subconscious planning to survive and cope with structural constraints, such parallelism can account for the complexities better. Researchers working on environmental policies in the wake of growing uncertainties and complexities related to climate change, globalization, risks of environmental hazards often realize that solutions cannot be formulated (Underdal, 2010; Ney, & Verweij, 2015; Perry, 2015). Adaptations are achieved in such scenarios in the form of clumsy unformulaic solutions.

2.4. Towards a Decolonized Political Ecology

Having an ethical leaning towards issues of environmental and social justice (Svarstad, & Benjaminsen, 2020), political ecologists condemn the negative outcomes of Western colonization and industrialization (Loftus, 2017). Conversations within the field now focus on decentering PE from the “Anglo-American citadel” where in the past it thrived the most (Kim et al., 2012; Bridge, McCarthy, & Perrault, 2015; Schulz, 2017; Loftus, 2017). PE scholars engaged in conversations on the impacts of colonization as not only limited to historical materialism of the time, but also how they shape ontologies of human knowledge in much of the colonized world (Schulz, 2017). They consciously revisit their own epistemological authenticity, identifying the paradox that PE faces in reproducing knowledge on the foundations of the very Eurocentric paradigms that it championed against (Loftus, 2017). A major aim at decentering involves "decolonizing" critical thinking as "historically instituted fracture lines of inequality" established through coloniality have not only pervaded human-nature relations or political economies, but also knowledge production (Bryant, 2015; Schulz, 2017; Neimark et al., 2019). These conversations developed ideas of identity, complicity, and entanglement where, political ecologists increasingly engage with conversations on the purpose of research, who benefits from research and whether the produced knowledge comply with coloniality (Sundberg, 2015).

Recent debates regarding the conceptualization of the Anthropocene (Haraway, 2015; Schulz, 2017; Loftus, 2019), brought PE discourses concerning power relations to the forefront within the context of global environmental outcomes including climate change. Here, political ecologists have been central in pointing out that humans cannot be identified as a homogenized actor in bringing environmental changes at a global scale (Schulz, 2017; Neimark et al., 2019). By doing so, they have questioned the hegemonic epistemologies of knowledge that have prevailed within science and academia (Sundberg, 2015).

In this regard, political ecologists found ways to take caution while approaching "subaltern" natures, because what is considered to be marginal in the west is very much "central and foundational in the non-west" (Gandhi, 1998, p. ix). Spivak, a noted scholar of postcolonial theory questioned the accuracy with which (hegemonic) Western ontologies can "touch the consciousness" of the muted subaltern voices (Spivak, 1988; Gandhi, 1998). Political ecologists heeded the caution and pondered ways to learn from the South and incorporate North-South dichotomies that exist within the knowledge systems (Joshi, 2015; Sundberg, 2015; Loftus, 2017).

Among other methods, political ecologists expanded their ontologies, epistemologies and methodologies to work with human subjects in field rather than working on them to incorporate non-hegemonic discourses within the field (Schulz, 2017).

For the purpose of this study, an internationalized and decolonized political ecology framework is used to explore how the "complex ramifications arising from the composition of [colonial] subordination" (Gandhi, 1998, p. 1) still bear their testimony on environmental and social outcomes on present-day agricultural systems. The methodology acknowledges the etic, or observations of the researcher as an outsider, as well as the emic or perceptions and opinions of the cultural representatives, verbatim within this study. Keeping Spivak's (1988) caution in mind, the methodology of this study incorporates the voices of the "historically perceived" subalterns, who are the farmers, adapting to the social-ecological system of Kurseong.

3. Materials and Methods

3.1. Background of the Study Area

Kurseong is one of the three jurisdictional subdivisions of the Darjeeling district of the State of West Bengal in India. During the British colonial regime about 150 years ago, the forested hills were largely transformed by the establishment of tea plantations. Currently 18% of the total area of the Darjeeling district is under tea plantation (Khawas, 2011). Although the global market of exported tea has declined for India (ranking 4^{th} in the world), the top three producers being China, Sri Lanka and Kenya (Voora et al., 2019), Darjeeling tea still has a substantial internal and international market (Navitha, & Sethurajan, 2018; India Tea Board, 2017 - 2018). Tea plantations require labor in abundance, so during the colonial establishment of tea plantations, a large number of people emigrated, mainly from Nepal (Besky, 2008; Biswas, 2013). The present-day labor class in the Darjeeling tea plantations are the descendants of these migrant workers (Bhowmik, 2011;

Khawas, 2011). However, amidst the three major tea producing regions of India, namely Assam, West Bengal and South India (Kerala and Tamil Nadu), and producing 75% of total tea production along with Assam, the wage of Darjeeling tea workers is the lowest (Sarkar, & Reji, 2019). In Darjeeling, tea plantations employ roughly 77% of the workforce and 33% of total the population (Census of India, 2011).

The establishment of tea plantations in the Darjeeling hills enabled auxiliary settlements, markets, livelihoods, and sporadic urbanization (Biswas, 2013). Darjeeling is also a tourist destination, however, in the Kurseong subdivision, tourism industry is not a major revenue earner yet. Tea dominates the region, with small-scale tourism surrounding the plantations. A second land-based livelihood in Kurseong explored here, is that of smallholder agriculture. Periodic destructions caused by landslides has also shrunk the smallholder agricultural sector.

With around 30,854 households residing in Kurseong (Census of India, 2011), general narratives of environmental degradation and farmer vulnerabilities, producing hegemony in the region, puts the onus on the high population density and maladaptive land-uses (deforestation, tea agriculture, urbanization) common in the Himalayas (Ives, & Messerli, 1989; Jodha, 2005; Arsenault et al., 2012; Das, 2014; Bhutiya, 2015). This paper makes a contrasting proposition that land-uses by local farmers both in plantations and smallholder regions are not maladaptive. Rather, results from previous study show that certain land-use choices by local farmers have fostered social and ecological resilience. Environmental degradation in major land-use areas exist however, but are shaped by limited resources made available to the land users by governmental and institutional powers. Based on these observations and a review of literature this paper argues that the tea industry in Darjeeling still carries the vestiges of a colonial plantation system, only now governed by private plantation owners and companies. Hence maladaptation, vulnerabilities of the labor farmers, and environmental degradation in Kurseong are rooted in histories of dominance, structural control over land resources, and the influence of capitalist ventures over such structural powers prevalent in the bigger eastern Himalayan region (Huber, 2019). Political conflicts arising from such dominance is salient in Kurseong with the 100-year-old Gorkhaland agitation, claiming to separate from the present governance and establish an ethnoscape controlled by the ethnic groups of the region (Benedikter, 2009; Jana, 2012; Wenner, 2013; Harris et al., 2016).

3.2. Methodology

This research employs archival research on the colonial history of Darjeeling and ethnographic methodologies to analyze primary field data on land management, adaptation and vulnerabilities, collected through key-informant interviews, community meetings and household surveys.

3.2.1. Archival Research

Academic literature on colonial establishment in Kurseong were studied in the form of archival research. According to Christian Kull (2002), archival research provides critical documentation of historical changes within landscapes, and societies, but they need to be used with extreme caution to reflect appropriate contextualization (Enfield, & O'Hara, 1999, also cited in Kull, 2002). In taking a decolonized PE approach, it is critical to revisit the beginning of coloniality that gradually got incorporated within the lives and livelihoods of the autonomous indigenous people, to untangle the largely hidden non-colonial ideals that local people may still follow to survive and foster resilience.

For this research, the district gazetteer of India, Darjeeling by M.S.S. O Malley, first published in 1907 was studied. This gazetteer is the most comprehensive documentation of the colonial rule and expansion in Darjeeling. It was also cross-referenced in the most extensive source of literature used in this paper, i.e., the research on frontier commodification of Darjeeling by Rune Bennike (2017). Other literature used for the archival research include literature on tea plantations, colonial infrastructure and peasant survival by authors Vimal Khawas, Jayeeta Sharma, Sarah Besky, Suvechha Ghatani, to name a few.

3.2.2. Ethnographic Research

The ethnographic research was partly conducted during fieldwork where primary data were collected via key-informant interviews, community meetings and household surveys. The data were processed and analyzed to obtain the results that are discussed in the following section.

Key-Informant Interviews:

Thirty key-informants were interviewed in Kurseong in Summer 2016 and Spring 2017 with government officials, plantation managers, and local land users having regional experience and expertise. Different sets of semi-structured questions were directed towards different stakeholders. Questions were primarily based on informants' contextual themes of expertise. Interviews included topics such as planning, disaster management, local vulnerabilities, farmer land-use, and relationships between farmers and the administrations (plantation and government).

To select key-informants, purposive and respondent-driven sampling methods were employed where a few key-informants, chosen initially, referred to other potential interviewees (Longhurst, 2012). To ensure minimum bias, each participant could refer to only one other key-informant. The interviews took 60 – 90 minutes to complete. While the initial themes were chosen based on thorough literature reviews, field reconnaissance and conversations with local connections, questions were kept open-ended to stress on interviewer perceptions and definitions on related themes (Wenger et al., 2017).

Key-informant perceptions also helped incorporate additional ideas for preparing questions for community meetings and household surveys. K-Is also helped select five field sites for detailed study within Kurseong. Community Meetings (CM) and Household Surveys (HS) were conducted in these areas that reflected a range of farmer vulnerabilities and adaptations. The field sites consisted of three plantation estates, namely Makaibari, Goomtee and Tingling; and two smallholder villages, namely Sittong and Sirubari.

Community Meetings

Five community meetings were held encompassing all five field sites. 10 – 22 people participated in each site. The community meetings provided information from a different group of stakeholders, i.e., local farmers (both smallholder and plantation), plantation staff (paramedics, supervisors, etc.) retired plantation workers, school teachers in smallholder regions, and former panchayat[2] administrators. Thus, diverse perspectives related to problems of lower wage, access to basic resources, such as water, land-use practices related to agriculture, constraints in waste disposal, sewerage problems, and alternative employments could be collected and processed. Community meetings took roughly 3 hours to complete. The participants of CM served as focus groups for household surveys.

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[2] Panchayats are a form of rural government system prevalent in India since its Independence in 1947. At the time of research, they were dysfunctional. Rural development is now under the Block Development Office of the Government of West Bengal.

Household Surveys

146 households were surveyed in plantation and smallholder regions belonging to each of the field sites. Structured closed and open-ended questions were directed on demography, livelihoods, amenities, facilities, vulnerabilities and perceptions of their environment and political systems. For the purpose of this research, data on farmer living conditions, land tenure, infrastructure, disaster aids, perceptions of vulnerability, and adaptations to all above variables are documented and analyzed.

Analysis

In an attempt to advance a decolonized political ecology, the findings are analyzed heeding to Schulz's (2017, p. 135) caution against resorting to "anthropological cherry-picking". In other words, this study recognizes that the observations, themes and data collected, are part of a more entangled reality, and hence are not presented inferentially. The regional archival research documents histories and historiographies of colonial establishment researched by other scholars to understand the present-day functioning of the same agro- ecology and -economy. This study also maintains that colonial-indigenous dualisms are blurry at best as both ideals have percolated in the other's realities where each exists in some capacity. The ethnographic data thus presents descriptively, the combined top-down and bottom-up approaches of different stakeholders who participated in the research.

For analysis, the themes of discussion topics were generated from the interviews and community meetings. First, the interviews were recorded by taking notes manually, and later transcribed in digital format (Wenger et al., 2017). Soon after, the transcribed data were coded using grounded coding techniques (Strauss, & Corbin, 1994; Charmaz, & Thornberg, 2020), that generated themes related to farmer land-use practices, institutional help during disasters as well as in daily lives, and socio-ecological vulnerabilities faced in Kurseong. Similar coding techniques were adopted to code the community meeting data. They are presented in the results in the form of aggregated percentage and verbatim quotes, where necessary. Related responses from household surveys were aggregated (average, descriptive stats) and presented together with the interview and meeting responses. Survey results were included to see where/how individual responses (perceptions/opinions) corroborate and contrast with opinions and perceptions of interviewers or community meeting participants. Finally, all perceptions on infrastructural constraints, land-use decisions, vulnerabilities and adaptation were analyzed together.

The common themes regarding land-management system, land-use and vulnerabilities that came up during key-informant interviews depict a largely top-down, aggregate perception. Focus group responses on similar themes provided knowledge from ground-up perspectives at a community level. Household responses further provided perspectives at a finer spatial scale. The household survey data corroborating to the K-I and CM themes and subthemes are presented in aggregate form, e.g., average land holding, income, etc. Data from these three ethnographic methods are presented in the results in the form of descriptive statistics. Individual perceptions are quoted (translations) at times. Field observations by the researcher are also included in the results where necessary. Thus, the results include (expert) local perceptions of socio-political system and structure, and farmer adaptations at regional, community and local levels. The complex SES are together termed as ‘wicked problems’ and the adaptations as ‘clumsy solutions.’ The findings are then discussed that are further shaped by the researcher’s training in western epistemologies as well as understanding of local cultures.

4. Colonial Occupation and Commodification of Land, Erasure of Indigenous History and Farmer Adaptations and Vulnerabilities in the Postcolonial Times

4.1. Colonial Land Acquisition, Commodification and the Creation of Darjeeling

The historical backdrop of the study area bears relevance within the present scholarship on peasant adaptations within a postcolonial agrarian system long after the colonial rule.

In the early 1800s, the British Raj in India transformed the forested hills of Darjeeling into vast acres of plantation agriculture to compete with the then Chinese monopoly of tea (Rasaily, 2013). Darjeeling, although a part of the Bengal prefecture of the British Raj, followed a different trajectory than that of the plains of Bengal (Bennike, 2017). The then Bengal, consisting of the present-day Indian State of West Bengal, Bangladesh and the Himalayan region of Darjeeling and Sikkim, came under the British Imperial Rule around 1772, after the latter defeated Nawab (Muslim ruler) Siraj-ud-Daulah in the Battle of Plassey in 1757. The British East India Company assumed jurisdictional access of land revenues with the establishment of the Permanent Settlement Act of 1793. This Act was applicable on the vast plains of Bengal where the Company assumed overlordship over the local landlords or *zamindars,* (the landed class of the Native elites who were, largely, patrons of British authority in India) (Bennike, 2017). According to this Act, a fixed tax/revenue were levied on the land of the zamindars (Rasaily, 2013). The Permanent Settlement bear a different story of exploitation and marginalization of the bonded laborers/ farmers who ploughed the fertile plain lands of the zamindars (Rasaily, 2013).

While the plains were well-established cultivated land, the hills of Darjeeling were seen as a frontier of what James Scott named as Zomia, i.e., a land "whose population have not yet been fully incorporated into nation-states" (Scott, 2010, p. ix; Hammond, 2011; Dove, 2011; Krasner et al., 2011, Michaud, 2017). Large parts of Burma, Indian Himalayas and South Western China were conceptualized by Scott as Zomia where the inhabitants represented tribes that fled political control of civilization to settle independently for the longest period of modern time (Scott, 2010; Michaud, 2017). The dominant narrative of the pre-British Darjeeling described its population as sparsely situated, around twenty families living sporadically without having a 'village' as the British identified it (Ghatani, 2015; Newman and Co., 1900, as cited in Bennike, 2017).

British alliance with the Monarch of Sikkim (situated in the north of Darjeeling) suggests that the latter got help to acquire the land from a local Gorkha tribe (Ghatani, 2015). Darjeeling was a strategic location to bring under the British Raj[3] as a buffer between the two independent kingdoms of Nepal and Bhutan (Bhattacharya, 2013). Moreover, the pristine beauty of the Himalayas became covetous for the British as a respite from the sultry tropical weather of the plains. So, during the 1830s the then Governor-General expressed his desire to the king of Sikkim to convert part of the hills as British sanatorium and a summer capital. The latter, as a friendly gesture, leased the land between the Mechi and Teesta rivers, later known as Darjeeling, to the Raj with a token price (almost as a gift) in 1835 (Khawas, 2011; Ghatani, 2015).

Bennike (2017) illustrated comprehensively, the British strategy to acquire and commodify the newly occupied land. They categorized Darjeeling as a '*wasteland'*. "Wastelands" were defined as unused lands, and hence, "a missed opportunity" for resource and revenue generation (Bennike, 2017, p. 8). Wastelands also provided an easy way for claiming ownership, i.e., anyone could obtain tenure of the land and start production (Rasaily, 2013; Besky, 2015; Bennike, 2017). As a result, almost one eighth of the total land area in Darjeeling (>90,000 acres) were auctioned to private owners with a very low, almost token value (between Rs. 2 – 8 per acre) (Bennike 2017, p. 10). The craze for buying property for tea plantation soared high, and by 1882, the British government sold 52,000 more acres at as low a price as 6 annas (38 Indian cents) per

[3] The term 'British Raj' or simply 'Raj' is still used to mean British rule in India

acre, with murky "wasteland" rules, e.g., selling regularly cultivated but unsettled lands of nomadic inhabitants, as well as "valuable forest lands" (Bennike 2017, p. 10).

With this occupation of land, the British needed an abundant influx of labor to clear the woods, and plant tea bushes (Bennike, 2017). Nepalese farmers were invited with a promise of secured wage, free housing, healthcare, and schooling for the children in the family (Khawas, 2002; Besky, 2008; Rasaily, 2013). The homogenous recruitment of Nepalese tribes in the plantations as well as in the military of the hills, as analyzed by Bennike (2017), was partly due to the sturdy and robust physique of the Gorkhas and also because they did not belong to the same ethnic groups who fought the British in the famous Sepoy Mutiny of 1857. A hegemony about farmers in Darjeeling as originally Nepalese still exist (Khawas, 2002; Dekens, 2005). This conflicted history has far-reaching consequences on the present-day social relations in the region.

This aforementioned documentation also hid an aboriginal history of Darjeeling that existed during the pre-British period, the erasure termed by Bennike (2017) as "*Terra Nullius*". The ethnic groups of Darjeeling e.g., Gorkhas, Lepchas, Bhutiyas (Khawas, 2002; Dekens, 2005), actually considered themselves aboriginal of Darjeeling. A recent academic finding corroborated to this narrative that Darjeeling was actually inhabited by advanced local communities of the Lepchas who practiced shifting cultivation in the hills (Mullard, 2015; Bennike, 2017). According to the District Gazetteers of Bengal, Darjeeling had its own local settlements with shops and residences before British occupation of the land (O'Malley, 1999 [1907]; Bennike, 2017). The British government grabbed the opportunity to categorize the region as '*wasteland'* due to a brief exodus of some 1200 people (400-800 families) of the inhabitant Barfung tribe to Nepal, following a rebellion against the Sikkim Government called the Kotapa rebellion in 1826 (O'Malley, 1999 [1907]; Bennike, 2017).

The British Governor-General, William Bentinck, helped the then monarch of Sikkim, restore their territory by sending two British officers to settle a dispute with the Nepalese Gorkhas, who had previously occupied the current land of Darjeeling for a long time in wars with Sikkim (Ghatani, 2015). Many of the tribes who fled to Nepal, later returned to their own land in Darjeeling to work in tea plantations or in the military. Now seen as Nepalese immigrants, the people in Darjeeling have fluid and fractured identity (Jana, 2012). The identity crisis of the local tribes (led by the Gorkhas) created the long-standing environment of ethno-political conflict with local claims of territorial autonomy and separation from the State of West Bengal (Tamang, & Sitlhou, 2018).

Returning back to the colonial histories, by the year 1864, the British established their summer capital in Darjeeling to escape the sultry and humid tropical weather of Calcutta (Sharma, 2016). Bennike (2017, p. 2) described Darjeeling as "an exceptional, mountainous frontier" transformed into a commodified land with the production of tea plantations (Elias, 2018; Sarkar, & Reji, 2019; Palani, 2019). Subsequently, roads and a railway were built by the year 1881 that connected the Darjeeling hills with the plains (Sharma, 2016). With the means to transport tea, the British established the Darjeeling monopoly and enjoyed its global revenues from tea until 1947.

The postcolonial development of Darjeeling started with transferring land ownership from the British Raj to the Indian Government (Dekens, 2005; Sharma, 2016). The tea estates along with their workers were then leased by the Indian Government to private proprietors as well as companies (Dekens, 2005). Through the continued domestic and international demand for tea after Indian independence (Beringer et al., 2020), Darjeeling tea plantations now operate with the same capitalist objectives of its former colonizers that exploits both land and labor.

Local small land owners settled in *khasmahals* or agricultural regions and practiced cultivation of cardamom, ginger, other spices, fruits and small kitchen gardens (Khawas, 2002). Although smallholder agricultural systems persist, this paper establishes that the past colonial political and economic dominance of plantations have not only led to the sustained exploitation of laborers within plantations but also amidst post-colonial governance outside the plantation system.

