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Climate Change Adaptation Strategies and Capabilities of Small-scale Farmers in Nepal: Signifiers from Manohara River Basin

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Abstract
Background: *Climate change is emerging as one of the most complex challenges of this century, and dealing with this change is particularly daunting to developing societies especially because of their limited capabilities to deal with the effects of hazardous events. As climate change takes place and the effects continue to spread and become more intense, a focus on adaptation is an important consideration. So this research attempted to seek evidence of adaptation undertaken as a result of climate change impacts and analyze the factors affecting capability and strategies adapted by small-scale farmers in Nepal.*
Methods*: A descriptive cum analytical (correlational) research design was employed following quantitative approach where the reliability and validity of the research instrument was tested with Cronbach's Alpha (α) Test, and descriptive statistics - Kendall Rank Correlation and Chi Square Test were used while analyzing the data and testing the hypotheses; and the inferences were made at 5% and 1% level of significance.*
Results: *The study argued that climate change adaptation is intervened by strategies and capabilities of farmers which depends upon their socio-economic condition and resulted with statistically significant association between the variables. The findings indicated that the small scale farmers are experiencing varied level of changes in climate and are realizing the dire need for further climate change adaptation strategies despite up-taking of various strategies, knowingly or unknowingly, to minimize its impacts.*
Conclusion: *It concluded that the farmers are prone to suffer from capability losses due to climate change, and implied that some influencing factors should be taken into prime consideration to enhance farmers' capabilities to better cope with climate change effects; improving their adaptation measures for maintaining a flourishing relationship with the changing climate.*
Keywords: *Climate Change Adaptation, Strategies, Capabilities, Small Scale Farmers, Nepal*

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I. Introduction

Studies certainly agree that climate changes are taking place, and the changed climate is affecting, in one or the other way, the economic activities, human welfare and livelihoods of the people all over the world. Climate change simply refers to a persistent change in the mean and variability of climate parameters such as temperature, rainfall, humidity, and soil moisture particularly due to change in composition of the atmospheric gases but complexly striking with ever escalating impacts. Climate change may have a permanent negative impact on the natural resource base upon which agriculture thrives especially considering that it is happening at a time of growing demand for basic human requirements such as food, fiber and fuel[1]. There are several impacts of climate change ranging from impacts on human health, on ecosystems, on species, on water resources, and on agriculture[2].

There is a growing concern among the scientists that it has highly adverse effects on the agricultural sector and the farmers in the least developed and developing countries are the hardest hit[3]. Land-locked least developed countries like Nepal primarily with a subsistence agrarian economy, endowed with a combination of landscape features of rugged mountainous terrain, high poverty levels, and narrowed government capability. The impacts of climate change on different sectors constitute a serious threat to Nepal's economy and society[4]. Globally, Nepal is ranked thirtieth, eleventh and fourth in terms of flood risks, earthquake and vulnerability to climate change respectively[5]. Already being the fourth most country in the Climate Change Vulnerability Index (CCVI), Nepal seems to remain in perilous condition according to a (study by Barlett et al. as cited in Poudel[6]) projected impact of climate change from 2030 to 2090; as depicted below:

Table 1: ***The Projected Impact of Climate Change in Nepal from 2030 to 2090 (A.D.)***

Temperature	➢ Significant rise in temperature (^{0}c): 0.5 to 2 by the 2030, 1.3 to 3.8 by 2060, and 1.8 to 5.8 by the 2090 ➢ Increased in the number of days and nights considered hot by current standards ➢ Highest temperature increase during the months of June to August at high elevations
Precipitation	➢ Wide range of mean annual precipitation changes: -34 to +22% by the 2030, -36 to +67% by the 2060, -43 to 80% by the 2090 ➢ Increase in monsoon rainfall towards the end of this century -14 to 40% by the 2030, -40 to +143% by the 2060, -52 to 135% by the 2090
Runoff	➢ Higher downstream flows in the short term but lower stream flows in the long term due to retreating glacier and snow melt and ice melt ➢ Shift from snow to rain in winter months ➢ Increased extreme events including floods and droughts.