4.2. Farmer Adaptation, Vulnerabilities and Resilience in the Postcolonial SES

From K-I interviews and CMs, common themes and subthemes related to post-colonial socio-ecological systems and functions were coded, on which household data were later collected. The coded responses of key-informants and focus groups are broadly categorized into two parts – the 'wicked problems' faced by locals within the SES; and 'clumsy solutions' that include adaptations at local to institutional levels (Table 4.1). The K-I and CM themes and subthemes further provide structure for the household survey questions. The findings from these three ethnographic data collection methods are presented together.

Table 4.1. Wicked Problems and Clumsy Solutions: Major Coded Themes on Institutional and Governmental Land Management and Farmer Adaptations (K-I and CM).

Wicked Problems		**Clumsy Solutions**	
Themes	Subthemes	Themes	Subthemes
Land Management	- Land Holding/Farmer Housing (23%*) - Land Tenure (30%* 100%[Δ])	*Perceptions*	- Environmental Vulnerability (100%[Δ]) - Socio-Economic Vulnerability (100%[Δ])
Infrastructure	- Low Economic Capital (100%[Δ]) - Entitlements: drinking water, sanitation, waste disposal (100%[Δ])	*Adaptation and 'Maladaptation'*	- Land-Use (37%* 60%[Δ]) - Infrastructural Constraints (100%[Δ]) - Community Development (40%[Δ])
Disaster Governance	- Farmer Aids (20%* 80%[Δ]) - Development/Maladaptations (17%* 40%[Δ])	*Grievances and Suggestions*	- Land tenure (100%[Δ]) - Jobs (100%[Δ]) - Compensation for disaster loss (ag. land, money) (100%[Δ])
Conflicts	- Resistance (3%*) - Ethnic discord (10%*) - Corruption (10%*)		

* Key-Informant responses; [Δ] Community Meeting responses

Wicked Problems

The assemblage of the environmental and socio-political problems encountered by participant stakeholders are termed 'wicked problems' due to their multi-pronged and connected nature. Systematic solutions to address any one of these problems have chances of endangering a connected situation. The common themes regarding wicked problems that came up during interviews and focus group meetings included land management, infrastructure, disaster governance, and conflict.

Land Management

The major issues surrounding land management in Kurseong involved land-use, land holding (farmer housing) and tenure. The tea plantations visited, have between 700 – 1200 farmers, roughly two-thirds of whom are permanent workers, living within the plantation (23% K-I). The average area of a plantation labor household is 93.1 square meters[4].

Within smallholder regions too, settlements are often clustered. Households, especially in the hillier region, are usually sparsely located, but in lower elevations, 50% of the households visited, have clustered settlements, with agricultural lands near but outside the premises. The average land holding there is 1.3 acres (131 decimals).

A key-informant explained the clustered settlements in rural areas as:

> You cannot delineate land-use in such a complex region. Tea plantations and smallholder regions are rural areas. But settlements have sprawled in these regions and the population is very high. So that baffles the definition of 'rural area'.

[4] Or 2.3 *decimals* where one decimal land is equivalent to one hundredth of an acre. This is the unanimous unit used in the region to describe smaller land area, e.g., households.

Land tenure is a contested issue in Kurseong and appeared in 13% of K-I interviews. No plantation worker has land tenure, i.e., property rights of their house and additional plot of land within the household premise, a condition continued from the colonial times to the present-day management system. Most smallholder farmers should have land tenure, but several have disputed land-ownership. Focus groups of two smallholder regions corroborated that it took an indefinite period to have land ownership especially for disaster victims (40% CM). Among smallholders, 21% households responded not having land rights.

Infrastructure

Economic capital and entitlements are included within the key-theme of infrastructure because within tea plantations, farmer income is universally set by the Tea Board. Opinions that low wage within plantations and lack of alternate permanent employment sectors were major constraints leading to low economic capital. For smallholders, economic capital depends largely on governance and market infrastructure. Often, landslide disasters and rains impact agricultural production ranging between temporary loss of crops to permanent loss of agricultural land. Lack of adequate government aid compound in making smallholder communities economically vulnerable, an ongoing issue that came up in 100% of focus group discussions.

Within plantations, the average household size surveyed was 4. 53% of the HH survey participants were plantation employees earning an average monthly income of ₹2588 (equivalent to 35.11 US dollars). Monthly household income of tea plantation workers, surveyed was ₹11,529 (~$156). Most of the additional household earnings came from plantation work (67%), agriculture (2.4%), automobile industry (9.4%), construction (5.8%), business (5.9%), school (8.2%), military employment (7%), and informal sectors (40%). 9.4% of the households did not have an additional income. Tea plantations sold a portion of their produce to fair-trade companies, a topic that came up with 23% of K-I responses. Focus groups responded that plantation workers do not get any extra share of profit from that (60% CM).

Within smallholder regions 72% of households practiced subsistence agriculture, and only 25% of the households reported selling part of their produce. The average reported monthly income of smallholders were ₹5255.50. Apart from agriculture, smallholders resorted to temporary jobs in the construction sector (23%), automobile (10%), business (6.6%), school (5%), military employment (1.6%), and informal sectors (34.4%).

Government schemes for rural development appeared in 20% K-I, and 80% CM responses regarding economic infrastructure. Aimed at providing temporary employment to unskilled, unemployed population, according to the rural development schemes, both smallholder and plantation members of households can apply to work. The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), more commonly known as the 100 days employment, includes creating pony roads, cleaning garbage, among other labor work (K-I)[5]. However, in many farmer households, people who qualify end up not applying for these jobs and unemployment allowances due to lack of communication with the government.

"Entitlements" or resources made available to farmer households from the government or plantation, include infrastructures for water supply, sanitation, and waste disposal (100% CM discussion). Although most households are provided with water supply pipes, 58% of households encountered severe water shortages several times of the year. 34.25% of households did not have proper toilets, and only 8.2% of households had a sewerage or drainage system near their household.

[5] For more discussion on MGNREGS in Darjeeling see Ghatani, 2016.

Disaster Governance

Kurseong is a landslide-prone environment. So, disaster governance was an important theme discussed by K-Is (20%) and CM focus groups (80%). Government disaster aids to farmer households and regional 'development/maladaptation' were two major subthemes discussed under disaster governance. Development/maladaptation are clubbed together because often, institutional development programs proves to be maladaptive.

Farmer households, especially landslide victims, require government and institutional aids to cope. 27.4% of HHs surveyed, were displaced by landslides at some point in their lives. 79% of households were situated near landslide-affected areas at the time of data collection. 74.7% of household participants considered themselves landslide victims, who either lived near active landslide areas or suffered losses from landslides. Among landslide victims, 69% of households received no government help, and 72% were dissatisfied with inadequate government aids.

Plantation managements independently participate in disaster management within their respective estates. 33% of plantation households received aid from plantation administration in the form of camp/shelter, no objection certificate (NOC) over a plot of plantation land to build a house, relocation to plantation housing, or compensation money. 46% of households had a very dissatisfactory to neutral opinion about the adequacy of disaster aid within plantations.

Key-informants (6%) discussed shortages of funds to relocate farmer households to safer living conditions. Some also discussed inadequate government infrastructure for disaster management (DM). Government employees selected to oversee DM were often given responsibilities for unrelated work, thus forcing them to deprioritize disaster affected regions and communities. It takes two to five years to relocate a disaster victim household (K-I, CM).

The developmental/maladaptive programs undertaken by the Central and State governments along with capitalist stakeholders include construction of roads, cable lines, and electricity (17% K-I, 40% CM). Government and private projects for hydropower generation in the hills require deforestation. When asked whether local people engage with deforestation, a major cause that triggers slope failures, a K-I responded:

> "People cut broom trees to make brooms. They don't deforest. But Kalijhora is developing a hydroelectric power project where local people work. You can see the NHPC hydroelectric power stations downslope. Landslides happened near Kalijhora in NH 55 at a place called *'Shetipur'*. There are villages upslope. That place has become a sinking area. People are smallholders there. They mostly cultivate orange and ginger. Many lost lands after the landslide. Government gave houses but no land."

Resistance and Conflicts

Within plantations, the meager wages of farmers often generate active resistance in the form of strikes, and rarely closure of a tea plantation that fails to generate adequate revenue. Very few key-informants (3%) and focus group members would talk about it, but would mention how wages get increased at an inadequate rate. A strong labor union helps with active worker resistance in the form of work strikes, but they too, are often rife with corrupt union leaders that dissipate the strikes through negotiations between union leaders and management (20% CM). In smallholder regions, passive resistance often comes through a Gandhian non-violence, non-cooperation, e.g., landslide survivors' refusal of inadequate government aids (6% K-I). Both resistances often merge with the identity politics and conflicts in Kurseong. They become integral to many decision-making processes involving regional, local and individual impacts. During the data-collection period, a political strike (with occasional violent riots) transpired in the study area (10% K-I). Plantation workers and all local government employees stopped work for more than three months, and boycotted (sometimes vandalized) government business. Schools were closed, transportation stalled and protest ensued against lack of proper governance for the people of the hills. Focus groups were not explicitly questioned on conflict and identity due to their (sometimes forced) involvement in the strike that stalled plantation and alternate jobs. However, to illustrate part of the complexities of identity politics, a focus group of farmers eloquently summarized:

> Our major problem is shortage of money to sustain our daily household needs. The wage strike of the tea board got converted to Gorkhaland. They are not really efficient in getting workers salvageable incomes. We live in poverty (CM).

Different stakeholders in conflict shared grievances towards the others. On one hand, the GTA were unhappy with government control over policies and funds (K-I). Others suggest inefficiencies and corruption among the GTA to have prevented development in the region. Cable lines in Mirik is an example of a GTA-led development project that involved unplanned slope cutting and had, at places, impacted slope failures and minor landslides (K-I). Corruption of the GTA in the form of money laundering, and unavailability of skilled engineers had previously stalled a road building grant issued by the central government (K-I).

Clumsy Solutions

Adapting to the aforementioned wicked problems is generally an inconsistent, chaotic, and piecemeal process. Such adaptations depend on environmental perceptions, perceived risks, and decision-making across multiple scales (household to regional). Thus, adaptations do not always have systemic or formulaic solutions, rather they involve localized processes, both in sustainable and maladaptive ways. Nevertheless, they persist and help local land users cope, survive, and in some instances, foster resilience. As such, these adaptations are 'clumsy solutions' (Hartmann, 2012). The major themes of clumsy solutions are categorized mainly from CM focus groups. Perceptions and opinions (grievances, suggestions) are included from household level responses of open-ended questions, to incorporate local knowledge as emic of this research.

Perceptions

The key subthemes of focus group conversations (100% CM) involved their perceptions of environmental and social vulnerability. In addition, 94.5% of households were aware of the local environmental predisposition to landslides and strongly felt vulnerable amidst everyday survival. 78% of households felt vulnerable socio-economically. Local farmers were aware that economic and infrastructural inadequacies impacted their land-use decisions or adaptations and in turn, social-ecological sustainability.

Adaptation and Maladaptation

Land-use involve both structural and local-level land-use processes. The most prominent land-use practice discussed by key-informants (23%) and in 60% community meetings challenge the deforestation myth. Known to have severely impacted landslides until the 1990s, deforestation and small-scale lumbering was made illegal by the government (37% K-I). The National Forest policy mandated 70% tree cover in the designated forest areas since 1995-96 (K-I). The State Government funds afforestation every year. Policies such as the Rashtriya Krishi Vikas Yojna[6] also aims for more afforestation near agricultural lands. Forest guards painstakingly monitor illegal lumbering that is known to exist covertly (10% K-I), and has been able to lower the rates considerably. Additionally, an environment day is celebrated by children from all schools in Kurseong by planting trees and cleaning their local areas.

Within a plantation land, a K-I quipped: “Our plantation workers plant between 500-1000 trees over 250 acres approximately”. Recent research on land-use changes corroborate to a rise in forest cover in both plantation and smallholder lands in Kurseong (Bandyopadhyay, n.d.).

[6] State Agricultural Improvement policy

Additionally, the Soil Conservation Division, under the administration of the Soil and Landuse Survey of India (SLUSI) have effectively conserved and stabilized landslide affected slopes through bioengineering methods.

At a household level, 72.6% of farmer families (plantation and smallholders) had vegetable gardens (ginger, *rai saag*[7], cardamom, etc.), fruit trees (orange), broom grass, or small livestock (hens, pigs, goats) within their land, even in a small plot (0.44 decimals). *"Jitna dekh rahi hai, zameen utnahi hai. Likh lijiye das by bees feet"*[8] - was a common response of a tea plantation worker when asked about the plot of land they use for subsistence farming.

Household-level adaptation to infrastructural constraints involved decisions to combat water-supply, sanitation, and waste disposal problems compounded with limited economic capitals. Due to inadequate water supply, households used streams to bathe, dump wastes and collect water for drinking purposes. 52.7% of households traveled between 1- and 5-kilometers to collect water for several days a year. 68.2 % of HHs surveyed, dumped wastes along slopes near their household and near streams, and 93% of HHs burned plastics. Most farmer households were aware that such practices were maladaptive. This topic came up during 100% of community meetings where farmer focus-groups unanimously preferred to use proper trash bins if/when they were available.

Community building, seen as a form of adaptation, generated the most diverse responses among focus groups. 20% of CM responses supported community building, e.g., from cooperatives run by plantation workers to help families at times of need. To certain farming communities, such cooperatives often contributed the most to help victims cope during landslides (farmers invest as little as an equivalent of 68 US cents every month - CM). When asked about disaster aids, a focus group explained:

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[7] Mustard greens or *Brassica Juncea*

[8] (Whatever you are seeing in front of you is all the land we have – about ten feet by twenty feet)

> Ten people complain about sinking ground near house, or damage, and only two get help. The Panchayat provides protection by supplying polythene to cover an area that shows signs of landslips. At some places, retention walls have been set up. The plantation works on channeling the water but a lot is yet to be done.

In other communities however, further hierarchies and marginalization exist (20% CM). Especially, in regions where political movements (ethnic separation) are predominant, farmer vulnerabilities are not addressed within a supportive community.

Grievances and Suggestions

Amidst adaptations, surviving with clumsy solutions, and fostering resilience in some instances, the social canvas of Kurseong is fraught with active, and traces of passive resistence. The interminable issue of local ethno-political conflict in Kurseong stems from the perceived government and management inadequacies discussed above. Local communities suggest that such structural inadequacies (e.g., the lack of government jobs, disaster aids and infrastructural developments, among others) remain because mountain communities, who are ethnically different from the majority of population in India, are considered 'outsiders' (K-I). Hence, less funds and resources are allocated for development in the hills (CM).

Active Resistance: Grievances among local populations remain latent until political forces mobilize active resistance in the form of labor strikes, boycotting State Government-run local businesses, among others. Between 1986 and 1988, the then Gorkha National Liberation Front (GNLF) and later the Darjeeling Gorkha Hill Council (DGHC), the major independent local political organization in Darjeeling, raised their century old demand of a separate State, Gorkhaland, once again. As demands were not met, the resistance turned violent. For example, a fully functioning Railway workshop was vandalized near Tindharia in Kurseong (K-I) (Fig. 4.1).

Throughout the last decade (major events in 2013 and 2017) local farmers, automobile drivers, and other small businesses began peaceful protests through strikes and immobilization of transportation within the region. Non-coopertion by the State Government again, turned such strikes into violent resistence in the form of torching Government tourist lodges, Railway workshops and State Government-run businesses, among other violent activities.

Fig. 4.1. Railway Workshop Structure vandalized and bombed between 1986 and 1988 in Tindharia, Kurseong. (Picture taken during fieldwork, 2016)

Focus group discussions during community meetings and some key-informant interviews reveal that the context and forms of resistance mobilization have complex impacts on farming communities. Farmer strikes within tea plantations are a more common form of active resistence to plantation management that keeps happening in the demand of wage raise and other demands. This form of resistance has been beneficial for farming communities to make the Tea Board (Government of India) raise wages somewhat. However, landslide survivors in tea plantations as well as smallholder regions also have grievances on inadequate disaster aids from both the State and the Central Government. The inability of mainly the State Government to meet these demands beget an unremitting distrust among local people. This distrust and grievances are mobilized by the local political group (e.g., the Gorkha Territorial Administration, or the GTA- as they are called now) during periods of political unrest. The local autonomous Gorkhaland administration also succeeds in ensuring allegiance from local communities by virtue of being their ethnic kin. Often tea plantation strikes are combined with this form of ethnopolitical conflict. The region-wide riot in 2017 that forced local farmers to go without work and without wage for 100 days is such an example. The impact of such resistances are, in contrast to common farmer strikes are not always beneficial to farming communities, and have a cumulating impact on their economic vulnerability. In 2017, the latter did not benefit from the negotiations between the State Government and the GTA, but paid a steep price of temporary unemployment in the process.

Passive Resistance: Passive resistances are covert and sometimes indirect forms of resistance that could not be fully explored. However, some K-I anecdotes mention illegal mining and lumbering activities within Kurseong. For example, illegal mining of poor-quality coal was surmised by K-Is to have caused massive landslides near Tindharia (central Kurseong) in the past. Such activities are reported near Sittong even to this day, in spite of strict mandates and fines against personal lumbering. However, such instances could not be corroborated beyond K-I information. Passive resistances in the form of being late at work, escaping duties, etc. were not reported.

Farmers were asked to provide direct suggestions to the State Government about systemic changes they would like to see to better their living conditions. Farmer suggestions to the government or employer institutions were coded from an open-ended household survey question incorporated after K-I interviews and CMs. A diverse range of opinions were received from 76%

of all surveyed households. Major suggestions from landslide victim households include adequate compensation with either cash, household, employment, accessibility (disrupted by landslides), and basic entitlements shortly after the disaster event, which at present, is largely inadequate. The second suggestion that most households ardently want is a change to property ownership. Thirdly, farmers suggest improvement in direct communications with government officials. Some grievances were received, too, including skepticism that anything will change for farmers because of corruption at the upper levels of social and political hierarchies. The final suggestion was for the researcher where several households requested to send the long report they felt would be generated from the household survey responses.

5. Discussion

The results reveal that the plantation agro-ecosystem in Kurseong, established by colonial land-grabbing, erasure of local pre-colonial existence, and commodification of land (Bennike 2017), has not significantly restructured itself in the post-colonial era. Infrastructural constraints, poor entitlements, and ethno-political conflicts have further hindered supporting local population both within and outside plantations. Still, farmers continue to cope with such social constraints amidst environmental vagaries through their perceptions, adaptations and resilience.

The political ecology framework, methodology and results together aim to advance a decentered, pluralistic and decolonial approach to explore adaptations to a post-colonial plantation agroecosystem. Although Kull (2002, p. 13) described political ecology as a "post-paradigmatic" approach because of its pluralism, recent scholars are cautious and more self-reflective toward decentering and decolonizing ontologies and epistemologies by avoiding dualisms of global north-global south concepts, dominant vs marginalized stakeholders, and so on. This research heeds such reflections to explore the profound implications of colonial legacies on a heretofore "ungoverned" frontier land (Scott, 2010).

Thus, the results are structured in terms of systems (SES) and functions (adaptations). The results reveal that an assemblage of systemic inadequacy in supporting agricultural producers with solvent wages, property rights and living infrastructure; combined with a proximal disaster vulnerability poses an almost untenable problem for administrators, land managers as well as local farmers in different ways. Sustainable adaptations too, are practiced and planned by both governance and local farmers. Maladaptations at a household level (e.g., waste disposal increasing landslide risk) are not faulty land-use decisions by farmers unaware of environmental implications, rather decisions to cope with infrastructural constraints. Administrators and land-managers too, struggle to provide aids due to limited available funding in the region. Maladaptations at regional (administrative) level (e.g., starting hydro-electric powerplant projects) aim to provide resources (electricity) to farmer households, and temporary employment to local, otherwise jobless people.

The wicked problem of Kurseong is deeper and more systemic. Results illustrate that colonial hegemonies in the region have translated in the postcolonial ecosystem, not only in terms of an exploitative and capitalist agricultural system, but also profoundly in conceptualizing the identities and rights of farmers. Aligning with Davis' (2004) observations on North African desertification, this research, set in a different spatial and ecological context, too, found that colonial legacies are seldom questioned by postcolonial governance. Policies formed through such hegemonies continue to overlook the productive labor class in a systemic basis, e.g., through minimal wages, lesser relative entitlements, etc. The colonial legacy of control over land resources still prevails in the form of absent land rights of plantation farmers. Such hegemonies result in the reluctance within post-colonial governance where property rights outside plantations are also non-transparent. Thus, the colonial infrastructure, established without keeping the labor class population in mind, has been internalized by post-colonial governance. The predominant forms of conflict and resistance observed in Kurseong during this research are active resistances. Passive (covert or indirect) resistances such as nonconformity to strict deforestation mandates through illegal mining and lumbering activities were reported but could not be explored in detail. Active resistances include plantation worker strikes and non-cooperation resistance within plantations where farming communities make their voices heard regarding wage raise, claims of land tenure, among others. Impacts of such resistances are sometimes beneficial, but sometimes are made complicated when they are politically mobilized by higher political groups. Then, the Government responses further hinder jobs and employment, because daily wage-earners get pay cuts for the days they are on strike. Such instances keep occurring sporadically over a few days, and occasionally over longer periods of time. The three-month long strike and riots in 2017 mentioned above, resulted in plantation workers having pay cuts for the entire time. Given their economic insolvency, households probably barely survived because of their independent small farming practices.

Rumbach (2016) explained the physical, and cultural distance of this region to be a reason for the lack of policies for regional development. Identity conflicts are deeply rooted in the colonial history of ‘legalized’ land grabbing from a historically independent population. Tea plantation management, rural government administration, and Gorkha administration, all work to ameliorate farmer conditions, yet farmer marginalization and labor exploitation continue to prevail. The embedded marginalization has translated into ethnic conflicts between a) the State, and b) the autonomous GTA. These conflicts often combine with economic marginalization of farmer households exacerbating social relations further.

The “wicked problems” are the major drivers that make a farmer household vulnerable. But in spite of such problems, farmers adapt through sustainable and unsustainable ways. The major sustainable adaptation at household level involves utilizing small plots of land for subsistence agriculture. In some farmer communities, setting cooperatives to support neighbors during distress is another effort to adapt. Most families increase their household income by three times working odd jobs in construction, and automobile businesses. Farmer perceptions on environment and their clumsy solutions fostered their resilience to cope and survive With a twist, this reminds us of James Scott's inhabitants of Zomia. Although incorporated within nation-states, and deeply entrenched in exploitative systems, local survival in this frontier region still thrives with indigenous resilience.

6. Conclusion

This study discusses local adaptations in the complex postcolonial society of Kurseong. Results suggest that the colonial legacies of power and control over land and labor exist profoundly within the post-colonial system, yet human resilience was fostered through clumsy adaptations and everyday acts of resistance. Colonial legacies have infiltrated within the non-plantation sectors as well in the form of common ideas of development (hegemonies), policies, planning and disaster aids that pay minimal importance to the working-class people (comprising of a majority farmer households). The monopoly of plantation agriculture has hindered other strong sectors of economy flourishing in Kurseong. E.g., smallholder regions have shrunk due to lack of government aids in the sector. To cope with such wicked problems, clumsy adaptations and maladaptations are found at multiple levels. At government levels environmentally, maladaptive developmental programs include setting up hydropower projects without environmental impact assessments. Maladaptations by farmers are mostly constrained by outdated infrastructures. Amidst such adaptations, local grievances and everyday peasant resistance often combine to take the form of identity politics in the demand of a separate Statehood. Such active resistence give local communities visibility on one hand, but often become violent. These further endanger farmer families already low social and economic capital.

A decentered political ecology approach and mixed methodology helped explore the complexities of human-environment interactions within context, however, this research is not free from limitations. The sample participants chosen for all three ethnographic methods used purposive, geographically stratified, and respondent-driven sampling methods that have a potential bias towards one group of population. Yet, plantation as well as smallholder households revealed satisfactory commonalities to enable confident description of the results.

Perceptions studied partly in this research have furthered the scopes for future research aimed at exploring pathways towards sustainable development in regions with deep indigenous histories. As Scott (2010) explained, colonial discourses shun and stigmatize local knowledge as barbarian, ethnic, tribal, etc., a decolonized attempt towards the PE approach as suggested by a host of PE scholars (Kim et al., 2012; Sundberg, 2015; Schulz, 2017; Loftus, 2017) will thus involve more entanglements of such histories and knowledges within the scientific discourses. This research attempts to include themes and ideas from stakeholders from such entanglements, but only scratches the surface, paving the path for future decentered approaches.

References:

Arsenault N., Hale L., Khedkar P., & Morimoto Y. (2012). Integrated Water Management in Kurseong. *Energising Local Capacities*, 81.

Bandyopadhyay, S. Land-Use/Land-Cover Change and Impacts of Landslide Vulnerability in Kurseong. Unpublished Results.

Bassett, T. J. (1988). The Political Ecology of Peasant-Herder Conflicts in The Northern Ivory Coast. *Annals Of The Association Of American Geographers*, *78*(3), 453-472.

Bassett, T. J., & Fogelman, C. (2013). Déjà Vu Or Something New? The Adaptation Concept In The Climate Change Literature. *Geoforum*, *48*, 42-53.

Benedikter, T. (2009). Solving Ethnic Conflict through Self-Government. *A Short Guide to Autonomy in South Asia and Europe. EURAC.*

Bennike, R. (2017). Frontier commodification: Governing land, labour and leisure in Darjeeling, India. *South Asia: Journal of South Asian Studies*, *40*(2), 256-271.

Beringer, T., Kulak, M., Müller, C., Schaphoff, S., & Jans, Y. (2020). First process-based simulations of climate change impacts on global tea production indicate large effects in the World's major producer countries. *Environmental Research Letters*, *15*(3), 034023.

Besky S. (2008). Can a plantation be fair? Paradoxes and possibilities in fair trade Darjeeling tea certification. *Anthropology of Work Review*, 29(1): 1-9.

Besky, S. (2014). *The Darjeeling distinction: Labor and justice on fair-trade tea plantations in India* (Vol. 47). Univ of California Press.

Besky, S. (2015). Agricultural justice, abnormal justice? An analysis of fair trade's plantation problem. *Antipode*, *47*(5), 1141-1160.

Beymer-Farris, B. (2013). Producing biodiversity in Tanzania's Mangrove Forests? A combined political ecology and ecological resilience approach to "Sustainably utilized landscapes". In, *Land Change Science, Political Ecology, and Sustainability: Synergies and Divergences,* eds. C. Brannstrom and J. Vadjunec, 84-106. Routledge.

Bhattacharya, N. (2013). Leisure, economy and colonial urbanism: Darjeeling, 1835–1930. *Urban history*, *40*(3), 442-461.

Bhowmik, S. K. (2011). Ethnicity and isolation: Marginalization of tea plantation workers. *Race/Ethnicity: Multidisciplinary Global Contexts*, *4*(2), 235-253.

Bhutia, S. (2015). A Spatio-Temporal Study on Urbanization in the Darjeeling Himalaya: A Demographic Perspective. *IOSR Journal of Humanities and Social Science*, *20*(4), 10-18.

Biswas, S. (2013). Urban Growth Centers In Darjeeling Hills Of West Bengal: A Geographical Analysis. *The Journal of Bengal Geographer, 2*(1), 30 – 48.

Blaikie, P., & Brookfield, H.C. (1987). *Land Degradation and Society.* London: Methuen.

Boafo, J., & Lyons, K. (2019). Expanding cashew nut exporting from Ghana's Breadbasket: A political ecology of changing land access and use, and impacts for local food systems. *The International Journal of Sociology of Agriculture and Food*, *25(*2), 152-172.

Bridge, G., McCarthy, J., & Perrault, T. (2015)." Editors' introduction". In, *The Routledge handbook of political ecology*. (Eds.) Perreault, T., Bridge, G., & McCarthy, J. Routledge.

Bryant, R. L. (1992). Political ecology: an emerging research agenda in Third-World studies. *Political geography*, *11*(1), 12-36.

Bryant, R. L., & Bailey, S. (1997). *Third world political ecology*. Psychology Press.

Bryant, R. L. (2015). Reflecting on political ecology. In *The international handbook of political ecology*. Edward Elgar Publishing.

Census of India, (2011). District Census Handbook – Darjeeling, India.

Charmaz, K., & Thornberg, R. (2020). The pursuit of quality in grounded theory. *Qualitative Research in Psychology*, 1-23.

D'Alisa, G., & Kallis, G. (2016). A political ecology of maladaptation: Insights from a Gramscian theory of the State. *Global Environmental Change*, *38*, 230-242.

Das, N., Chatterjee, S., & Roy U. (2011). An assessment of anthropogenic impact on natural landscape–The case of Kurseong Town, Darjeeling, West Bengal. *Indian Journal of Geography & Environment*, 12, 40-50.

Das, R. (2014). Impact of civilized intervention on the eco-fitness of Kurseong municipality, West Bengal, India. *International Journal of Advanced Research in Management and Social Sciences*, 3(9), 217-237.

Davis, D. K. (2004). Desert 'wastes' of the Maghreb: desertification narratives in French colonial environmental history of North Africa. *Cultural geographies*, *11*(4), 359-387.

Davis, D. K., & Robbins, P. (2018). Ecologies of the colonial present: Pathological forestry from the *taux de boisement* to civilized plantations. *Environment and Planning E: Nature and Space*, *1*(4), 447-469.

Dekens, J. (2005). Livelihood change and resilience building: a village study from the Darjeeling Hills, Eastern Himalaya, India.

Dove, M. R., Jonsson, H., & Aung-Thwin, M. (2011). James C. Scott, The art of not being governed: An anarchist history of upland Southeast Asia. *Journal of the Humanities and Social Sciences of Southeast Asia*, *167*(1), 86-99.

Duncan, J. S. (2002). Embodying colonialism? Domination and Resistance in nineteenth-century Ceylonese coffee plantations. *Journal of Historical Geography*, *28*(3), 317-338.

Elias, K. A. (2018). *Value Creation: The Dynamic Position of Policy Change in the Global Tea Industry* (Master's Thesis, University of Oregon).

Enfield, G. H., & O'Hara, S. L. (1999). Degradation, drought, and dissent: an environmental history of colonial Michoacán, west Central Mexico. *Annals of the Association of American Geographers*, *89*(3), 402-419.

Escobar, A. (2006). Difference and conflict in the struggle over natural resources: a political ecology framework. *Development*, *49*(3), 6-13.

Fairhead, J., & Leach, M. (1995). False forest history, complicit social analysis: rethinking some West African environmental narratives. *World development*, *23*(6), 1023-1035.

Forsyth, T. (2004). *Critical political ecology: the politics of environmental science*. Routledge.

Gandhi, L. (1998). *Postcolonial theory: A critical introduction*. Columbia University Press.

Ghatani, S. (2015). *Sustainable Urban Water Management in Darjeeeling* (Doctoral dissertation).

Ghatani, S. (2016). *Impact of Mahatma Gandhi National Rural Employment Guarantee Scheme on the Livelihoods of Rural Poor: A Study of the Naxalbari Block in Darjeeling District* (Doctoral dissertation, Sikkim University).

Gramsci, A. (1978). *Selections from Political Writings 1921-1926*, trans. Quentin Hoare, International Publishers, New York

Hammond, R. (2011). The battle over Zomia. *Chronicle of Higher Education*, B9.

Haraway, D. (2015). Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin. *Environmental humanities*, *6*(1), 159-165.

Harris, T., Holmes-Tagchungdarpa, A., Sharma, J., & Viehbeck, M. (2016). Global Encounters, Local Places: Connected Histories of Darjeeling, Kalimpong, and the Himalayas—An Introduction. *The Journal of Transcultural Studies*, *7*(1), 43-53.

Hartmann, T. (2012). Wicked problems and clumsy solutions: Planning as expectation management. *Planning Theory*, 11(3): 242-256.

Holmes, G. (2014). Defining the forest, defending the forest: Political ecology, territoriality, and resistance to a protected area in the Dominican Republic. *Geoforum*, *53*, 1-10.

Huber, A. (2019). Hydropower in the Himalayan hazardscape: Strategic ignorance and the production of unequal risk. *Water*, *11*(3), 414.

India, Tea Board (2017-18), *Report.* Ministry of Commerce and Industry, Government of India.

Ives, J. D., & Messerli, B. (1989). *The Himalayan Dilemma: Reconciling Development and Conservation*. Routledge: NY.

Jana, A. K. (2012). Backwardness and Political Articulation of Backwardness in the North Bengal Region of West Bengal. In, *Rethinking State Politics in India: Regions Within Regions*, ed. A Kumar, 153-196. Routledge: India.

Jodha, N. S. (2005). Adaptation strategies against growing environmental and social vulnerabilities in mountain areas. *Himalayan Journal of Sciences*, 3(5), 33 – 42.

Joshi, S. (2015). Postcoloniality and the North–South binary revisited: The case of India's climate politics. In *The International Handbook of Political Ecology*. Edward Elgar Publishing.

Khawas, V. (2002). Environment and rural development in Darjeeling Himalaya: Issues and concerns. *Centre for Environmental planning and Technology, Ahmedabad, India*.

Khawas, V. (2011). Status of tea garden labourers in eastern Himalaya: a case of Darjeeling tea industry. *Socio-Economic Conditions of Resident Tea Garden Labourers in Darjeeling Hills-A Pilot Study*.

Kim, S., Ojo, G. U., Zaidi, R. Z., & Bryant, R. L. (2012). Other political ecologies: introduction. *Singapore Journal of Tropical Geography*, *33*(1), 29-33.

Krasner, S. D., Roberts, N., Greenhouse, C. J., Manicas, P. T., & Clunan, A. (2011). State, Power, Anarchism: A Discussion of" The Art of Not Being Governed: An Anarchist History of Upland Southeast Asia".

Kull, C. A. (2002). Isle of fire: The political ecology of grassland and woodland burning in highland Madagascar. *Doctoral Dissertation.*

Leach, M., Mearns, R., & Scoones, I. (1999). Environmental entitlements: dynamics and institutions in community-based natural resource management. *World development*, *27*(2), 225-247.

Le Billon P. (2015). Environmental Conflict. In, *The Routledge Handbook Of Political Ecology*. (Eds.) Perreault, T., Bridge, G., and McCarthy, J. Routledge.

Loftus, A. (2015). A time for Gramsci. In, *The International Handbook of Political Ecology*. Edward Elgar Publishing.

Loftus, A. (2017). Political ecology I: Where is political ecology? *Progress in Human Geography*, 43(1): 172-182.

Loftus, A. (2018). Political ecology II: Whither the State? *Progress in Human Geography*, *44*(1), 139-149.

Loftus, A. (2019). Political ecology III: Who are 'the people'? *Progress in Human Geography*, *44*(5), 981-990.

Longhurst, R. (2012). Semi-structured interviews and focus groups. In, *Key methods in geography*, eds. N Clifford, S. French and G. Valentine, 103-115. Sage, London.

Malley, L. O. (1999) [1907]. *Bengal district gazetteer: Darjeeling*. Concept Publishing Company.

McKittrick, K. (2013). Plantation futures. *Small Axe: A Caribbean Journal of Criticism*, *17*, 1-15.

Michaud, J. (2017). What's (written) history for?: On James C. Scott's Zomia, especially Chapter 6½. *Anthropology Today*, *33*(1), 6-10.

Mullard, S. (2015). Reading Ethnic Conflict in Sikkimese History: The Case of the Assassination of Chancellor Bho lod. *From Bhakti to Bon: Festschrift for Per Kvaerne*, 367-380.

Navitha, B., & Sethurajan, S. (2018). The Problems and Prospects of Indian Tea Exports Industries. *International Journal of Research and Analytical Reviews*, 2348-1269.

Netting, R.M. (1986). Cultural Ecology. Long Grove: Waveland Press.

Neimark, B., Childs, J., Nightingale, A. J., Cavanagh, C. J., Sullivan, S., Benjaminsen, T. A., ... & Harcourt, W. (2019). Speaking power to "post-truth": Critical political ecology and the new authoritarianism. *Annals of the American Association of Geographers*, *109*(2), 613-623.

Ney, S., & Verweij, M. (2015). Messy institutions for wicked problems: How to generate clumsy solutions? *Environment and Planning C: Government and Policy*, *33*(6), 1679-1696.

Oas, S. E., & Hauser, M. W. (2017). The Political Ecology of Plantations from the Ground Up. *Environmental Archaeology*, *23*(1), 4-12.

Palani, S. (2019) A Study on Tea Export Trend in Indian Economy. *Journal of Information and Computational Science.*

Pant, B. R. (2003). Degrading environment and growing population of the Indian Himalaya. *Envis Bull Himal Ecol Dev*, 11(1), 23-34.

Panwar, T. (2017). Living Condition of Tea Plantation Workers. *International Journal for Advance Research and Development*, *2*(8), 4-8.

Perry, J. (2015). Climate change adaptation in the world's best places: A wicked problem in need of immediate attention. *Landscape and Urban Planning*, *133*, 1-11.

Ranganathan, M. (2015). Storm drains as assemblages: The political ecology of flood risk in post-colonial Bangalore. *Antipode*, *47*(5), 1300-1320.

Rasaily, R. (2013). Changing land utilisation patterns in tea plantation sector in West Bengal: some policy imperatives. *NRPPD Discussion*.

Rayner, S. (2006). Jack Beale Memorial Lecture on Global Environment Wicked Problems: Clumsy Solutions–diagnoses and prescriptions for environmental ills.

Rittel, H. W., & Webber, M. M. (1973). Planning Problems Are Wicked. *Polity*, *4*(155).

Robbins, P., McSweeney, K., Chhangani, A. K., & Rice, J. L. (2009). Conservation as it is: illicit resource use in a wildlife reserve in India. *Human Ecology*, *37*(5), 559.

Robbins, P. (2012). *Political ecology: A critical introduction* (Vol. 16). John Wiley & Sons.

Robbins, P. (2015). The trickster science. In, *The Routledge handbook of political ecology*, eds. Perreault, T., Bridge, G., & McCarthy, J. Routledge, 89-101.

Robbins, P., Tripuraneni, V., Karanth, K. K., & Chhatre, A. (2020). Coffee, Trees, and Labor: Political Economy of Biodiversity in Commodity Agroforests. *Annals of the American Association of Geographers*, 1-16.

Roy Chowdhury, R., & Turner, B. L. (2006). Reconciling agency and structure in empirical analysis: smallholder land use in the southern Yucatán, Mexico. *Annals of the Association of American Geographers*, *96*(2), 302-322.

Rumbach, A. (2016). Disaster Governance in Small Urban Places: Issues, Trends, and Concerns. In, *Disaster Governance in Urbanising Asia* (p. 109-125). Springer Singapore.

Sarkar, S., & Reji, B. (2019). A cup full of woes: wages & tea industry. *Indian Journal of Economics and Development*, *7*(2).

Schulz, K. A. (2017). Decolonizing political ecology: ontology, technology and 'critical' enchantment. *Journal of Political Ecology*. 24(1), 125-143.

Scott, J. C. (2010). *The art of not being governed: An anarchist history of upland Southeast Asia*. Nus Press.

Sen, A. (1982). *Poverty and famines: an essay on entitlement and deprivation*. Oxford University Press.

Sharma, J. (2016). Producing Himalayan Darjeeling: Mobile people and mountain encounters. *HIMALAYA, the Journal of the Association for Nepal and Himalayan Studies*, *35*(2), 12.

Spivak, G. C. (1988). Can the subaltern speak? *Can the subaltern speak? Reflections on the history of an idea*, 21-78.

Srivastava, S.C. (2005). Protecting the Geographical Indication of Darjeeling Tea. In, *Managing the Challenges of WTO Participation: 45 Case Studies, eds. P Gallagher, P Low, A. L. Stoler.* Cambridge University Press.

Strauss, A., & Corbin, J. (1994). Grounded theory methodology. *Handbook of qualitative research*, 17(1), 273-285.

Sundberg, J. (2015). Ethics, entanglement, and political ecology. In *The Routledge Handbook of Political Ecology,* (eds.) Perreault, T., Bridge, G., & McCarthy, J. (pp. 139-148). Routledge.

Svarstad, H., & Benjaminsen, T. A. (2020). Reading radical environmental justice through a political ecology lens. *Geoforum*, *108*, 1-11.

Tamang, S., & Sitlhou, H. (2018). Identity, contestation and ethnic revivalism among Nepalis in Darjeeling. *Economic and Political Weekly*, *53*(1), 33-39.

Tatham, P., & Houghton, L. (2011). The wicked problem of humanitarian logistics and disaster relief aid. *Journal of Humanitarian Logistics and Supply Chain Management*.

Tiffen, M., Mortimore, M. (1990). *Theory and Practice in Plantation Agriculture*. Boulder: Westview Press.

Underdal, A., & Wei, T. (2015). Distributive fairness: A mutual recognition approach. *Environmental science & policy*, *51*, 35-44.

Verweij, M., Douglas, M., Ellis, R., Engel, C., Hendriks, F., Lohmann, S., ... & Thompson, M. (2006). Clumsy solutions for a complex world: the case of climate change. *Public administration*, *84*(4), 817-843.

Voora, V., Bermudez, S., & Larrea, C. (2019). Global Market Report: Tea. *International Institute For Sustainable Development (IISD).*

Wainwright, J., Jiang, S., & Liu, D. (2014). Deforestation and the world-as-representation: The Maya forest of Southern Belize. In *Land Change Science, Political Ecology, and Sustainability* (pp. 191-212). Routledge.

Watts, M. J. (2015). The origins of political ecology and the rebirth of adaptation as a form of thought. *The Routledge handbook of political ecology*, 19-50.

Wenger, K., Vadjunec, J. M., & Fagin, T. (2017). Groundwater governance and the growth of center pivot irrigation in Cimarron County, OK and Union County, NM: Implications for community vulnerability to drought. *Water*, *9*(1), 39.