Source: Barlett et al, (2010) cited in Poudel (2015)[6]

Table 1 recites the impacts of climate change on temperature and precipitation triggering runoff in the 21st century Nepal. This prediction is an alarming situation for Nepal where majority of population depends on farming for livelihood, and specially buzzing small-scale farmers who depend heavily on their culture, habit and traditional practices to earn their livelihood without understanding the science behind climate change. Rapid change in the climate is, however, making such traditional practices and indigenous knowledge obsolete in no time that costs heavily to the farmers[7] who are so innocent either to be aware of the changing figures that threatens their livelihoods or be aware and indulge in debate behind the change.

Most of the debate on climate change for the past 15 years has been on the impact of climate change rather than the role of adaptation[8]. As climate change takes place and the effects continue to spread and become more intense, a focus on adaptation is an important consideration[9]. Adaptation is the only response available for the climate change impacts that will occur over the next several decades before mitigation efforts can have a realization effect (if any). Adaptation is any 'Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects'[10].

Although climate change is a global phenomenon, it manifests itself differently at the regional and local levels[11] and researches done at the international and national level data fail to capture the location specificity of smaller areas. This calls for the need of detailed explorations of people's capability and strategies to adapt climate change impacts at the finer spatial level in the vulnerable areas. Even at the local level, the section of the community whose livelihood is dependent to natural resource base must be the focus as they are the ones who are comparatively more vulnerable[12]. Hence, in this direction, the general objective of this study was set to seek the evidence of climate change adaptation by examining the factors affecting the capabilities and strategies of small scale farmers by basically addressing the problem: either the small-scale farmers are developing strategies for coping with the changing climate or are suffering capability losses due to climate change?

The study remained inclined with the following hypotheses:

$H1_1$: *There is a significant relationship between farmers' well-being (satisfaction) and the chances of following adaptive strategies.*

$H1_2$: *Small scale farmers are suffering from capability losses due to climate change.*

These prediction or presumptions directed for review of related literature confining to understand theoretical concepts of climate change adaptation along with empirical studies.

II. Review Of Literature

Studies generally agree that, for better or worse, several critical sectors of the economy and other aspects of human welfare will be affected by climate change[13], and climate change adaptation is unescapable. The literature of climate change adaptation (CCA), basically, revolves around the ideas for coping with climate change, especially dealing with the questions of why, what and how climate change adaptation takes place. First, why adaptation is so important? Adaptation is an important complement to greenhouse gas mitigation policies as though reducing greenhouse gas emissions is the only effective mechanism for preventing adverse impacts of climate change, however, given that additional future climate change is now inevitable regardless of mitigation efforts, adaptation is an essential strategy for reducing the severity and cost of climate change impacts[13]. Study on climate change has long focused on mitigation; but regardless of how much mitigation is achieved or will be achieved, the climate is already changing, and significant change is expected in the coming decades due to past emission of greenhouse gases, therefore, adaptation has drawn more and more attention in recent years[14]. Adaptation actions are needed to ensure that individuals and societies are capable of dealing with the detrimental impacts of both natural and anthropogenic (or human-induced) climate change[15].

Second, what is CCA? Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities[16]. Adaptation is a process by which strategies to moderate and cope with the consequences of climate change can be enhanced, developed and implemented[17]. It as a process through which societies make

themselves better able to cope with an uncertain future and adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes[1]. The word 'adaptation', as important as it is to climate policymakers and researchers, is, however, not defined in the same way by all who use it, for the sake of improved communication and understanding across disciplines and cultures, more people must become aware that several words, including (but not limited to) acclimatization, alteration, accommodation, modification, adjustment, are used as synonyms for adaptation[18]. Adaptation practices by communities and institutions can be either anticipatory or reactive and, depending on the degree of spontaneity, can be autonomous or planned[14]. Adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions and often involves a combination of various individual responses at the farm level[19].

Third, and most important notion is about how we can practice CCA or addressing the question of adaptive capacity and strategies. Literature concludes that adaptive capacity may encompass a complex range of strategies to adapt climate change. The IPCC, in its Third Assessment Report (TAR), underlines how the ability to adapt to climate-induced changes is a function of several strategic factors including wealth, technology, information, skills, infrastructure, institutions, equity, empowerment and the ability to spread risk. On the household level this translates into control over land, money, credit and tools; low dependency ratios; good health and personal mobility; household entitlements and food security; secure housing in safe locations; and freedom from violence[20].