Wenner, M. (2013). Challenging the state by reproducing its principles. The demand for "Gorkhaland" between regional autonomy and the national belonging. *Asian ethnology*, *72*(2), 199-220.

Yeh E. T., Nyima Y., Hopping K. A. and Klein J. A. 2014. Tibetan Pastoralists' Vulnerability To Climate Change: A Political Ecology Analysis Of Snowstorm Coping Capacity. *Human Ecology*, 42(1): 61-74.

CHAPTER V

CONCLUSION

Dissertation Summary

Kurseong, a district subdivision in the eastern Himalayan Mountains in India, is vulnerable to an increasing threat of landslides (Basu and De 2003). With changing government regimes, market economies and population growth, Kurseong also experiences extensive land-use/land-cover change (LULCC) through deforestation, tea-plantations and built-structure expansion. This research explored the role of LULCC in increasing landslides, and the underlying socio-economic and political drivers that impact local vulnerability and resilience.

Landslides are comparatively less explored than other disasters due to the inaccessibility of mountains. Landslide inventories are often incomplete due to the scarcity of data, with fewer empirical analyses of the human impacts on the environment. Much less are explored about the assemblage of complex social interactions that influence environmental outcomes. This research fills this gap by exploring several potential aspects of human-induced land change that have influenced environmental outcomes and vulnerabilities to landslides in Kurseong. To do so, this dissertation has integrated theoretical frameworks from post-positivist and constructivist paradigms and a mix of quantitative and qualitative methods to obtain not only information, but perspectives for a holistic analysis and synthesis of findings.

This research employs the transdisciplinary Land Systems Science framework, and a Political Ecology framework to explore landslide disasters and its impacts in a Himalayan environment. The geography of the Himalayas consists of a very important ecosystem in the world with 52.7 million people inhabiting the place (Apollo 2017). The integrated framework helped observe and monitor broad regional changes within the environment and identified the human-induced drivers of such change. Additionally, this research explored at historical depths, how a postcolonial social-economic and political system have influenced local land-use. The socio-political system has influenced resource management, livelihoods, and adaptations of local land-users.

The mixed methods approach, designed for this study integrated household and community level data with regional level satellite data. The methods are used for data collection, analysis and synthesis, and include: 1) Digital satellite image classification and change detection to identify the patterns of LULCC and distribution of landslides in Kurseong over the last 40 years; (2) Key-Informant Interviews, community meetings and extensive household surveys to understand socio-economic conditions of local land-users, factors that influence land-use decisions, disaster vulnerability and institutional/political situations of infrastructural development and disaster management; (3) Archival Research to document land-use trajectories and past landslides; and 4) Integrating the socio-economic data and the satellite data to identify underlying drivers that impact LULCC and landslide vulnerability.

In Chapter 2, the role of human-induced LULCC was explored that correlated with landslide susceptibility and vulnerability. Using the integrated Land Systems Science framework this paper first used remote sensing analysis to map land-use/land-covers in Kurseong for the years 1988, 1999, 2009 and 2019. Digital change detection showed LULCC in a bitemporal analysis for every consecutive decade. Local level LULCC mapping of five study areas was also conducted. Maps of landslide distribution over all four years of study were made. An overlay analysis of the landslide distribution maps and the LULC maps determined the total area of each land-use/land-cover destroyed by landslides for all years of study. This remote sensing analysis monitored land-use/land-cover change and land-use/land-cover patterns that are particularly vulnerable to landslides. Ethnographic methods including key-informant interviews (n=30), community meetings (n=5) and household surveys (n=146) explored the drivers of land-use/land-cover change. Land-use choices, constraints of sustainable land-use, land management and landslide vulnerability were explored in this research.

The findings showed an overall increase in forest cover and stabilization of landslides. Still people's vulnerability to landslides continue to intensify within heavily settled and deforested areas, and somewhat along streams where people travel and have land-use records. The proximate drivers of LULCC include afforestation measures in designated areas within and outside plantations; regional level institutional developmental programs such as hydropower stations, cable lines, etc. that involve slope cutting, and less-sustainable but only available options of less sustainable land-uses such as dumping wastes along slopes, probable but occasional lumbering, and mining, at individual and household levels. The underlying drivers of LULCC that increased vulnerability to landslides are inadequate infrastructure for drainage, sewerage and landslide recovery that constrain local land-use. Waste disposal and inaction over households affected by potential landslides further aggravate land-use along settlement areas.

Chapter 3 (Article 2) investigated the multidimensional ways people in Kurseong are vulnerable using the multidimensional livelihood vulnerability index (MLVI) framework. The framework was used to compute vulnerabilities of tea plantation workers and smallholder farmers belonging to the five study sites. The index gave a detailed insight and a mathematical explanation of people's vulnerabilities to several identified indicators and helped analyze the nature and extent of their vulnerability. The MLVI framework was integrated with a Political Ecology analytical framework to explore the chain of explanations that make a household and individual communities multidimensionally vulnerable. The MLVI framework identified 24 variables under 12 components nested under the three dimensions of vulnerability, namely, exposure, sensitivity and adaptive capacity. Results revealed, the MLVI of Makaibari to be 0.44, Tingling as 0.56, Goomtee – 0.24, Sittong – 0.7, and Sirubari – 0.49 meaning except Goomtee about 50% of all households in the rest of the four study areas were multidimensionally vulnerable. The MLVI framework also decomposed the individual share of vulnerability for each dimension, component and indicator providing an insight to the nature, extent and degree of vulnerability for each community. The political ecology chain of explanation identified the existing system of exploitation within the plantation system, inaccessibility of the environment and political and infrastructural constraints amidst which farmers adapt. The political ecology of adaptation and the historical roots of the exploitative system was explored further in chapter four.

Chapter 4 (Article 3) integrated political ecology and postcolonial studies to identify how a historical root of British colonial exploitation translated within the post-colonial system. This paper also explored local adaptation in a postcolonial commodified environment using several themes of political ecology. Carrying the colonial legacy of plantation agriculture, local people are still marginalized and exploited. Neocolonial attitudes of ethnic separation by dominant groups created an indigenous class of people who instigates conflicts with the use of identity politics. The powerful groups mobilize poor people's appeals e.g., on better employment and living conditions according to their own agenda, and thereby further exploit and marginalize them. To top the hostile social and political condition, the local plantation workers and smallholder farmers face multiple negative impacts of environmental degradation, e.g., pollution, destruction of land and houses from landslides among others. Amidst these complex wicked problems, they find ways to adapt and sustain themselves.

In sum, this dissertation tried to comprehensively understand at considerable depth and extent, the complexities of human adaptation in a fragile environment using hybrid quantitative and qualitative theoretical and methodological frameworks. Article 1 used a mix of both approaches, article 2 used a complex mathematical formulation to understand multiple dimensions of vulnerability, and finally chapter 3 delved deeper into the historical roots of the current socio, economic, political contexts in which people's vulnerability were assessed. The findings of this dissertation reinforced that disaster vulnerability is just a symptom of a more chronic systemic social condition, that gets manifested at times of an extreme event. So, it is more important to understand the conditions to approach an answerable solution.

Intellectual Merit and Significance

The intellectual merit of this work lies in conducting a multi-scalar and multi-temporal analysis of human-environment processes and impacts in a tough-access landslide-prone mountain region. This study acknowledges that disasters are not always extreme events and aberrations of the norm, but also result from systematic changes within the environment, often accelerated by human actions. Using an integrated LSS-PE framework in a disaster study, this research aims to contribute to the idea that disaster vulnerability is embedded in social processes. The mixed methods design links satellite and household data to identify and analyze human processes of land change and their impacts. The design also provides a working methodology for human-environment research on landslides around the world. By scientifically exploring the role of human actions on disaster vulnerability this research potentially contributes to advance the interdisciplinary fields of sustainability science, disaster research and global environmental change research.

This research studies vulnerability, an essential component of Disaster research, in the light of systemic and processual changes within the SES. It contributes to theory development by applying the key-concepts of LSS and PE in Disaster research. The integrated theoretical framework acknowledges that local processes are impacted by multi-scalar socio-economic and political factors. The mixed methods approach links multi-scalar and multi-temporal data to answer the relevant questions based on these concepts. Finally, the interdisciplinary nature of this research combines scientific and exploratory results that can potentially contribute in the advancement of Sustainability Science, Global Environmental Change studies and Disaster studies. Hence, it aims to contribute to a variety of scientific inquiry establishing its relevance across disciplines.

The Himalayas, along with other mountain ranges around the world, have a significant contribution in restoring ecological balance of the world. Productive areas of mountains are rich in biodiversity and they have provided resources to sustain livelihoods. In the present-day world, increased global demand for resources have impacted mountains as they have in other parts of the world. However, it is difficult to conduct a systematic study of human impacts on mountains due to their inaccessibility. Scarcity of data is a common issue to conducting research in mountains around the world (Ghosh et al. 2012, Petley 2012). This case study seeks to conduct a thorough empirical analysis with the help of the available inventory on landslides and LULCC. It aims to provide a working methodology to conduct research in similar mountain environments and track human derived degradation in such regions.

Limitations and Further Scope of Study

This dissertation has some limitations that is a scope for future research.

First, in article 1 a more extensive application and incorporation of imagery using the unmanned aerial system (UAS) could deliver detailed information of the land covers. Only GPS waypoints were collected. It is extremely difficult to accurately measure the area of landslides using a GPS. So, an extensive use of UAS could help immensely in the accuracy of land cover as well as landslide area calculation. Additionally, land-use/land-covers (LULC) were categorized into 6 broad classes. While these classes serve the purpose of understanding land stability, in future a detailed investigation of types of agriculture will add to the understanding of agricultural productivity and their impacts in slope stability.

Secondly, overall, the household surveys were not selected via random sampling methods. Geographically stratified sampling was used but the households were not pre-determined and lesser accessible households were also visited. Although these households might not be reflective of the range of the population, the bulk of the population will reflect similar livelihood and demographic patterns among plantation and smallholder populations.

Lastly, the socio-political context in Kurseong is very complex. Each of the themes identified in this research can be expanded upon. Interaction with only a few of the members of the Gorkha Territorial Administration (GTA) were possible due to the political turmoil during the time of fieldwork. Expanding ethnographic research through interviews and interactions with GTA can open up new avenues to add to the knowledge base. Previous research has been done on the Gorkhaland movements as well as marginalization of plantation workers, women and children, but they are mainly a part of anthropology/labor studies/political science/Asian ethnographic studies (see Wenner 2013, Sarkar and Bhowmik 1998, Jana 2012). However, a study of their evolving ecologies and decision-making with respect to their influence on environmental changes are untraded avenues that will add to the knowledge base of geography and James Scott's (2010) evolution of Zomia, from the land of the 'ungoverned' to what is yet to be understood.

Broader Impacts

The broader impacts ensuing from this research are manifold. The social impact of this study will involve better understanding of the systemic processes that increase vulnerability to a disaster. While in the field, interactions with local land-users were conducted not only to translate their local knowledge to science, but also to establish a social capital that could be used for future research in the area. This research is expected to help in a Ph.D. degree completion and publication of insights related to the complex factors influencing global environmental change. The findings will be published as journal articles, book chapters and presented in conferences. The results of this research will be disseminated to local offices after the publication of this dissertation, hoping to inform policies based on proper understanding of the human impacts in a disaster-prone environment.

Future Directions

This research contributes to integrated and interdisciplinary cross-paradigmatic fields of Land Systems Science, Disaster Vulnerability and Political Ecology. Tracing back the social, cultural and historical roots of a hill region in eastern India, this research aims to understand the choices and constraints of land-use and their social-ecological outcomes. The intricacies of local vulnerabilities amidst a constant threat of landslide disasters and the existing socio-political context opens up further avenues for research. Conducting further interviews and surveys with questions related to an in-depth history of colonial roots and identity of local people in Kurseong is a plan. The importance of post-colonial identity of locals was only revealed at a later stage of research. Deeper studies of identity politics might help understand better people's vulnerability.

Another important aspect to explore in this region is to disseminate findings in a way that mobilizes policies and planning. Participation of various stakeholders from managers to land-users, to administrators are expected to enhance sustainability and foster resilience. While in the field, interactions with government officials, local journalists, social workers, tea plantation management and other stakeholders provided sufficient encouragement and stimulus to share the results. After publication of this dissertation, a copy will be shared with each of them with the hope that it can help them in any way.

References:

Apollo, M. 2017. The population of Himalayan regions–by the numbers: Past, present and future. W: R. Efe, M. Öztürk (red.). *Contemporary Studies in Environment and Tourism. Cambridge: Scholars Publishing*, 145-160.

Basu, S. R. and S. K. De 2003. Causes and consequences of landslides in the Darjiling-Sikkim Himalayas, India. *Geographia Polonica*, 76(2): 37-52.

Ghosh, S., C. J. van Westen, E. J. M. Carranza, V. G. Jetten, M. Cardinali, M. Rossi, and F. Guzzetti. 2012a. Generating event-based landslide maps in a data-scarce Himalayan environment for estimating temporal and magnitude probabilities. *Engineering Geology*, 128: 49-62.

Jana, A. K. 2012. Backwardness and Political Articulation of Backwardness in the North Bengal Region of West Bengal. In, *Rethinking State Politics in India: Regions Within Regions*, ed. A Kumar, 153-196. Routledge: India.

Petley, D. 2012. Global patterns of loss of life from landslides. *Geology*, 40(10): 927-930.

Sarkar, K., and S. K. Bhowmik 1998. Trade unions and women workers in tea plantations. *Economic and Political Weekly*, L50-L52.

Scott, J. C. 2010. *The art of not being governed: An anarchist history of upland Southeast Asia*. Nus Press.

Wenner, M. 2013. Challenging the state by reproducing its principles. The demand for "Gorkhaland" between regional autonomy and the national belonging. *Asian ethnology*, 72(2): 199-220.

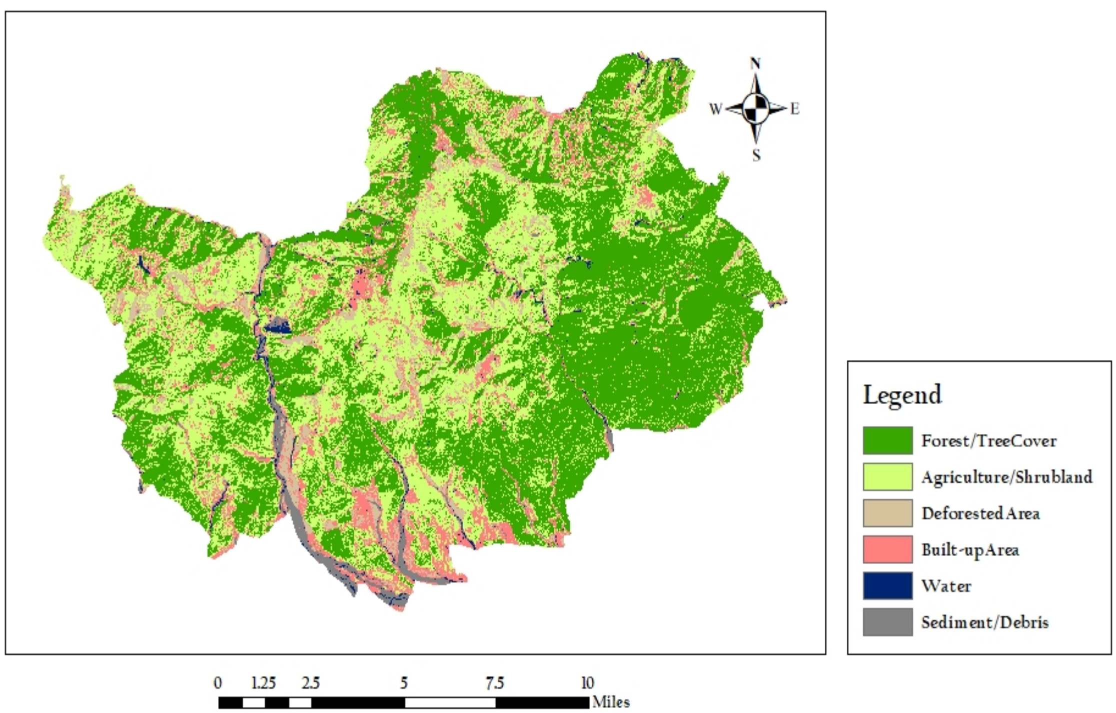
5.1. The small plot of land tea plantation households uses for cultivating vegetables.

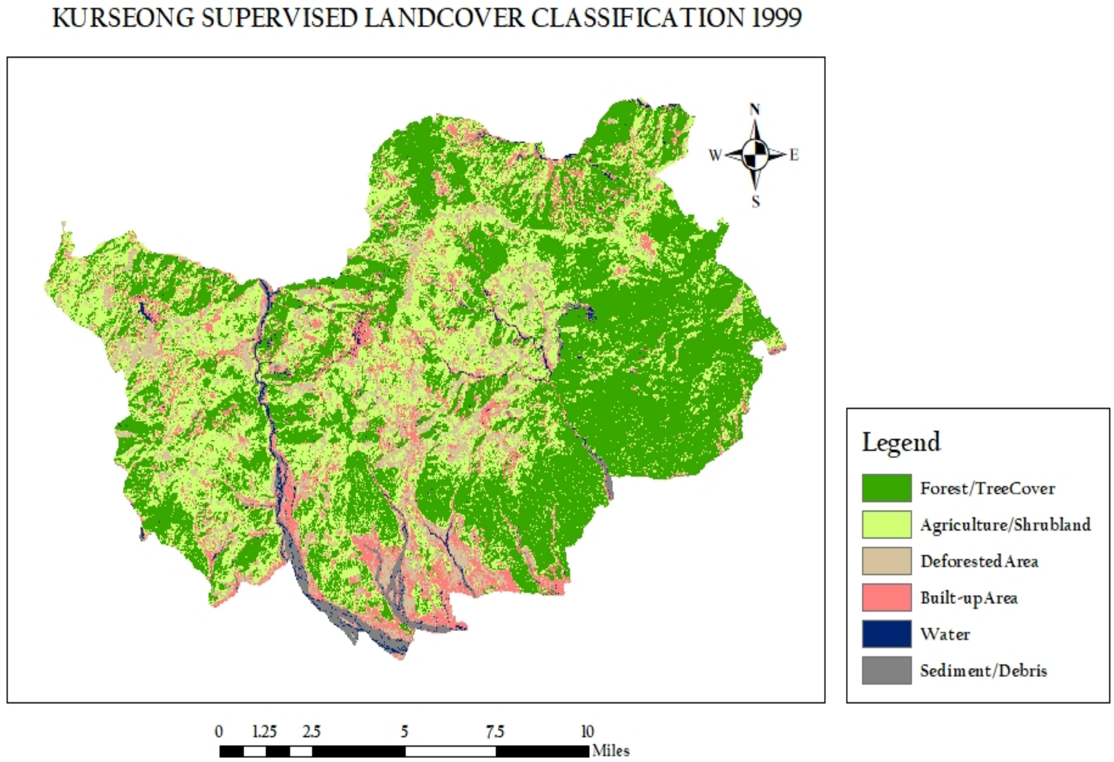
Picture Courtesy: Roshan Hussain

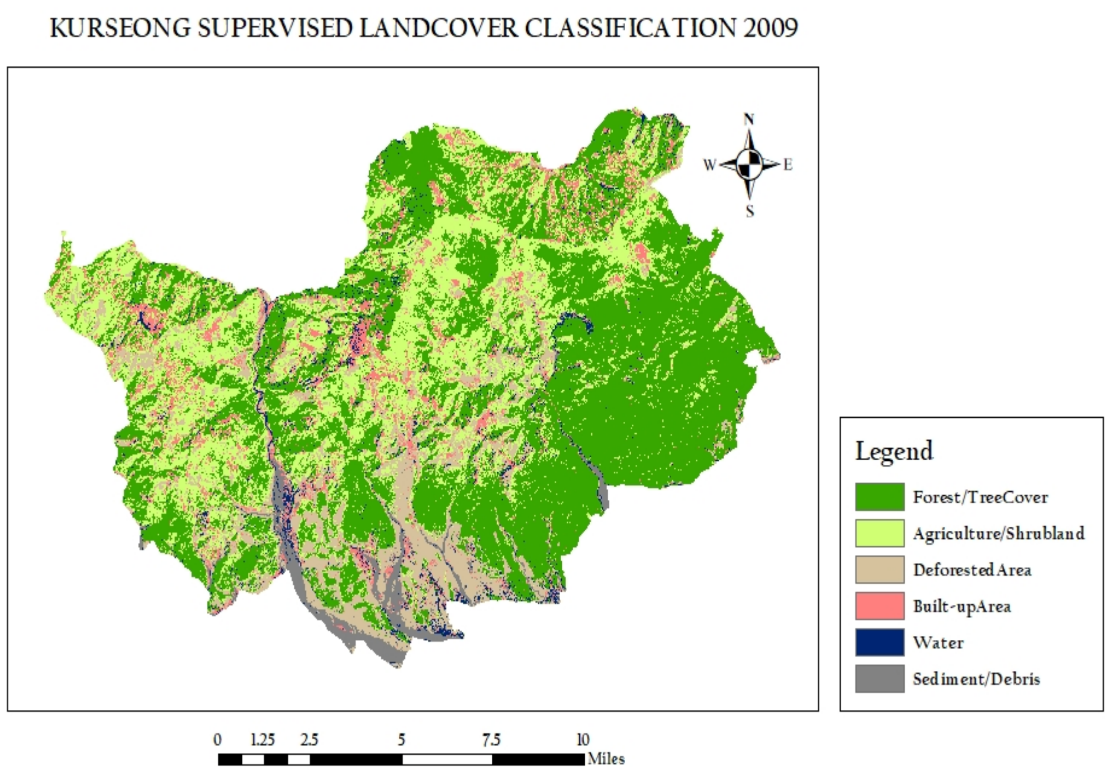
APPENDICES

APPENDIX A: LAND-USE/LAND-COVER MAPS OF KURSEONG (1988 – 2019)

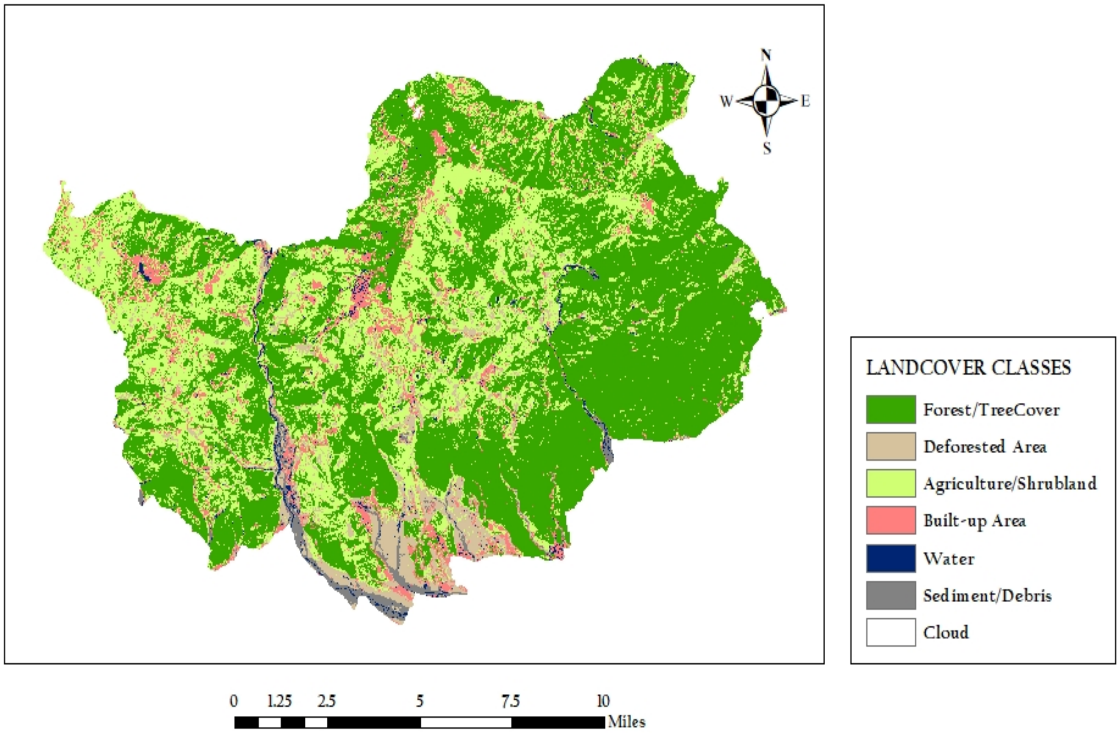
KURSEONG SUPERVISED LANDCOVER CLASSIFICATION 1988



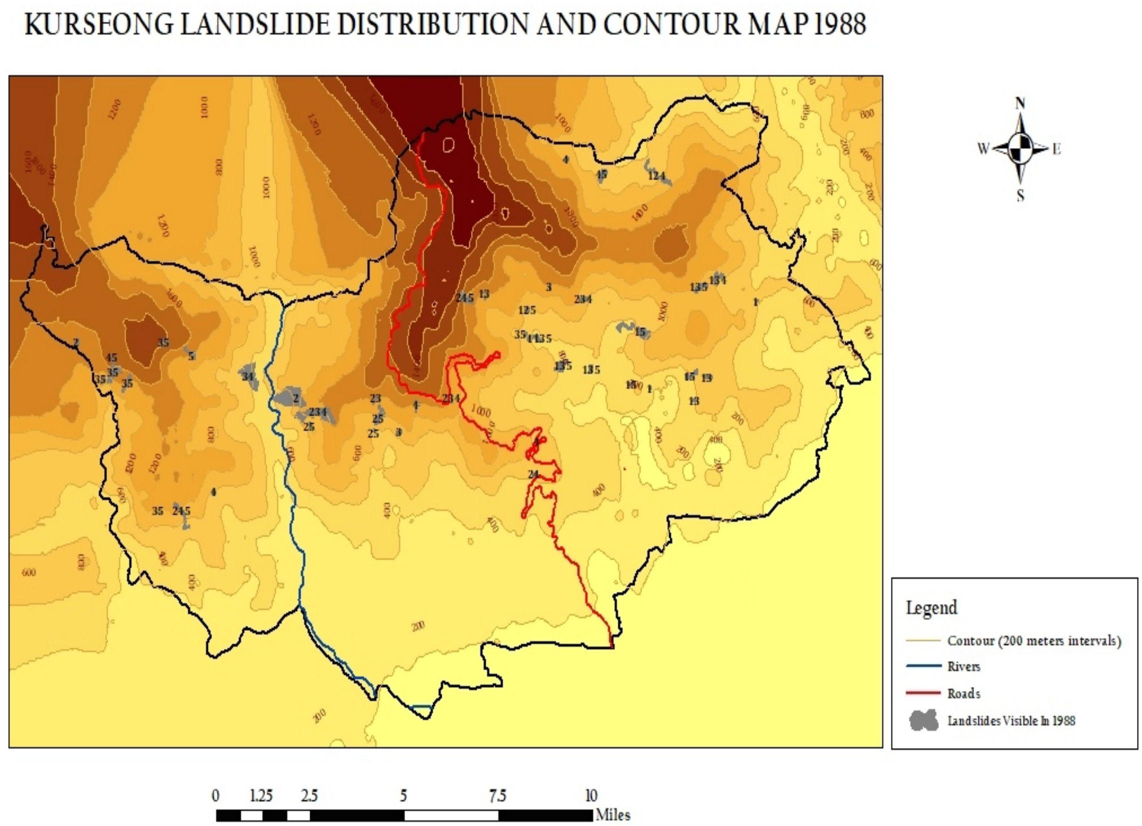

KURSEONG SUPERVISED LANDCOVER CLASSIFICATION 1999
N
W
E
S
Legend
Forest/TreeCover
Agriculture/Shrubland
Deforested Area
Built-upArea
Water
Sediment/Debris
0
1.25
2.5
5
7.5
10
Miles


KURSEONG SUPERVISED LANDCOVER CLASSIFICATION 2009
N
W
E
S
Legend
Forest/TreeCover
Agriculture/Shrubland
Deforested Area
Built-upArea
Water
Sediment/Debris
0
1.25
2.5
5
7.5
10
Miles

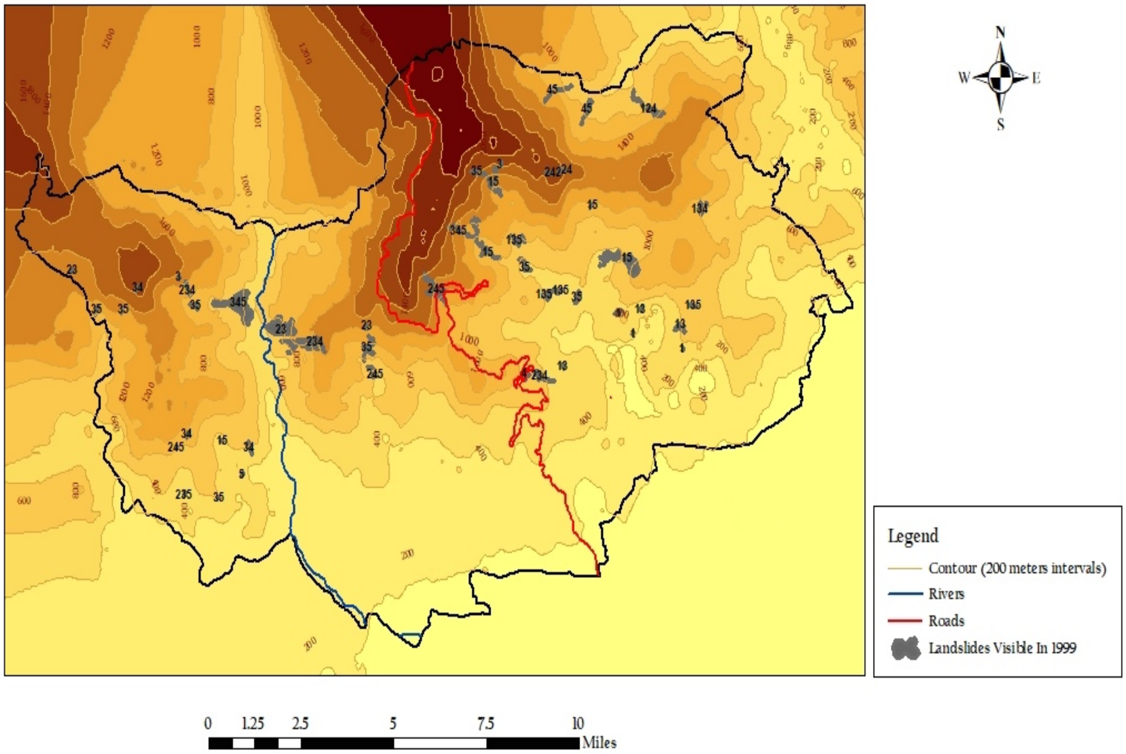
KURSEONG SUPERVISED LANDCOVER CLASSIFICATION 2019



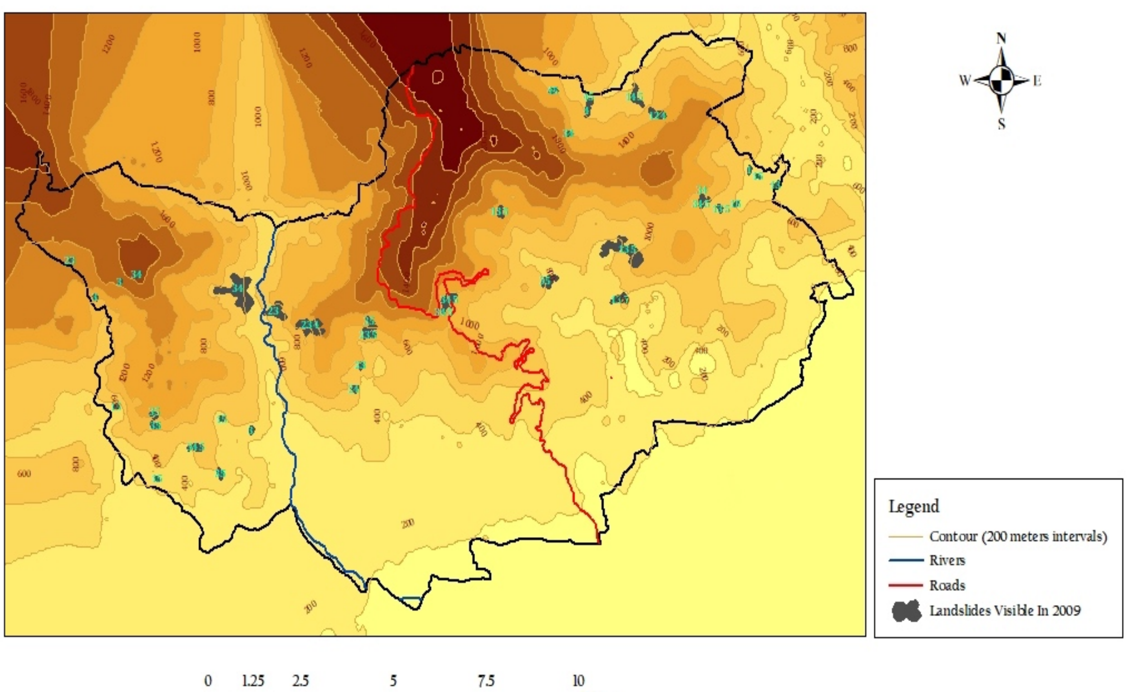
APPENDIX B: LANDSLIDE DISTRIBUTION MAPS OF KURSEONG (1988 – 2019)



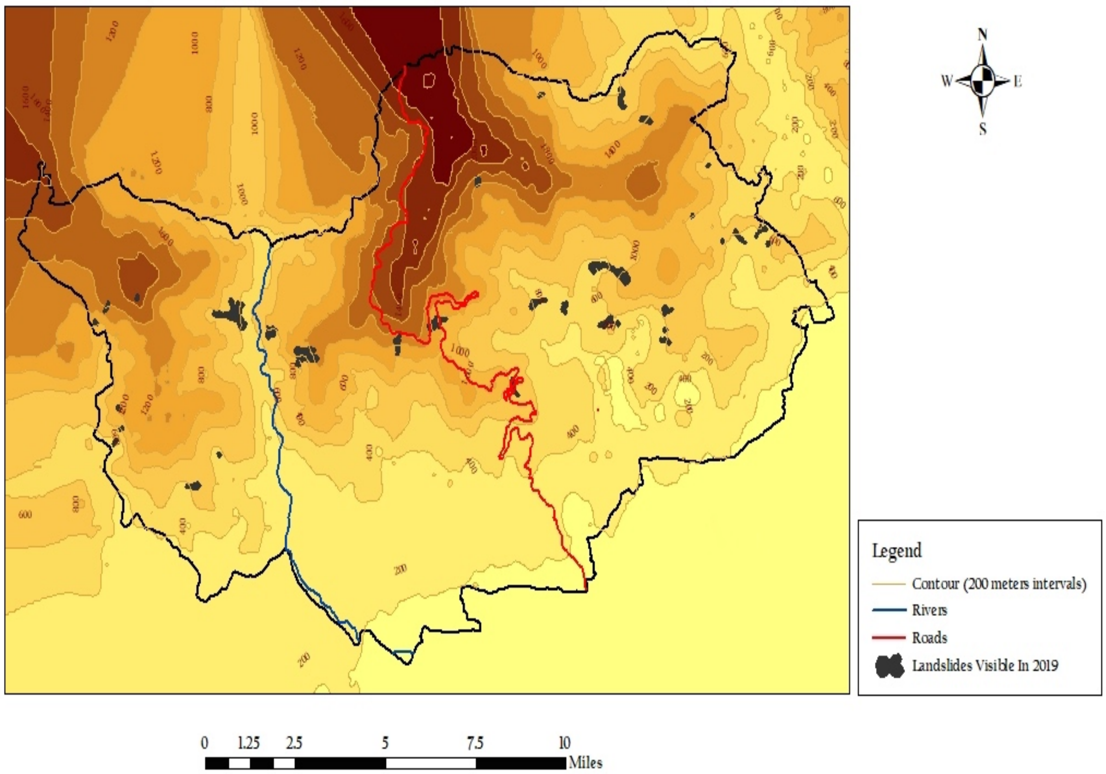
KURSEONG LANDSLIDE DISTRIBUTION AND CONTOUR MAP 1999



KURSEONG LANDSLIDE DISTRIBUTION AND CONTOUR MAP 2009



KURSEONG LANDSLIDE DISTRIBUTION AND CONTOUR MAP 2019



APPENDIX C: KEY-INFORMANT INTERVIEW AND HOUSEHOLD SURVEY QUESTIONNAIRES

a. KEY-INFORMANT INTERVIEW QUESTIONNAIRE

MANAGERS/OWNERS OF TEA ESTATES

1. How long are you associated with this tea plantation?
2. When was this plantation established? (Could you provide any insights on the land-use/land-cover before the establishment of this plantation?)
3. How many workers are employed in this plantation? Where do the workers come from (immigrants or local workers)?
4. How would you describe the maintenance of the plantation? (Insights on how to ensure quality of tea bushels, protecting and enhancing the soil nutrients, other beneficial activities such as planting big trees intermittently to provide canopy for better growth of tea, people who are involved in maintenance, if they do a good job, if there is enough funds to ensure proper maintenance, etc.)
5. Have there been incidences of landslides in and around the plantation in the past? How many times and in what magnitude?
6. What aids did the workers and the overall plantation receive from the government?
7. How do plantation workers recover after a landslide event? How do they prepare to cope with the disaster in the long run?
8. Is this plantation Fair-Trade certified? How are workers paid at different hierarchical levels?
9. Could you shed insight on how plantation revenues impact maintenance of tea plantations and how the household incomes of plantation workers impact their land-use?
10. Can you correlate land degradation or landslide occurrences with improper land management? What are your suggestions for a sustainable development of the tea plantations in a landslide-prone environment?

GOVERNMENT OFFICERS

1. What are the major land-uses in the urban areas?
2. Are there any specific land-use type/s that are most vulnerable to landslides? Which one and provide insights on inhabitants dwelling there (e.g., if construction sites, slums, roads etc. are more vulnerable and why?)
3. Is it difficult to implement environmentally sustainable planning in the highly populated urban areas? Why?
4. Are urban areas more vulnerable to landslides than rural areas? Please provide evidence to support your assertion.
5. What aids are available during a disaster event?
6. Does the state or central government provide enough funds for sustainable development in the urban areas?
7. What difficulties do they encounter to develop the infrastructure? (For example, proper sewerage, water pipelines, electricity, etc.)
8. What role does the municipality play to increase awareness of local communities for effective disaster management?

TOURISM EXPERTS

1. What are the major tourist spots in Kurseong?
2. When do people mostly visit the tourist spots?
3. Are there significant degradation due to waste dumping and other irresponsible activities (e.g., urination in open slopes)?
4. Are there specific funds allocated for environmental protection in tourist spots? If yes, where do they come from?
5. Are there rules that prevent tourists from littering their environment?
6. Is the revenue earned through tourism enough to implement proper maintenance of the tourist spots?

WEST BENGAL FOREST DEPARTMENT

1. What percentage of the entire subdivision of Kurseong forested?
2. What is the percentage change in forest cover recorded since 1966?
3. What major land-use types persist in deforested areas?
4. Have landslides increased in particular deforested slopes?
5. Is there a correlation between low landslide occurrences in protected or reserved forests?
6. Are there people who depend on forests and forest products for livelihoods and survival? What percentage of the population depends on forests for livelihoods? Do these livelihoods and local practices require major deforestation?
7. Is afforestation in degraded slopes a solution to prevent landslides? Are there policies or projects that engage in afforestation programs?
8. Are there specific trees that degrade the soil and trigger landslides (such as the invasive species Criptomania Japonica)? What is being done to prevent the growth of such trees?

VILLAGE KEY-INFORMANTS

1. What major land-uses are there in the village?
2. Approximately how many households are there and what are primary occupations of the people?
3. What percentage of people engages in land-based livelihoods?
4. What LULCC have you observed during your lifetime in and around the village?
5. What amenities are available in the villages that ensure proper maintenance of the land?
6. Is this place vulnerable to landslides? Do you recall past landslide events that have devastated regions in and around the village?
7. Who are most vulnerable people to landslide disasters? (Socio-economic status, ethnicity and cultural background, etc.)
8. How do communities in the village respond and adapt to a disaster event?

b. HOUSEHOLD SURVEY QUESTIONNAIRE

Adapted from

Vadjunec, J.M. (2014). Experiencing Drought in the Grasslands of the American West. NSF Grant, Oklahoma State University.

Land-Use/Land-Cover Change and Vulnerability to Landslides in Kurseong (Darjeeling Himalayas), India – Household Survey (2017-18)

Survey #: _________ Interviewers: ________________________________Date: __________

Oral Consent given (see script): Yes ☐ No ☐

Part 1: General Information/ Demographics

Training Site: # ☐ __________________________ Gender: M ☐ F ☐

Age: _________________ years

Birthplace (country and state):

____

Ethnicity: Tribal ☐ (name) _______________ Bengali ☐ Other (Name) ☐

____

Occupation(s): Laborer ☐ Farmer ☐ Other (specify) ☐ ____________________________

Level of Education:

Primary School (Grade _____) ☐ Secondary/High School (Grade _____) ☐ Some College ☐

Graduate ☐ Other Diploma (name) ☐ ____

Type of family: Nuclear ☐ Joint ☐ Other (specify) ☐ _______________________________

Total number of people living in the household: ____________________

Number of people not residing in the household ___________,

relationship with you ______________

Occupation/s of non-resident family member/s

____

____

Current household (HH) members residing in the household:

HH Members	Relationship with participant	Age (Years)	Gender (M/F)	Level of Education	Occupation(s)
1					
2					
3					
4					
5					
6					
7					
8					

Have you always lived at your current residence? Y ☐ N ☐

For how many years have you been living at your current residence? ______________________

Were you living elsewhere before? Please list all places that you have lived before, duration of stay and occupation/reason of stay.