More agreeably, some authors emphasized that adaptation and adaptive capacity, in particular, can also be analyzed with Nobel Laureate economist Professor Amartya Sen's Capability Approach (SCA) also known as Capability Approach (CA). Grasso[21] referred to the SCA as primarily a method for making comparisons of well-being which provide an ethically sound basis for the allocation of adaptation resources, and to the ability to turn them into actions. Similarly, Kronlid[22] insisted that the capabilities approach can help climate change research in identifying if, and if so which, intrinsic values of people's wellbeing are vulnerable to climate change in various social, ecological, and economic contexts and on a generic level. IPCC's third assessment report claims that extreme weather and climate events in the mid to late 21st century will affect people's ability to execute excellence in their work in agriculture and forestry and industry, settlement and social sectors; increased heavy precipitation is very likely to damage crops, increase soil erosion and hamper the ability to cultivate the land.

The core characteristic of SCA is its focus on what people are effectively able to do and to be; that is, on their capabilities. According to Sen[23], development can be defined as increasing people's choices in life referred to as capabilities. The conceptual foundations of the CA can be found in Sens critiques of traditional welfare economics, which typically conflate well-being with either opulence (income, commodity command) or utility (happiness, desire fulfilment)[24]. Sen distinguishes between commodities, human functioning/ capability and utility as follows:

Figure 1: Commodities, Human Functioning/ Capability and Utility

Commodity ⟶ Capability (to function) ⟶ Function(ing) ⟶ Utility (e.g. happiness, satisfaction)

Sen suggested that well-being should be considered in terms of function(ings) and capabilities. Functionings are the various things a person may value doing or being[25], and with Sen's word, capabilities are the various combinations of functionings (beings and doings) that the person can achieve. The two concepts (Functionings and Capabilities) are interrelated but have distinct meanings. Sen makes the following distinctions: "A functioning is an achievement of a person: what she or he manages to do or be. A functioning is an achievement, whereas a capability is the ability to achieve. Functionings are, in a sense, more directly related to living conditions. Capabilities, in contrast, are notions of freedom, in positive sense: what real opportunities you have regarding the life you lead"[26]. Sen's theory of capability approach has provided a clear hint for determining broad (dependent and intervening) variables of this climate change adaptation capability research.

Empirical researches further helps to have the better understandings of key factors influencing climate change adaptation. For instance, gender factor can be taken as a significant factor as some of the agricultural operations are gender specific. From a gender perspective, women's involvement in agriculture is significant in developing countries[27, 28] while land preparation for crop cultivation, irrigation, and threshing of grains are predominantly performed by men, transplanting of rice, sowing, manure application, weeding, intercultural operations, and harvesting are primarily done by women[29]. In India, women play a crucial role in the conservation of land, water, flora and fauna and in overall agricultural development[30].

In Austria and the US, and even in India, a survey conducted by National Sample Survey Organization reported that about one-half of the farmers wanted to quit farming[31]. It was believed that a job in off-farm sector is expected to have relatively higher return than farming, and educated individuals wanted to take up a job in other sector rather than taking up agriculture as a profession. They also mentioned that education increases

access to information, which enhances farmers' ability to process information ultimately helping to increase their income. Similarly, Thomas et al.[32] found a large number of adaptation strategies by farmers in South Africa, such as changing farming practices (plant drought- resistant varieties, have more livestock and less crops, build cattle shelter), diversifying livelihood (get off-farm work, start a business) and forming networks (like cooperatives, community, horticulture projects etc.). Contrastingly, Alpizar et al.[33] revealed in a study which considered various socio-economic variables and found that age and education do not have any significant effect on adaptation decisions.

In regards to other factors affecting adaptation, Hasssan and Nhemachena[34] indicated that per capita income has a positive influence on farmers' decisions to take-up adaptation measures. Similarly, Dinar et al.[35] conducted a study across eleven countries of Africa to assess what kind of farmers are more likely to perceive changes in climate and variable considered included age, education, gender, marital status, land ownership etc. It was found that more experienced farmers are more likely to perceive climate change, and nine out of the eleven countries' farmers were using different varieties of the same crop as one of the most important adaptation methods. Likewise, Gbetibouo[36] explained that wealthier farmers are more interested to adapt by changing planting practices, using irrigation, and altering the amount of land farmed while Kim et al.[37] found that household income positively and significantly influences the adoption of adaptive to climate change.

Further, Abeka et al.[38] examined women farmers adapting to climate change and notably found that they take advantage of the knowledge inherited from ancient culture by postponing planting season when the rains delay, crop rotation, production diversification, production of native crops and migration to look for jobs among others. Sekaleli and Sebusi[39] found that some of the farmers' adaptation strategies included water harvesting technologies, conservation tillage, use of keyhole and trench gardens, agro-forestry and application of traditional medicine to control pests and diseases.

Critical factors influencing climate change adaptation are being up-healed by various studies. For instance, Esham and Garforth[40] insisted that the farmers should have a clear under-standing of the genuine changes and trends in climatic conditions, associated hazards, and how to cope up with the potential impacts if they want to adapt effectively to the very real phenomenon of climate change. Various cognitive structures such as trust, climate change beliefs and perceived risk help to shape people's perceptions of climate change[41], which in turn are influenced by their socio-economic and cultural backgrounds and attitudes, principles and interests[42]. People's perceptions eventually shape their decision-making pathways to adapt to climate change[43].

Moreover, Khanal, Wilson, Hoang and Lee[44] investigated the elements that influence farmers' decision-making in adopting climate change adaptation strategies and how these adaptations influence on farm production where they found that 77% of farming households responded that rice production and yield has decreased due to the changes in temperature and rainfall, which has forced them to embrace obtainable adaptation choices. In contrast, Budhathoki and Zander[45] explored the impacts of Nepali small-scale farmers' climate change understandings and perceptions on their farming activities over the time period of (1980–2014), and results from a survey with 496 farmers indicated that almost all farmers recognized changes in crop varieties and cropping patterns mostly to technological and market-related issues and not to climate change. IPCC[46], in its special report mentioned that practices that contribute to climate change adaptation and mitigation in cropland include increasing soil organic matter, erosion control, improved fertilizer management, improved crop management, for example paddy rice management, and use of varieties and genetic improvements for heat and drought tolerance. Smallholder farmers' adaptation practices were found to be influenced by both climatic and non-climatic factors[47].

The literature review revealed that there are less than expected empirical works on climate change adaptation particularly in relation from the capability perspective, especially in the Nepalese agricultural context focusing the small-scale farmers residing in the vulnerable areas of urban settlements. However, it aided to further the advancement of methodology for this study: helping to derive conceptual framework and significant variables required to analyze the climate change adaptation capabilities and strategies of small-scale farmers.

III. Methodology

Conceptual Framework:

The conceptual framework for this study is shown below (Figure 2) which is particularly based on the capability approach. Climate change adaptation is the dependent variable which depends upon the capabilities and strategies of farmers. It has been found especially from the Sen's capability theory, and literature review that functioning(s) (in this study: capability and up-taking of strategies for adaptation) depends on internal (gender, experience or age of farmers) and external characteristics (capitals: physical such as land owning, financial such as savings and social such as association and education level or knowledge) of an individual or group (farmers).