	Place	Duration	Occupation
1			
2			
3			

What is/are the primary reason/s for your move to your current residence?

Livelihood/Occupation ☐ Previous house/land destroyed due to landslides ☐ Landslide-prone area ☐ Expensive housing ☐ Lack of amenities/facilities ☐ Other (please explain) ☐

____

<u>Part 2: Section A – Household and Land Tenure</u>

Where is your current residence located?

Municipality township ☐ Tea plantation ☐ Rural area ☐ Other (specify) ☐

____

What is the ownership status of your current residence? (Cross ☒ all that apply)

Own house and land ☐ Rented ☐ Plantation housing ☐ Government Quarter ☐ Government Land* ☐[9]

What rights do you exercise over your current residence? (Cross ☒ all that apply)

☐ Full ownership of house

☐ Right to live only during the span of current employment with subsidized rent

☐ Right to live for life as well as lease continued to future generations if they work in the same tea plantation, right to construct/ expand housing on the allotted plot of land at own expense, but no ownership of land, on which the residence is constructed. *(Applicable to laborers of tea plantations.)*

☐ Right to live as long as rent is paid to the private owner of the house.

[9] Land provided by the Government to victims of landslides where they can build a small house and do minimal agriculture.

Part 2: Section B – Current Land Holdings and Land-Use

How many decimals of land do you currently own? _______ Rent? ________

If you rent a land, whom do you rent it from?

____

Of your total land holdings, how many decimals of land are in:

Land-Use	Decimals (=1 Acre/100)	Explanation (name of trees/grains/flowers, own/rented land, quality of fallow land, etc.)
Forest/Tree Cover		
Agricultural Land		
(a) Grains		
(b) Vegetables		
(c) Fruit Orchards		
(d) Spices		
Garden		
Poultry/Livestock keeping		
Fallow Land		
Other		

What is/are the most important land-use/s for your household operations?

____

Part 3: Agricultural Operations & Household Earnings (A. Smallholder, B. Plantation Agriculture)

Section A: Smallholder Agriculture

(Smallholder agriculture involves any agricultural production for subsistence and/or commercial purposes. This section is not directed toward tea-plantation households.)

Do you and your household members engage with subsistence agriculture? Y ☐ N ☐

What agricultural activities do you engage with for subsistence purposes? (☒ all boxes that apply)

Growing crops ☐ Poultry and Livestock raising ☐ Other (please explain) ☐

____

Do you also engage with commercial agriculture alongside your subsistence farming?

Y ☐ N ☐

If yes, please rank the following activities in order of importance to your household income (1 being most important).

Growing Crops ____________________

Livestock Raising (cattle, yak, goats, etc.) _______________

Poultry Farming (chicken) _______________________

Gardening ________________

Other agricultural activities (please name) _____________________

Other non-agricultural work (please name) ____________________

Do you work as a laborer on someone else's farm in return for a wage? Y ☐ N ☐

How many decimals of land have you farmed for each cultivated crop in 2017? Please list them.

Crop	Decimal Land	Explanation (names of crops, seasons of cultivation, etc.)
Rice		
Maize (Corn)		
Wheat		
Fruits		
Vegetables		
Broom Grass		
Coffee		
Ginger/Cardamom		
Other		

In addition to your agricultural activities, do you engage with other non-agricultural activities to supplement your household income? Y ☐ N ☐

If yes, what activities do you engage with or depend on?

____

Please answer the following questions on a scale of 1 through 5 (where, 1 = not important, 2 = slightly important, 3 = moderately important, 4 = very important, 5 = extremely important).

Rate the importance of agricultural activities for your

a) Household income: 1 2 3 4 5

b) Subsistence: 1 2 3 4 5

Rate the importance of non-agricultural activities for your

a) Household income: 1 2 3 4 5

b) Subsistence: 1 2 3 4 5

Please list the quantity of production, consumption, sales, and income of all agricultural operations over the last three years (2017, 2016 and 2015) in the following table.

	2017					2016					2015				
	Produce	Units Sold	Price (Rs.)	Location Sold	Use	Produce	Units Sold	Price (Rs.)	Location Sold	Use	Produce	Units Sold	Price (Rs.)	Location Sold	Use
Rice (Kgs.)															
Wheat (Kgs.)															
Maize (Kgs.)															
Other Crops (name)															
Broom-grass (bunches)															
Vegetables (name)															
Fruits (name)															
Cows (#)															
Calves (#)															
Cow Milk (ltr/day)															
Yak (#)															
Yak Milk (ltr/day)															
Goats (#)															
Goat Milk (liter/day)															
Poultry (#)															
Eggs (#)															
Others (name)															

Part 3: Section B – Plantation Agriculture

(This section is directed towards laborers who work in the tea plantations. Skip this section if the participant is not a plantation worker).

Which tea plantation are you associated with? ____

How long have you been associated with the tea plantation? ___________ Years.

What is your role/job within the plantation? (☒ all boxes that apply)

Laborer ☐ Factory Worker ☐ Supervisor ☐ Owner ☐ Engineer ☐ Medical personnel ☐ Other ☐

Please explain briefly your daily work in the plantation. _________________________________

____

____

How many acres/fractions of acres of land do you manage for your work in the plantation?

____

____

If you are a laborer or plantation supervisor, has the total land area of the plantation you work on/ supervise expanded or decreased over the years of your experience? Expanded ☐ Decreased ☐ Same ☐

Please document the total land area you have managed over the years of your work in the tea plantation until 2010; and the average land you had managed in the decades before.

Year	2017	2016	2015	2010	2000s	1990s	1980s	1970s
Ha/Decimals								

Of the total land area you managed within the plantation, list the area of the land covers (LC) (approx.).

Year	2017	2016	2015	2010	2000s	1990s	1980s	1970s
Tea bushes (ha)								
Forest cover (ha)								
Others (name LC)								

Provide your opinion on a scale of 1 through 5 (where, 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

In my experience, the overall production of tea has increased over the years within this plantation.

1 2 3 4 5

The overall qualities of tea have improved over the years within this plantation.

1 2 3 4 5

The overall health of the tea plantation has improved over the years.

1 2 3 4 5

Have increases/decreases of tea production impacted your monthly salary? Y ☐ N ☐

If yes, how? ____

If not, why? ____

Is this a fair-trade certified tea plantation? Y ☐ N ☐

Do you have extra benefits compared to laborers not belonging to fair-trade plantations? Y ☐ N ☐

Please explain:

____

Please document your average annual earnings over the years of your work in the tea plantation until 2010, and the average approximate earnings in the decades before.

Year	2017	2016	2015	2010	2000s	1990s	1980s	1970s
Earnings in Rs.								

In addition to your own income, do you depend on other sources of income to sustain your household?

Y ☐ N ☐

If yes, what other sources of income do you depend on? ________________________________

Answer the following questions on a scale of 1 - 5 (where, 1 = strongly disagree, 5 = strongly agree).

My work in the tea plantation is very important for my household income. 1 2 3 4 5

My family's other sources of income are very important to sustain my household.

1 2 3 4 5

Section C: Additional Earnings

(Question directed towards everyone. All households, i.e., both smallholders and plantation workers should answer to this table if they have different sources of household income.)

Please document your household earnings from other possible sources of income in the following tables:

Sources of Income	Tea plantation	Smallholder Agriculture			Road/Rail Construction	Clerical Job
		Crops	Livestock	Garden		
Earnings (rupees/month)						

Sources of Income	Automobile Industry	Business/ Freelance	School		Military	Other (please explain)
			Teacher	Staff		
Earnings (rupees/month)						

Part 4: Amenities and Social Vulnerabilities

In this section I am going to ask you about conditions you face in your everyday life for sustenance, the amenities you have (e.g., fresh water and sanitation), and your access to facilities (e.g., roads, transportation and healthcare). These conditions are indicators of your ability to cope with or adapt to your social environment (i.e., the conditions are indicators of your social vulnerability).

A. Household Income

How many dependent (unemployed) adults (above age 18) do you have in your household?

____

Please answer the following statements on a scale of 1 - 5 (1 = strongly disagree, 5 = strongly agree).

My household income is enough to provide for food, clothing and shelter to all household members.

1 2 3 4 5

We have enough resources to feed and shelter our livestock and chicken.

1 2 3 4 5

B. Sanitation

Does your household have proper toilet and sanitation? Y ☐ N ☐

If not, please briefly explain how you meet your daily sanitary needs.

Do you have a proper bath place for ablution and washing clothes at home? Y ☐ N ☐

If not, how far and where do you have to travel for ablution and washing clothes?

____

How often in a week do you travel for the purposes of ablution and cleaning clothes?

____

C. Drainage and Waste Disposal

Does your household have proper sewerage system for waste disposal? Y ☐ N ☐

If not, where do you dispose your household wastes?

a) Kitchen Wastes: Nearby slopes ☐ Streams (jhoras) ☐ Trash bins ☐ Drains ☐ Others ☐

b) Toilet Wastes: Nearby slopes ☐ Streams ☐ Trash bins ☐ Drains ☐ Others ☐

c) Other Wastes (name) ___________: Nearby slopes ☐ Streams ☐ Trash bins ☐ Drains ☐ Others ☐

Are there untreated/open solid-waste disposal grounds within near your household?
Y ☐ N ☐

How far can we find untreated/open solid-waste disposal grounds from your household?

____

D. Household Water Supply

From where do you receive your daily water supply?

Nearby stream (jhora) ☐ Municipality water supply ☐ Wells ☐ Others ☐

____

What is your household's daily requirement of water? Y ☐ N ☐

_________________________ liters

Do you receive adequate and fresh water supply for household purposes? Y ☐ N ☐

How far (kms) do you/family have to travel to collect water for drinking and cooking purposes?

____

How often in a week do you/family travel to collect water for drinking and cooking purposes?

____

Please state any problem that you face to secure adequate supply of daily water for your household?

____

E. Water Supply for Agriculture: *Please answer this section if you are engaged with agriculture, livestock-raising and fruit/vegetable/spice orchards.*

Please list the quantity of water (in liters) that you use for your agricultural operations.

Operations	Agriculture				Livestock-raising
	Crops/Grains	Vegetables	Fruit Orchards	Spices	
Litres of water/day					

Please answer the following statement on a scale of 1 – 5

(1 = strongly disagree, 5 = strongly agree).

I receive adequate water supply for agricultural purposes.

1 2 3 4 5

Where does most of your agricultural water supply come from?

Nearby Streams ☐ Rainfall ☐ Irrigation ☐ Municipality/ Corporation Water ☐ Others ☐

____

What problems do you face in your agricultural operations due to seasonal or irregular rainfall?

Flooding ☐ Inadequate water supply during dry periods ☐ Poor irrigation water ☐ Other ☐ No problem ☐

Briefly explain any other issue(s) you face with water supply for agriculture.

____

____

F. Road Access and Transportation
Do you have access to roads within 1 kilometer of your household? Y ☐ N ☐

Do you have access to roads to carry agricultural produce to and from your agricultural field? Y ☐ N ☐

How far is the nearest market place from your home? ______________________ Kilometers.

What distance do you have to travel to work every day? ______________________ Kilometers.

What modes of transportation do you use to travel to the market/your work every day?

(☒ all that applies)

Public transport ☐ Tractor ☐ Bicycle ☐ Other personal vehicle ☐ Walk to work ☐

Other ☐ ___________

G. Health Care
Do you and your family have access to healthcare? Y ☐ N ☐

What healthcare facilities do you and your family have? (☒ all that applies)

Government hospitals ☐ Private hospital ☐ General free checkups ☐

Who provides for your family's healthcare costs?

Self ☐ Employer ☐ Government ☐ Partly provided by Employer/Government ☐

How far do you travel to avail the nearest health care center for small illnesses and regular checkups? ____

How far is the nearest hospital that you visit for serious illnesses/injuries? ________Kilometers.

What modes of transport do you use to visit health care facilities/hospitals?

(☒ all that applies)

Walk ☐ Public Transport ☐ Private Transport ☐ Other ☐ ______________________________

Part 5: Vulnerability to Landslide Disasters

In this section, I will ask you about your experience with landslides: i.e., how you possibly are vulnerable to this environmental hazard, and your idea about coping with the disaster.

Has your household been impacted by landslides? Y ☐ N ☐

If yes, please answer the following questions ((a) through (e)):

(a) How far was the landslide area from your household? ______________________________

(b) How would you identify the landslide area (e.g., the land-cover immediately around the area)?

Streams ☐ Agricultural area ☐ Tea plantation ☐ Waste disposal ground ☐ Urban area ☐
Roads ☐ Railway tracks ☐ Construction site ☐ Forests ☐ Others ☐

____

(c) How often do landslides occur in the area?

____

(d) How were you and your family been affected by landslide/s?

____

____

(e) What is the money value of losses you incurred from landslides? ______________ Rupees.

Answer the following question on the same scale of 1 - 5 (1 = strongly disagree to 5 = strongly agree). Questions are directed to everyone.

I think human actions contribute to landslides in the region. 1 2 3 4 5

What human actions do you think are primarily responsible for triggering such events?

Slope cutting for construction of settlements☐ Road/rail construction ☐ Clustered settlements ☐

Deforestation due to wood collection ☐ Agriculture ☐ Plantation work ☐ Others ☐ (explain)

____

Do you think landslides are natural phenomena (usually occurring after a heavy rainfall or earthquake) on which human actions do not have significant influence? Y ☐ N ☐

If there hasn't been a landslide near your household yet, do you think it might affect your family and neighborhood any day in the future? Y ☐ N ☐

Why, or why not?

____

Part 6: Institutions and Disaster Management

If you have been a victim of landslides, which institution/s have provided help to you and your family?

Government: Municipality ☐ BDO office ☐
GTA ☐
Employer Institutions ☐
Others ☐ Specify

____

What help have these institutions provided after a landslide? Check ☑ the boxes.

	Government	GTA	Employer	Other Institutions	Satisfaction *
Food and Water					
Camp Shelter					
Clothing					
Compensation Money					
Land					
Houses					

*1 = very dissatisfactory, 2 = dissatisfactory, 3 = neutral, 4 = satisfactory, 5 = very satisfactory

Have you been denied or avoided help or compensation by the government or your employer after losing properties during a landslide disaster? Y ☐ N ☐

Please explain briefly the loss you incurred and why you think you were denied help/compensation.

____

____

What **long-term** measures do the Central and State governments take to reduce disaster impacts in your residential area?

Relocate people from a high-risk area ☐
Build retention walls ☐
Implement afforestation measures ☐
Take actions against deforestation ☐
Build parallel roads/railway tracks to optimize communication ☐
Establish policies and awareness programs for proper land-use, waste disposals, etc. ☐
Stop illegal land-use, e.g., coal and rock mining, deforestation, etc. ☐
Other ☐ ____

Do you think the aforementioned measures can reduce landslides considerably? Y ☐ N ☐

Do you think these measures have been effective in practice? Y ☐ N ☐
If you answered no, what do you think are the obstacles in establishing long-term and effective measures of landslide disaster management?

____

____

____

What, in your opinion, the government, employers and other non-government institutions should focus on to reduce people's vulnerability to landslides?

____

____

____

Part 7: Perceptions of LULCC, Landslide Disasters and Vulnerability; and Adaptive Practices

(Land-use means each and every possible way in which you use the land. It includes your house, animal sheds, planted trees, gardens, farms, etc. Land-cover is anything that covers the land surface of the earth, e.g., barren land, forests, lakes, rivers, etc. Land-use and land-cover have overlaps, and are used together here to understand what consists the land surface naturally as well as modified by humans. Land-use/Land-cover change (LULCC) refers to any changes that you can observe in terms of increase or decrease of forests, built areas, barren lands, etc. The following questions will seek to document your experience and views on LULCC and whether you think current LU practices have caused damage to the environment and your society including the impact of landslides.)

A. Perceptions:

In your own lifetime experience what land-use and land-cover changes have you observed around your household/s? Number of years of experience: ____________________________________

LULCC	Increase/Decrease	Explanation (e.g., legal/illegal land-use)
Forest cover		
Agricultural land		
Mining Areas		
Road/Rail Construction		
Urban Areas		
Slums		
Waste dumping grounds		
Slope Cutting Areas		
Landslide Areas		

Do you consider some land-uses to trigger/cause landslides in these mountains?

Y ☐ N ☐

If yes, what land-uses do you consider being dangerous to the environment to trigger the disaster?

____

Why do you think illegal and dangerous land-uses e.g., coal mining, deforestation, rock extraction, etc. by the locals are still in practice when it makes them more vulnerable to a landslide disaster?

Unemployment ☐
Poor economic conditions ☐
Illegal business ☐
Lack of awareness ☐
Lack of government control over illegal actions ☐

In case of a landslide event, how long does it take the government and NGOs to provide aid to the victims?

____

If you have suffered losses during a landslide, how long has it taken you to start living your normal way of life?

____

Please answer the statement questions ((a) through (n)) according to the following scale:
1 2 3 4 5
1 = Strongly disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly agree

a) I feel vulnerable to landslides. 1 2 3 4 5

b) I feel more vulnerable to meet our daily household needs than landslides.
1 2 3 4 5

c) I believe that I do not have adequate economic resources to provide a normal life to my family if a landslide happens near our household. 1 2 3 4 5

d) I believe that my employer will compensate my family with food and shelter in the case of a landslide event. 1 2 3 4 5

e) I believe tribal people are more marginalized compared to Bengalis and other mainstream population in terms of securing high paid employments. 1 2 3 4 5

f) I believe my employment (or income) forces me to live in and around landslide-prone or inaccessible areas. 1 2 3 4 5

g) There is a lack of funds in the BDO office/the municipality to provide promised help in landslide-affected areas. 1 2 3 4 5

h) There is a communication gap between the government and general public in creating awareness for a sustainable environment. 1 2 3 4 5

i) Government employment of local tribal people was better in previous governments than the current Government. 1 2 3 4 5

j) Unemployment in today's youth despite having high educational background is one cause of illegal land-use that sometimes provide quick money. 1 2 3 4 5

k) Illegal land-uses such as mining, deforestation and others in turn, make the environment more prone to landslides. 1 2 3 4 5

l) Enrollment in plantation and smallholder agriculture has declined considerably among the educated young population due to the low-income, intensive nature of the job. 1 2 3 4 5

m) The overall situation of lack of employment and poverty within a large population has directly and indirectly made the people and the environment of Kurseong more vulnerable to landslides. 1 2 3 4 5

n) My experience of previous landslides has better prepared me to take necessary precautions to avoid further losses during a disaster. 1 2 3 4 5

B. Adaptive Practices:

Please indicate adaptations you have made to continue a normal life amidst the threat of landslides:

a) My previous house was affected by landslides, so I relocated to a better place.
   Y ☐ N ☐
b) My spouse/children took up new job/s to compensate for losses during the past landslide.
   Y ☐ N ☐ Explain: ____
c) I have lost some agricultural land due to landslides, so taken up jobs in other sectors.
   Y ☐ N ☐
d) My household was affected by landslides, so I have made renovations to the house.
   Y ☐ N ☐

e) I have planted more trees near my house to stabilize the slopes due to threats to landslides.

Y ☐ N ☐

f) Every year I plant trees within my agricultural farm to prevent landslides in the monsoon.

Y ☐ N ☐

g) Within the tea plantation where I work, more trees have been planted after the last landslide.

Y ☐ N ☐

Please indicate adaptations you have made to continue a normal life amidst socio-economic constraints:

a) I had to sell some livestock due to economic constraints.

Y ☐ N ☐

b) I do construction (side) business to earn more when there is temporary job availability.

Y ☐ N ☐

c) I do less farming than before and started another job, to improve our economic condition.

Y ☐ N ☐

d) We have sent our children for higher education with the hope that they do not face similar economic constraints as we do now, being smallholders/plantation workers.

Y □ N ☐

e) Due to water shortage, we have connected pipes to bring water from rivers to our houses.

Y ☐ N ☐

f) We have constructed pipelines to bring water from nearby rivers to agricultural fields.

Y ☐ N ☐

In what other ways do you and your family adapt to the constant threats of landslides amidst economic crises and limited means of survival? Please provide your opinion briefly.

____

____

____

____

____

What suggestions would you provide to the Government that can help victims of landslide disaster as well as other local people to reduce their vulnerability to landslides?