Figure 2: Conceptual Framework

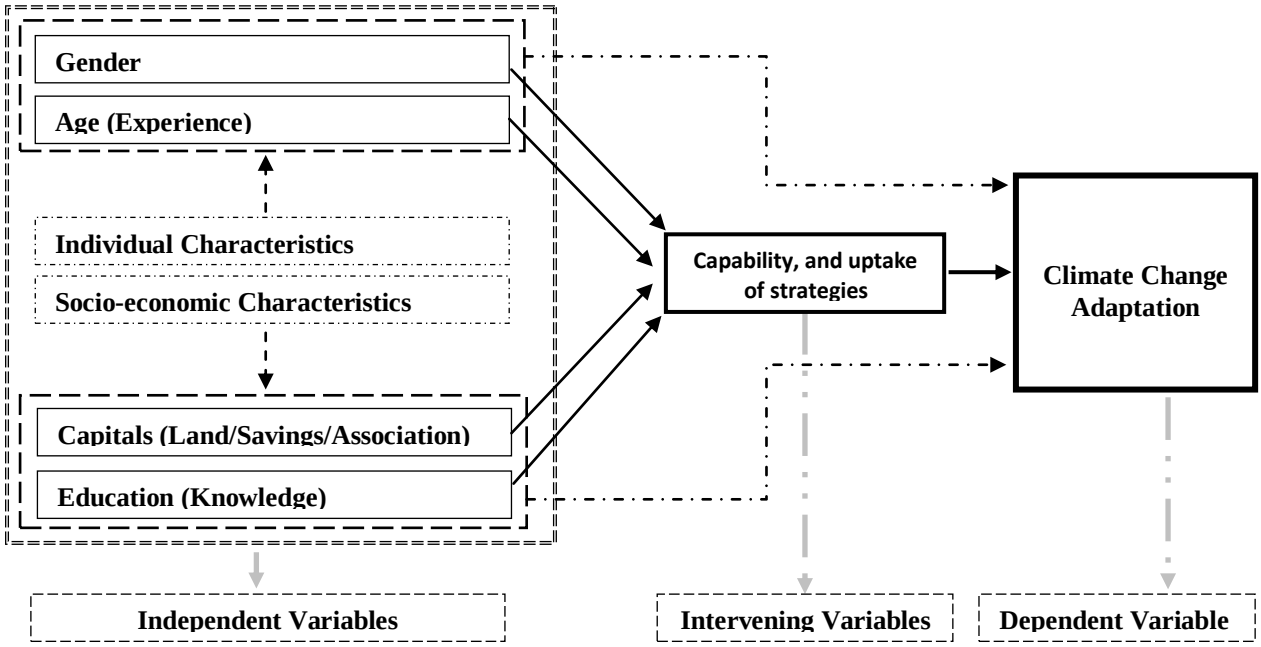

Figure 2: conceptual framework shows the dependent, intervening and independent variables derived for this study. The framework basically tried to establish two relations among the variables restraining to their measuring indicators along with their operational definitions (as depicted in Annex I). The two relations are as follows:

1st empirical relation: The relation between independent and intervening variables:- capability and strategies = *f* (individual characteristics, socio-economic characteristics)

2nd empirical relation: The relation between intervening variable and dependent variable:- climate change adaptation = *f* (capability and up-take of strategies); where *f* denotes function.

Research design, data collection techniques and tools:

This is a case study research in which a descriptive cum analytical (correlational) research design was employed in this study as descriptive research design helps to describe the current practices and events and analytical research design enables us to establish relationship between variables. Data has been collected through multiple sources and mainly triangulated with interaction/interview and observation as 'hallmark of case study research is the use of multiple data sources, a strategy which also enhances data credibility'[48]. Primary data were collected by utilizing the mixed method i.e. by using quantitative as well as qualitative information. Questionnaire was the major instrumentation developed for the field survey, which was of semi-structured nature comprising mostly structured question (items) with few space for unstructured questions and open-ended responses. As the nature of the information collected would be predominantly subjective and not directly quantifiable, the questions were mostly in closed format with ordinal scaling developed by following the 5 point Likert scaling. Pilot testing was conducted, prior to actual data collection, to: see the need of guidance in administering the questionnaire, revise and refine it, and to check its validity and reliability. Cronbach's Alpha Test is used to measure internal consistency (reliability) as per George and Mallery[49], and Gliem and Gliem[50].

Data were collected by using a non-probability sampling, i.e. convenience sampling due to lack of exact data of target population. A total of 120 questionnaire were administered among the farmers, however, clear and complete responses from 67 sampled respondents (in total) were successfully drawn despite of the several challenges such as local language. Nevertheless, this sample size is significant to represent the total population of vegetable farmers as informed/shared by the authorized municipal members of the core study areas. The data collected for the study were presented and analyzed particularly by using Microsoft Excel (2013) and Statistical Package for the Social Sciences (SPSS Statistics, Version 20).

The research employed Kendall Rank Correlation, a non-parametric test, to measure the strength of dependence between two variables and the inferences were made on 1 percent and 5 percent level of significance. A non-parametric Chi-square test was performed for statistically testing the presented hypothesis.