Additional Comments:

APPENDIX D: INSTITUTIONAL REVIEW BOARD APPROVALS

I

Oklahoma State University Institutional Review Board

Date:	Wednesday, June 01, 2016
IRB Application No	AS1659
Proposal Title:	Land-Use/Land-Cover Change and Vulnerability to Landslide Distasters I Kurseong (Darjelling Himalayas), India
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 5/31/2019

Principal Investigator(s):

Samayita Bandyopadhyay	Jacqueline Vadjunec
337 Murray	337 Murray Hall
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1.Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2.Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3.Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4.Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters In Kurseong, (Darjeeling Himalayas) India

Recruitment Script for Key-Informant Interviews

Investigators -
Researcher: Samayita Bandyopadhyay, Graduate Student, Oklahoma State University
Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

Hello (insert name here), my name is Samayita Bandyopadhyay. I am a Ph.D. student in Oklahoma State University in the Department of Geography. I am studying the impacts of land-use/land-cover changes in this landslide prone mountain region of Kurseong. I also wish to understand how socio-economic and political factors influence land-use/land-cover change in this region. I would like to arrange an interview with you. The interview will last for approximately 60 – 90 minutes and will be arranged at a time and place that is convenient for you. Your identity will be protected. Any notes taken will remain completely anonymous, and your identity will not be recorded. You are also free to withdraw from this interview at any point if you feel uncomfortable, as well as skip any question that you do not want to respond.

Are you interested in learning more about the interview procedure and then participating in this research?

(If agreed, the participant will be given a copy of the participant information or the verbal consent sheet as well as the interview guide)

Permission script for accessing archives (Archival Research)

Hello (Insert name here), My name is Samayita Bandyopadhyay. I am a Ph.D. student in Oklahoma State University in the Department of Geography. I am studying the impacts of land-use/land-cover changes in this landslide prone mountain region of Kurseong. I also wish to understand how socio-economic and political factors influence land-use/land-cover change in this region. To do so, I wish to explore archives that document land-use/land-cover changes, e.g., changes in forest cover; infrastructural development in urban areas, as well as past data on losses from landslides in different parts of the study area. I will protect all personal information of any individual if I can physically identify that person, living or dead.

Could you please let me access the archives for the purpose of this research? If you are interested, I can give you a copy of the research plan and will be happy to share the results from my research to your office.

Participant Information Sheet for Key-Informant Interviews
Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters in Kurseong (Darjeeling Himalayas), India

Investigators
Researcher: Samayita Bandyopadhyay, Graduate Student, Oklahoma State University
Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

Purpose: The purpose of this project is to conduct key-informant interviews with land-managers and land-users, government officials, and village heads of Kurseong, in India to understand the factors that drive land-use/land-cover change (LULCC) and the factors that increase their vulnerability to landslides in the study area. The interviews will also focus on the local perceptions and adaptations to LULCC in the existing political and economic conditions of the study area.

Procedures: The interviews will be semi-structured and conducted in an informal setting. Each interview will last approximately 60 – 90 minutes. Questions will be asked based upon one or more of the themes provided in the interview guide (please see attached) based on the expertise of the participant on the theme. For example, a tea plantation owner might be asked questions based on a theme that focuses on land management and landslides in tea plantations, government officials will be asked questions on the theme that focuses on infrastructural development and so on. The themes will be identified in advance and you will have the opportunity to see the questions in advance. I will take notes throughout the interview, but no physically identifiable information will be documented.

Risks of Participation: There are no known risks (emotional, psychological or legal) associated with this project that are greater than those ordinarily encountered in daily life. You are free to skip any questions you do not want to answer. You can also withdraw from the interview at any point in the interview if you are uncomfortable, without further explanation. Under no circumstances, will you be coerced or influenced unduly to participate in the interview.

Benefits of Participation: The results generated from the collected data will provide valuable insights into the factors that increase vulnerability to landslides. Results will be shared with local land-users and land-managers, as well as government offices to, hopefully, inform better policies for sustainable development.

Confidentiality: Throughout the interview process anonymity of the interviewee will be maintained. Names, designations and other physically identifiable information will not be documented. The original anonymous field notes will be stored in a password-protected computer that will only be accessible to me, the principal investigator. Due to this anonymity, future publications of this research will not contain any personally identifiable information of the participants.

Contacts: If you have any questions about the research, procedures and purpose of this interview, please feel free to ask me during any time in the interview. If you want to contact for a follow up please email me, the PI at samayita.bandyopadhyay@okstate.edu, or call at 949-542-2553. You can also email my advisor, Dr. Jacqueline Vadjunec at jacqueline.vadjunec@okstate.edu.

Participant Rights: Your participation is voluntary and you are free to withdraw from the interview at any point without further explanation. If you choose to withdraw any information, that will be given back to you or destroyed. Any information that you do not want to be disclosed will be cut out in the final notes. If you have further questions about your rights as a research volunteer, please contact the Oklahoma State University Institutional Review Board (IRB) Manager, Dawnett Watkins at 223 Scott Hall, Stillwater, OK – 74078. Phone and Email contacts are – 405-744-3377 and dawnett.watkins@okstate.edu.

Participant Information Sheet for Key-Informant Interviews (Bengali)

প্রকল্প শিরোনাম: কার্শিয়ং জেলা মহকুমায় (দার্জিলিং হিমালয়, ভারতবর্ষ) ভূমি ব্যবহারের / ভূমি কভার পরিবর্তন এবং ভূমিধ্বস বিপর্যয়ের সম্ভাবনা
মুখ্য-তথ্যকারী সাক্ষাতকার জন্য নিয়োগ স্ক্রিপ্ট
তদন্তকারীরা -
গবেষক: শময়িতা বন্দ্যোপাধ্যায়, গ্রাজুয়েট স্টুডেন্ট, ওকলাহোমা স্টেট ইউনিভার্সিটি
উপদেষ্টা: ডাঃ জ্যাকুলিন ভাদ্‌জুনেক, সহযোগী অধ্যাপক, ওকলাহোমা স্টেট ইউনিভার্সিটি

উদ্দেশ্য: এই প্রকল্পের উদ্দেশ্য হলো ভূমি-পরিচালক এবং ভূমি-ব্যবহারকারী, সরকারি কর্মকর্তা, এবং গ্রামবাসীদের মুখ্য-তথ্যকারী সাক্ষাত্কারের মাধ্যমে তথ্য সংগ্রহ করা যে কী কী কারণে ভূমি-ব্যবহার ও ভূমি-কভার পরিবর্তন হয় এবং তাদের মধ্যে কোন কারণগুলি ভূমি ধ্বসের জন্য দায়ী। সাক্ষাৎকার থেকে আরো অধ্যয়ন করা হবে যে এলাকার বিদ্যমান রাজনৈতিক ও অর্থনৈতিক অবস্থার মধ্যে স্থানীয় বাসিন্দারা কিভাবে জমি ব্যবহার করে।

পদ্ধতি: সাক্ষাৎকার অর্ধেক কাঠামোবদ্ধ এবং একটি অনানুষ্ঠানিক সেটিংয়ে পরিচালিত হতে হবে। প্রতিটি সাক্ষাত্কার প্রায় 60 - 90 মিনিট স্থায়ী হবে। প্রশ্ন (সংযুক্ত দেখুন) সাক্ষাত্কার নির্দেশিকায় প্রদত্ত এক বা একাধিক থিম-এর উপর ভিত্তি করে বলা হবে থিমে অংশগ্রহণকারী দক্ষতার উপর ভিত্তি করে। উদাহরণস্বরূপ, একটি চা বাগানের মালিক যে ভূমি ব্যবস্থাপনা ও চা চাষ ভূমিধ্বসের উপর গুরুত্ব দেয় একটি থিম উপর ভিত্তি করে প্রশ্ন জিজ্ঞাসা করা যেতে পারে, সরকারি কর্মকর্তাদের যে অবকাঠামোগত উন্নয়ন এবং তার উপর গুরুত্ব দেয় যে থিম তার উপর প্রশ্ন জিজ্ঞাসা করা হবে। থিম আগাম চিহ্নিত করা হবে এবং আপনার আগাম প্রশ্ন দেখতে সুযোগ থাকবে। আমি ইন্টারভিউ-এর উপর নোট নেব, কিন্তু কোন শারীরিকভাবে শনাক্তযোগ্য তথ্য নথিভুক্ত করা হবে না।

পার্টিসিপেশন ঝুঁকি: এই প্রকল্পের সঙ্গে যুক্ত কোন পরিচিত ঝুঁকি (শারীরিক, মানসিক, বা আইনগত) নেই যা সাধারণতঃ দৈনন্দিন জীবনের সম্মুখীন ঝুঁকির তুলনায় বেশী। যদি আপনি কোন প্রশ্নে অস্বস্তি বোধ করেন তো তত্ক্ষনাত সেই প্রশ্ন এড়িয়ে যেতে পারেন। এছাড়াও আপনি ইন্টারভিউ যে কোন সময়ে সাক্ষাত্কার থেকে আরও ব্যাখ্যা ছাড়াই উত্তোলন করতে পারবেন যদি আপনি অস্বস্তি বোধ করেন। কোন পরিস্থিতিতে, আপনি নিগৃহীত বা সাক্ষাৎকারে অংশগ্রহণের জন্য অসঙ্গতভাবে প্রভাবিত হবেন না।

পার্টিসিপেশন উপকারিতা: সংগৃহীত তথ্য থেকে উত্পন্ন ফলাফল যে বিষয়গুলি ভূমিধস থেকে দুর্বলতা বৃদ্ধি করে তার উপর মূল্যবান অর্ন্তদৃষ্টি প্রদান করবে। ফলাফল স্থানীয় ভূমি ব্যবহারকারী এবং জমি-পরিচালকদের পাশাপাশি সরকারি অফিস সঙ্গে ভাগ করা হবে, এবং আশা করা যায়, উন্নয়নের জন্য ভাল নীতি অবহিত করতে পারবে।

গোপনীয়তা: সর্বত্র সাক্ষাত্কারী সাক্ষাৎকার প্রক্রিয়া অপ্রকাশিতনামা বজায় রাখা হবে। নাম, পদবী ও অন্যান্য শারীরিক শনাক্তযোগ্য তথ্য নথিভুক্ত করা হবে না। মূল বেনামী ক্ষেত্র নোট একটি পাসওয়ার্ড সুরক্ষিত কম্পিউটার যে শুধু আমার, প্রধান তদন্তকারীর কাছে সংরক্ষণ করা হবে এবং একমাত্র তারই অধিগত করার ক্ষমতা থাকবে। এই নাম প্রকাশে অনিচ্ছুক কারণে, এই গবেষণার ভবিষ্যৎ প্রকাশনা অংশগ্রহণকারীদের কোনো ব্যক্তিগতভাবে সনাক্তকরণযোগ্য তথ্য থাকবে না।

Recruitment Scripts (Bengali)

প্রকল্প শিরোনাম: কার্শিয়ংজেলা মহকুমায় (দার্জিলিং হিমালয়, ভারতবর্ষ) ভূমি ব্যবহারের / ভূমি কভার পরিবর্তন এবং ভূমিধ্বস বিপর্যয়ের সম্ভাবনা
মুখ্য-তথ্যকারী সাক্ষাতকার জন্য নিয়োগ স্ক্রিপ্ট
তদন্তকারীরা -
গবেষক: শময়িতা বন্দ্যোপাধ্যায়, গ্রাজুয়েট স্টুডেন্ট, ওকলাহোমা স্টেট ইউনিভার্সিটি
উপদেষ্টা: ডাঃ জ্যাকুলিন ভাদ্‌জুনেক, সহযোগী অধ্যাপক, ওকলাহোমা স্টেট ইউনিভার্সিটি

হ্যালো (এখানে নাম সন্নিবেশ), আমার নাম শময়িতা বন্দ্যোপাধ্যায়। আমি ওকলাহোমা স্টেট ইউনিভার্সিটির ভূগোল বিভাগের পিএইচডি ছাত্রি। আমি কার্শিয়ং এ ভূমিধ্বস প্রবণ পর্বত অঞ্চলের ভূমি ব্যবহারের / জমি-কভার পরিবর্তনের প্রভাব অধ্যয়নরত করছি। আমি এও বুঝতে চাই কিভাবে আর্থ-সামাজিক এবং রাজনৈতিক বিষয়গুলো এই অঞ্চলের ভূমি ব্যবহার / জমি-কভার পরিবর্তনে প্রভাব বিস্তার করে। আমি আপনার সাথে একটি সাক্ষাৎকার পেলে ভিশন খুশি হব। সাক্ষাত্কার প্রায় 60 - 90 মিনিট জন্য স্থায়ী হবে, এবং একটি সময় এবং স্থান, যা আপনার জন্য সুবিধাজনক সময়ে ব্যবস্থা করা হবে। আপনার পরিচয় রক্ষা করা হবে। কোন নোট সম্পূর্ণভাবে বেনামী থাকবে, এবং আপনার পরিচয় লিপিবদ্ধ করা হবে না। আপনি যে কোনো সময়ে এই সাক্ষাত্কার থেকে নিজেকে প্রত্যাহার করতে পারেন যদি কোনো প্রশ্নে আপনি অস্বস্তি বোধ করেন।

আপনি ইন্টারভিউ পদ্ধতি সম্পর্কে আরও শেখার এবং তারপর এই গবেষণায় অংশগ্রহণ করতে আগ্রহী?
(যদি একমত, অংশগ্রহণকারী অংশগ্রহণকারী তথ্য বা মৌখিক সম্মতি চাদরের একটি কপি পাশাপাশি সাক্ষাত্কার নির্দেশিকা হিসেবে দেয়া হবে)

আর্কাইভ অ্যাক্সেস অনুমতি স্ক্রিপ্ট (সংগ্রহশালার গবেষণা)
হ্যালো (এখানে নাম ঢোকান), আমার নাম শময়িতা বন্দ্যোপাধ্যায়। আমি ওকলাহোমা স্টেট ইউনিভার্সিটির ভূগোল বিভাগের পিএইচডি ছাত্রি। আমি কার্শিয়ং এ ভূমিধ্বস প্রবণ পর্বত অঞ্চলের ভূমি ব্যবহারের / জমি-কভার পরিবর্তনের প্রভাব অধ্যয়নরত করছি। আমি এও বুঝতে চাই কিভাবে আর্থ-সামাজিক এবং রাজনৈতিক বিষয়গুলো এই অঞ্চলের ভূমি ব্যবহার / জমি-কভার পরিবর্তনে প্রভাব বিস্তার করে। এর জন্য, আমি আর্কাইভ যে নথিতে ভূমি ব্যবহারের / জমি-কভার পরিবর্তন, যেমন, বনভূমির পরিবর্তনের অন্বেষণ করতে চাই; শহরাঞ্চলে অবকাঠামো উন্নয়ন, সেইসাথে অধ্যয়ন করতে চাই এলাকার বিভিন্ন অংশে ভূমিধস থেকে লোকসান।

আপনি দয়া করে আমাকে এই গবেষণার উদ্দেশ্যে আর্কাইভ থেকে তথ্য সংগ্রহ করার অনুমতি দিতে পারেন ? আপনি যদি আগ্রহী হন, তাহলে আমি গবেষণা পরিকল্পনার একটি কপি দিতে পেরে খুশি হব এবং আপনার অফিস থেকে আমার গবেষণা থেকে ফলাফল ভাগ খুশি হব।

Oklahoma State University Institutional Review Board

Date:	Thursday, December 21, 2017	**Protocol Expires: 12/20/2018**
IRB Application No:	AS1659	
Proposal Title:	Land-Use/Land-Cover Change and Vulnerability to Landslide Distasters I Kurseong (Darjelling Himalayas), India	
Reviewed and Processed as:	Expedited **Modification**	

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Samayita Bandyopadhyay 337 Murray Stillwater, OK 74078	Jacqueline Vadjunec 337 Murray Hall Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

☐ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

The reviewer(s) had these comments:

The following modifications are approved:
1. Addition of 300 household surveys
2. Addition of 10 community meetings/focus groups
3. Change in years of analysis to 1968-2017

Signature :

Hugh Crethar, Chair, Institutional Review Board

Thursday, December 21, 2017
Date

Community Meeting on Land-Use/Land-Cover Change and Vulnerability to Landslides

Date: (Insert date here)
Time: (Insert time here)
Place: (Insert place here)

You are cordially invited to a general (community) meeting to discuss about daily life in the Kurseong hills and people's vulnerability to landslides. This meeting is conducted for part of my research that studies community resilience and vulnerabilities in the landslide-prone hills of Kurseong. Your inputs on landslides and environmental change (e.g., land-use/land cover change) will be very helpful for me to understand local situations and perceptions. This meeting will also help better understand whether your community is vulnerable or resilient to the disaster. Your opinions will not only contribute immensely to this research, but will also seek to communicate with Government offices to help with problems you might face. If you are a resilient community, your responses will be shared to help other communities adapt measures to improve their resilience. Please come for a visit at (insert venue and time). Your participation will be invaluable for this synergistic research that will help us all.

Light refreshments will be served.

Many Thanks!!
Samayita Bandyopadhyay
Ph.D. Candidate
Oklahoma State University
USA

OKLAHOMA STATE UNIVERSITY
IRB Office
Approved: 12-21-17
Expires: 12-20-18
IRB#: AS-16-59

Community Meeting on Land-Use/Land-Cover Change and Vulnerability to Landslides Flyer (Hindi)

तथिि: (दनिांक यहां डालें)
समय: (यहां समय सम्मलिति करें)
स्थान: (यहां जगह डालें)

कुर्सीओंग पहाड़ियों में दैनकि जीवन के बारे में चर्चा करने और भूस्खलन के लोगों की भेद्यता के बारे में चर्चा करने के लिए आपको एक सामान्य (समुदाय) मीटगि में आमंत्रति कयिा जाता है। यह बैठक मेरे शोध के भाग के लिए आयोजति की जाती है जो कुर्सेओंग के भूस्खलन-प्रवण पहाड़ियों में समुदाय के लचीलेपन और कमजोरियों का अध्ययन करती है। स्थानीय स्थतियिों और धारणाओं को समझने के लिए भूस्खलन और पर्यावरण परवर्तिन (जैसे भूमि उपयोग / भूमि कवर परवर्तिन) पर आपकी जानकारी बहुत उपयोगी होगी I यह बैठक भी बेहतर ढंग से समझने में सहायता करेगी कि क्या आपका समुदाय आपदा के लिए कमजोर या लचीला है। आपकी राय न केवल इस शोध के लिए योगदान देगी, बल्कि आपको उन समस्याओं के साथ संवाद करने का भी प्रयास करेंगे, जनिसे आप सामना कर सकते हैं। यदि आप एक लचीला समुदाय हैं, तो आपके प्रतक्रियिाओं को अन्य समुदायों को उनके लचीलेपन में सुधार के लिए उपायों को अनुकूलति करने में सहायता करने के लिए साझा कयिा जाएगा। कृपया (यात्रा स्थल और समय डालें) पर एक यात्रा के लिए आइए। आपकी सहभागति इस सहक्रयिात्मक अनुसंधान के लिए अमूल्य होगी जो हमें सभी की सहायता करेगी।

जलपान की व्यवस्था की जाएगी।

बहुत धन्यवाद!!
Samayita Bandyopadhyay
Ph.D. Candidate
Oklahoma State University
USA

IRB Office
Approved: 12-21-17
Expires: 12-20-18
IRB#: AS-16-69

Participant Information Sheet for Community Meetings

Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters in Kurseong (Darjeeling Himalayas), India

Investigators
Researcher: Samayita Bandyopadhyay, Ph.D. Candidate, Oklahoma State University
Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

Purpose: The purpose of this project is to conduct community meetings and household surveys with land-managers and local land-users of Kurseong in India to understand the factors that drive land-use/land-cover change (LULCC) and the factors that increase their vulnerability to landslides in the study area. The methods will also focus on the local perceptions and adaptations to LULCC in the existing political and economic conditions of the study area.

Procedures: The community meetings will be conducted in a town hall or informal gathering area with local residents. Each meeting will last approximately 60 minutes or more depending on the nature of the meeting. Questions will be asked based on the research agenda (please see attached). Questions will be asked on the perceptions of environmental change (e.g., land-use/land cover change), livelihood, disaster, and household vulnerability. I will take notes throughout the meeting, but no physically identifiable information will be documented.

Risks of Participation: There are no known risks (emotional, psychological or legal) associated with this project that are greater than those ordinarily encountered in daily life. You are free to skip any questions you do not want to answer. You can also withdraw from the meeting at any point during the meeting if you are uncomfortable, without further explanation. Under no circumstances, will you be coerced or influenced unduly to participate.

Benefits of Participation: The results generated from the collected data will provide valuable insights into the factors that increase vulnerability to landslides. Results will be shared with local land-users and land-managers, as well as government offices to, hopefully, inform better policies for sustainable development.

Confidentiality: Throughout the meeting process full confidentiality of the participants will be maintained. Names, designations and other physically identifiable information will not be documented. The original anonymous field notes will be stored in a password-protected computer that will only be accessible to me, the principal investigator. Due to this anonymity, future publications of this research will not contain any personally identifiable information of the participants.

Contacts: If you have any questions about the research, procedures and purpose of this meeting, please feel free to ask me during any time in the meeting. If you want to contact for a follow up please email me, the PI at samayita.bandyopadhyay@okstate.edu, or call at 949-542-2553. You can also email my advisor, Dr. Jacqueline Vadjunec at jacqueline.vadjunec@okstate.edu.

Participant Rights: Your participation is voluntary and you are free to withdraw from the meeting at any point without further explanation. If you choose to withdraw any information, that will be given back to you or destroyed. Any information that you do not want to be disclosed will be cut out in the final notes. If you have further questions about your rights as a research volunteer, please contact the Oklahoma State University Institutional Review Board (IRB) Manager, Dawnett Watkins at 223 Scott Hall, Stillwater, OK – 74078. Phone and Email contacts are – 405-744-3377 and dawnett.watkins@okstate.edu.

Participant Information Sheet for Household Surveys

Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters in Kurseong (Darjeeling Himalayas), India

Investigators

Researcher: Samayita Bandyopadhyay, Ph.D. Candidate, Oklahoma State University

Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

Purpose: The purpose of this project is to conduct community meetings and household surveys with land-managers and local land-users of Kurseong in India to understand the factors that drive land-use/land-cover change (LULCC) and the factors that increase their vulnerability to landslides in the study area. The methods will also focus on the local perceptions and adaptations to LULCC in the existing political and economic conditions of the study area.

Procedures: The household surveys will be selected randomly from different training sites to conduct surveys. Each survey will take approximately 120 minutes. Questions will be asked on socio-economic conditions and demographic structure of the household as well as perceptions of land-use, environment and disaster vulnerability. I will take notes throughout the survey, but no physically identifiable information will be documented.

Risks of Participation: There are no known risks (emotional, psychological or legal) associated with this project that are greater than those ordinarily encountered in daily life. While I will ask specific information about household members, land-use, agricultural/plantation work, etc., which may narrow down personally identifiable information about your household, the original information will be protected by the researcher. The surveys will be available only to the researcher and will be kept in a secure locker in my study. To further protect confidentiality, the results will be published in aggregate form only (household averages). Furthermore, you are free to skip any question you do not want to answer. You can also withdraw from the survey at any point during the survey if you are uncomfortable, without further explanation. Under no circumstances, will you be coerced or influenced unduly to participate.

Benefits of Participation: The results generated from the collected data will provide valuable insights into the factors that increase vulnerability to landslides. Results will be shared with local land-users and land-managers, as well as government offices to, hopefully, inform better policies for sustainable development.

Confidentiality: Throughout the household survey process anonymity of the participants will be maintained. Names, designations and other physically identifiable information will not be documented. The original anonymous surveys (and any accompanying field notes) will be stored in a password-protected computer that will only be accessible to me, the principal investigator. Due to this anonymity, as well as the aggregation of household data (averages), future publications of this research will not contain any personally identifiable information of the participants.

Contacts: If you have any questions about the research, procedures and purpose of this survey, please feel free to ask me during any time in the survey. If you want to contact for a follow up please email me, the PI at samayita.bandyopadhyay@okstate.edu, or call at 949-542-2553. You can also email my advisor, Dr. Jacqueline Vadjunec at jacqueline.vadjunec@okstate.edu.

Participant Rights: Your participation is voluntary and you are free to withdraw from the survey at any point without further explanation. If you choose to withdraw any information, that will be given back to you or destroyed. Any information that you do not want to be disclosed will be cut out in the final notes. If you have further questions about your rights as a research volunteer, please contact the Oklahoma State University Institutional Review Board (IRB) Manager, Dawnett Watkins at 223 Scott Hall, Stillwater, OK – 74078. Phone and Email contacts are – 405-744-3377 and dawnett.watkins@okstate.edu.

Participant Information Sheet for Community Meetings - Hindi
Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters in Kurseong (Darjeeling Himalayas), India

Investigators
Researcher: Samayita Bandyopadhyay, Ph.D. Candidate, Oklahoma State University
Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

उद्देश्य: इस परियोजना का उद्देश्य भारत में कुर्सीओग के भू-प्रबंधकों और स्थानीय भूमि-उपभोक्ताओं के साथ सामुदायिक मीटिंग और घरेलू सर्वेक्षण करने के लिए कारकों को समझने के लिए है जो भूमि उपयोग / भूमि कवर परिवर्तन (एलएलसीसी) और कारकों को बढाने के लिए कारगर है। अध्ययन क्षेत्र में भूस्खलन के लिए उनकी भेद्यता। अध्ययन क्षेत्र की मौजूदा राजनीतिक और आर्थिक स्थितियों में एलएलएलसीसी को स्थानीय धारणाओं और अनुकूलन पर भी ध्यान दिया जाएगा।

प्रक्रियाएं: स्थानीय बैठकों के साथ स्थानीय निवासियों के साथ एक टाउन हॉल या अनौपचारिक सभा क्षेत्र में आयोजित किया जाएगा। बैठक की प्रकृति के आधार पर प्रत्येक मीटिंग लगभग 60 मिनट या उससे ज्यादा की जाएगी। शोध एजेंडे (कृपया संलग्न देखें) के आधार पर प्रश्न पूछे जाएंगे। प्रश्न पर्यावरण परिवर्तन (उदा।, भूमि उपयोग / भूमि कवर परिवर्तन), पर्यावरण और आपदा भेद्यता के विचारों से पूछा जाएगा। मैं सारी बैठक में नोट लेता हूँ, लेकिन कोई शारीरिक रूप से पहचाने जाने योग्य जानकारी दस्तावेज नहीं की जाएगी।

भागीदारी के जोखिम: इस परियोजना से जुड़ा कोई भी ज्ञात जोखिम (भावनात्मक, मनोवैज्ञानिक या कानूनी) नहीं है, जो आमतौर पर दैनिक जीवन में सामने आये हैं। आप उन सवालों को छोड़ने के लिए स्वतंत्र हैं जिन्हें आप जवाब देना नहीं चाहते हैं। यदि आप असुविधाजनक हैं, तो बैठक के दौरान किसी भी बिंदु पर आप मीटिंग से वापस ले सकते हैं, और बिना स्पष्टीकरण के। किसी भी परिस्थिति में, आप को भाग लेने के लिए मजबूती से या प्रभावित होने पर प्रभाव डालना होगा।

सहभागिता के लाभ: एकत्रित आंकड़ों से उत्पन्न परिणाम उन कारकों में महत्वपूर्ण जानकारी प्रदान करेंगे जो भूस्खलन के प्रति कमजोर पड़ते हैं। परिणाम स्थानीय भूमि-उपयोगकर्ताओं और भूमि-प्रबंधकों के साथ-साथ सरकारी कार्यालयों के साथ साझा किया जाएगा, उम्मीद है, टिकाऊ विकास के लिए बेहतर नीतियों को सूचित करें।

गोपनीयता: मीटिंग प्रक्रिया के दौरान प्रतिभागियों की अनमोलता बनाए रखा जाएगा। नाम, पदनाम और अन्य शारीरिक रूप से पहचाने जाने योग्य जानकारी दस्तावेज नहीं होंगे। मूल अनाम फील्ड नोट एक पासवर्ड-संरक्षित कंप्यूटर में संग्रहीत किया जाएगा जो केवल मेरे लिए पहुंचेगा, प्रमुख अन्वेषक इस नाम न छापने के कारण, इस शोध के भविष्य के प्रकाशन में प्रतिभागियों की व्यक्तिगत रूप से पहचान योग्य जानकारी शामिल नहीं होगी

संपर्क: यदि इस बैठक के शोध, प्रक्रिया और उद्देश्य के बारे में आपके कोई प्रश्न हैं, तो कृपया मीटिंग में किसी भी समय मुझसे पूछने के लिए स्वतंत्र महसूस करें। यदि आप किसी अनुवर्ती कार्रवाई के लिए संपर्क करना चाहते हैं, तो कृपया मुझे ईमेल करें, पीएमआई पर samayita.bandyopadhyay@okstate.edu, या 949-542-2553 पर कॉल करें।

प्रतिभागी अधिकार: आपकी भागीदारी स्वैच्छिक है और आप आगे की व्याख्या के बिना किसी भी बिंदु पर बैठक से वापस लेने के लिए स्वतंत्र हैं। अगर आप किसी भी जानकारी को वापस लेने के लिए चुनते हैं, तो वह आपको वापस दे दिया जाएगा या नष्ट कर दिया जाएगा। किसी भी जानकारी जिसे आप खुलासा नहीं करना चाहते हैं, अंतिम नोट्स में कटौती की जाएगी यदि आपके पास एक अनुसंधान स्वयंसेवक के रूप में आपके अधिकारों के बारे में और प्रश्न हैं, तो ओक्लाहोमा स्टेट यूनिवर्सिटी इंस्टीट्यूशनल रिव्यू बोर्ड (आईआरबी) प्रबंधक, 22 9 स्कॉट हॉल, स्टिलवॉटर, ओके- 74078 पर डॉनेट वाटकिन्स से संपर्क करें। फोन और ईमेल संपर्क हैं - 405-744- 3377 और dawnett.watkins@okstate.edu

IRB Office
Approved: 12-21-17
Expires: 12-20-18
IRB#: AS-16-59

Participant Information Sheet for Community Meetings - Hindi

Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters in Kurseong (Darjeeling Himalayas), India

Investigators

Researcher: Samayita Bandyopadhyay, Ph.D. Candidate, Oklahoma State University

Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

उद्देश्य: इस परयिोजना का उद्देश्य भारत में कुर्सीओग के भू-प्रबंधकों और स्थानीय भूमि-उपभोक्ताओं के साथ सामुदायकि मीटगि और घरेलू सर्वेक्षण करने के लिए कारकों को समझने के लिए है जो भूमि उपयोग / भूमि किवर परविर्तन (एलएलसीसी) और कारकों को बढाने के लिए कारगर है। अध्ययन क्षेत्र में भूस्खलन के लिए उनकी भेद्यता। अध्ययन क्षेत्र की मौजूदा राजनीतकि और आर्थकि स्थतियिों में एलएलएलसीसी को स्थानीय धारणाओं और अनुकूलन पर भी ध्यान दयिा जाएगा।

प्रक्रयिाएं: सर्वेक्षण करने के लिए घरेलू सर्वेक्षण अलग-अलग प्रशक्षिण स्थलों से चुना जाएगा। प्रत्येक सर्वेक्षण में करीब 120 मनिट लगेंगे। प्रश्नों के लिए सामाजकि-आर्थकि स्थतियिों और घरेलू जनसांख्यकिीय संरचना पर वचिार कयिा जाएगा साथ ही साथ भूमि उपयोग, पर्यावरण और आपदा भेद्यता की धारणाएं। मैं सर्वेक्षण के दौरान नोट लेता हूँ, लेकनि कोई शारीरकि रूप से पहचानी जाने योग्य जानकारी दस्तावेज नहीं की जाएगी।

भागीदारी के जोखमि: इस परयिोजना से जुड़ा कोई भी ज्ञात जोखमि (भावनात्मक, मनोवैज्ञानकि या कानूनी) नहीं है, जो आमतौर पर दैनकि जीवन में सामने आये हैं। आप उन सवालों को छोड़ने के लिए स्वतंत्र हैं जनि्हें आप जवाब देना नहीं चाहते हैं। यदि आप असुवधिाजनक हैं, तो बैठक के दौरान कसिी भी बदिु पर आप मीटगि से वापस ले सकते हैं, और बनिा स्पष्टीकरण के। कसिी भी परस्थितिि में, आप को भाग लेने के लिए मजबूती से या प्रभावति होने पर प्रभाव डालना होगा।

सहभागति के लाभ: एकत्रति आंकड़ों से उत्पन्न परणिाम उन कारकों में महत्वपूर्ण जानकारी प्रदान करेंगे जो भूस्खलन के प्रति कमजोर पड़ते हैं। परणिाम स्थानीय भूमि-उपयोगकर्ताओं और भूमि-प्रबंधकों के साथ-साथ सरकारी कार्यालयों के साथ साझा कयिा जाएगा, उम्मीद है, टकिाऊ वकिास के लिए बेहतर नीतयिों को सूचति करें।

गोपनीयता: मीटगि प्रक्रयिा के दौरान प्रतभिागयिों की अनमोलता बनाए रखा जाएगा। नाम, पदनाम और अन्य शारीरकि रूप से पहचाने जाने योग्य जानकारी दस्तावेज नहीं होंगे। मूल अनाम फील्ड नोट एक पासवर्ड-संरक्षति कंप्यूटर में संग्रहीत कयिा जाएगा जो केवल मेरे लिए पहुंचेगा, प्रमुख अन्वेषक इस नाम न छापने के कारण, इस शोध के भवषि्य के प्रकाशन में प्रतभिागयिों की व्यक्तगित रूप से पहचान योग्य जानकारी शामलि नहीं होगी

संपर्क: यदि इस बैठक के शोध, प्रक्रयिा और उद्देश्य के बारे में आपके कोई प्रश्न हैं, तो कृपया मीटगि में कसिी भी समय मुझसे पूछने के लिए स्वतंत्र महसूस करें। यदि आप कसिी अनुवर्ती कार्रवाई के लिए संपर्क करना चाहते हैं, तो कृपया मुझे ईमेल करें, पीएमआई पर samayita.bandyopadhyay@okstate.edu, या 949-542-2553 पर कॉल करें।

प्रतभिागी अधकिार: आपकी भागीदारी स्वैच्छकि है और आप आगे की व्याख्या के बनिा कसिी भी बदिु पर बैठक से वापस लेने के लिए स्वतंत्र हैं। अगर आप कसिी भी जानकारी को वापस लेने के लिए चुनते हैं, तो वह आपको वापस दे दयिा जाएगा या नष्ट कर दयिा जाएगा। कसिी भी जानकारी जसिे आप खुलासा नहीं करना चाहते हैं, अंतमि नोट्स में कटौती की जाएगी यदि आपके पास एक अनुसंधान स्वयंसेवक के रूप में आपके अधकिारों के बारे में और प्रश्न हैं, तो ओक्लाहोमा स्टेट यूनविर्सिटी इंस्टीट्यूशनल रवि्यू बोर्ड (आईआरबी) प्रबंधक, 22 9 स्कॉट हॉल, स्टलिवॉटर, ओके- 74078 पर डॉनेट वाटकनि्स से संपर्क करें। फोन और ईमेल संपर्क हैं - 405-744- 3377 और dawnett.watkins@okstate.edu

Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters In Kurseong (Darjeeling Himalayas), India

Investigator – Samayita Bandyopadhyay
Researcher: Samayita Bandyopadhyay, Graduate Student, Oklahoma State University
Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

Introduction Script for Community Meetings

Dear ladies and gentlemen, my name is Samayita Bandyopadhyay. I am pursuing my Ph.D. in the Department of Geography, at Oklahoma State University. I am here to study the impacts of landslides on local people in Kurseong. Discussions on environmental changes (especially, land-use/land-cover change) with you all will help me get insights on detailed local experiences, and help better understand where and how landslides influence local vulnerability to the disaster. This meeting is also arranged to discuss if this community faces any problem due to landslides, and how vulnerable or resilient this community is to the disaster. The meeting will last for an hour or more if the participants are willing to share more. Your identity will be protected. Any notes taken will remain completely anonymous, and your identity will not be recorded. You are also free to withdraw from this meeting at any point if you feel uncomfortable, as well as skip any question that you do not want to respond.

Thank you for participating in this meeting.

(The participant information or the verbal consent sheet will be read to the participants following the introduction).

Recruitment script for Household Surveys

Hello (insert name here), my name is Samayita Bandyopadhyay. I am a Ph.D. student in the Department of Geography at Oklahoma State University. I am studying the impacts of land-use/land-cover changes in this landslide prone mountain region of Kurseong. I also wish to understand how socio-economic and political factors influence land-use/land-cover change in this region. I would like to conduct a household survey for your household. The survey will last for approximately 90 – 120 minutes. Your identity will be protected. Any notes taken will remain completely anonymous, and your identity will not be recorded. You are also free to withdraw from this survey at any point if you feel uncomfortable, as well as skip any question that you do not want to respond.

Are you interested in learning more about the survey procedure and then participating in this research?

(If agreed, the participant will be given a copy of the participant information or the verbal consent sheet as well as the household survey guide)

Community Meeting and Household Survey Recruitment Scripts – Hindi

Project Title: Land-Use/Land-Cover Change And Vulnerability To Landslide Disasters In Kurseong (Darjeeling Himalayas), India

Investigator – Samayita Bandyopadhyay
Researcher: Samayita Bandyopadhyay, Graduate Student, Oklahoma State University
Advisor: Dr. Jacqueline Vadjunec, Associate Professor, Oklahoma State University

परचिय सामुदायकि बैठक के लिए स्क्रप्टि

प्रयि देवयिों और सज्जनो, मेरा नाम समीत बंद्योपाध्याय है। मैं अपना पीएचडी का पीछा कर रहा हूं। ओकलाहोमा स्टेट यूनविर्सटिी में भूगोल वभिाग में मैं कुर्सीओंग में स्थानीय लोगों पर भूस्खलन के प्रभावों का अध्ययन करने के लिए यहां हूं। आप सभी के साथ पर्यावरण परविर्तन (वशिेषकर, भूम-िउपयोग / भूम-िआवरण परविर्तन) पर चर्चाओं से मुझे वसि्तृत स्थानीय अनुभवों पर अंतर्दृष्ट िप्राप्त करने में मदद मलिेगी, और यह समझने में बेहतर होगा क िभूस्खलन कसि प्रकार आपदा के लिए स्थानीय भेद्यता को प्रभावति करते हैं। इस बैठक को भी चर्चा करने की व्यवस्था है क िक्या इस समुदाय को भूस्खलन के कारण कसिी भी समस्या का सामना करना पड़ता है, और इस समुदाय को आपदा के लिए कतिना कमजोर या लचीला है। अगर प्रतभिागयिों को और अधकि साझा करने के लिए तैयार हैं तो बैठक एक या उससे अधकि घंटे तक चली जाएगी। आपकी पहचान संरक्षति होगी कोई भी नोट पूरी तरह से गुमनाम रहेगा, और आपकी पहचान दर्ज नहीं की जाएगी। आप इस बैठक से कसिी भी बदिु पर वापस लेने के लिए भी स्वतंत्र हैं यद िआप असुवधिाजनक महसूस करते हैं, साथ ही साथ कसिी भी सवाल को छोड़ दें, जसिे आप जवाब देना नहीं चाहते हैं।

इस बैठक में भाग लेने के लिए धन्यवाद।

(प्रतभिागी की जानकारी या मौखकि सहमत िपत्र परचिय के बाद प्रतभिागयिों को पढा जाएगा)

घरेलू सर्वेक्षण के लिए भर्ती स्क्रप्टि

हैलो (नाम डालें), मेरा नाम समीत बंद्योपाध्य है। मैं एक पीएच.डी. ओकलाहोमा स्टेट यूनविर्सटिी में भूगोल वभिाग में छात्र मैं कुर्सीओंग के इस भूस्खलन प्रवण पर्वत क्षेत्र में भूम िउपयोग / भूम िकवर परविर्तन के प्रभावों का अध्ययन कर रहा हूं। मैं यह भी समझना चाहता हूं क िसामाजकि-आर्थकि और राजनीतकि कारकों में इस क्षेत्र में जमीन-उपयोग / भूम-िआवरण परविर्तन का क्या प्रभाव है। मैं आपके परवािर के लिए घर के सर्वेक्षण का संचालन करना चाहता हूं यह सर्वेक्षण लगभग 90 से 120 मनिट तक होगा। आपकी पहचान संरक्षति होगी कोई भी नोट पूरी तरह से गुमनाम रहेगा, और आपकी पहचान दर्ज नहीं की जाएगी। आप इस सर्वेक्षण से कसिी भी बदिु पर वापस लेने के लिए भी स्वतंत्र हैं यद िआपको असहज महसूस होता है, साथ ही साथ कसिी भी सवाल को छोड़ दें, जसिे आप जवाब देना नहीं चाहते हैं।

क्या आप सर्वेक्षण प्रक्रयिा के बारे में अधकि जानने और फरि इस शोध में भाग लेने में रुच िरखते हैं।

(यद िसहमत िहै, तो भागीदार को प्रतभिागी की जानकारी या मौखकि सहमत िपत्र की एक प्रत िके साथ-साथ घरेलू सर्वेक्षण गाइड भी दयिा जाएगा)

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VITA

Samayita Bandyopadhyay

Candidate for the Degree of

Doctor of Philosophy

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Major Field: Geography

Education:

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Completed the requirements for the Bachelor of Science in Geography at the University of Calcutta, Kolkata, West Bengal/India in 2005.

Experience:

Oklahoma State University, Department of Geography, Stillwater, OK.
Research Assistant – Aug 2020 – Present

Oklahoma State University, Department of Geography, Stillwater, OK.
Graduate Teaching Assistant – Aug 2013 – Dec 2016

Awards/Honors:

Evelyn Pruitt National Fellowship for Dissertation Research 2017-18.
Robert E. Norris Field Research Award, Department of Geography, Oklahoma State University, 2014-2015