Study area:

This study is a case oriented research to have an in-depth investigation in real life setting, carried out in Manohara River Basin which is located in the northeast of the Kathmandu Valley (The Capital City) of Nepal (Map 1 in Annex II). Kathmandu Valley is situated in middle mountain region of Nepal (Map 2, Annex II) which lies between latitudes 27032'13'' and 27049'10'' north and longitudes 85011'31'' and 85031'38'' east. Kathmandu valley comprises of three districts - Bhaktapur, Kathmandu, and Lalitpur whose boundaries are separated by rivers. Bagmati River separated the Kathmandu and Lalitpur districts, whereas Kathmandu and Bhaktapur is separated by the Manohara River. It [Manohara river] is elongated in shape having 28 km length from NE to SW covering 83 sq. km of area[51]. This study was focused on the Manohara River basin (Map 3, Annex II) particularly from Karki Gaun Bridge, Mulpani to the upstream of Sanothimi Bridge in Madhyapur Thimi Municipality (Map 4 & 5, Annex II). The core study area was around 5 km long stretch of the Manohara River Basin as indicated in Map 5 (Annex II, between number 1 & 2). The particular places covered were Sanothimi, Gothatar, Bodegaun (including Nagadesh) and Mulpani where majority of small-scale farmers were concentrated fully towards vegetable farming, and are sampled in the study. Frequent observations and interactions were done in the core study area and places (Map 5, Annex II) during primary data collection (almost from June to August, 2020) via semi-structured (mostly structured) questionnaire survey for results and discussions.

IV. Results And Discussion

Farmers' Perception on Climate Change Impacts:

Farmers are likely to take adaptive actions when they take changes in climate as the serious considerations; as for someone to take action to adapt to climate change autonomously, s/he has to recognize climate change first. To make the farmers clear with the confusion of seasonal variation and climatic variation they were asked to share their experience of past 15 to 30 years. This was in accordance with the World Meteorological Organization (WMO) which has given the standard of 30 years as the classical period for performing the statistics used to define climate. Every one of the sampled farmers in Manohara river basin shared their experience reporting varied level of changes in climate.

Climate change affects farmers and other agricultural workers in a various manner including: hampering their ability to cultivate land, increasingly damaging the crops, causing lower yields of crops, and increased risk of water shortage for harvesting etc. However, as climate change manifest itself differently at regional and local levels, this effects may vary across the socio-economic conditions. The association between the given socio-economic characteristics of farmers and their perceptions of climate change effects is presented in Table 2.

Table 2: ***Socio-economic Characteristics and Perception of Climate Change Effects***

Socio-economic Characteristics	**Climate change Impacts/effects**			
	Hampering the ability to cultivate land	Increasingly damaging crops or vegetables	Causing lower yields of crops or vegetables	Increased risk of water shortage for harvesting
Gender	-0.274*	-0.148	-0.236	0.216
	0.026	0.229	0.055	0.79
Age(Years)	-0.037	0.030	-0.070	0.122
	0.746	0.796	0.542	0.288
Education	0.033	-0.008	0.143	0.133
	0.772	0.945	0.207	0.239
Land Ownership (Tenancy status)	-0.096	0.249*	0.093	-0.092
	0.413	0.034	0.426	0.431
Average Saving per Month	0.233*	-0.147	0.115	0.012
	0.045	0.208	0.323	0.919
Association with organizations	0.029	0.063	0.003	0.025
	0.817	0.610	0.980	0.840
Training	0.112	0.084	0.105	-0.96
	0.363	0.409	0.396	0.436

** Correlation is significant at 0.05 level*

Table 2 depicts the bivariate correlation of farmers' perception of climate change effects with their socioeconomic characteristics. It revealed that gender and saving factor are significantly associated with the climate change effects that hampers the farmers' ability to cultivate land. The negative correlation with the gender has not been interpreted while its significance denotes that climate change is hampering their ability to cultivate land. Gender factor is significant for the analysis in this study, probably due to the reason that generally females are the ones to appear in the cultivating the land rather than male. Males are particularly active in marketing and transporting tasks rather than fieldworks. This result is observed in consistent with the IPCC documents, as reviewed by Kronlid[22], which highlighted that 'from a capabilities approach however, the

IPCC's results and predictions indicate that climate change threatens people's intrinsic abilities to execute excellence in work in affluent as well as scarce communities'.

Similarly, average savings (per month) of farmers showed positive and significant correlation with the climate change effect i.e. hampering the ability to cultivate land. This signified that higher the savings higher is the perceptions that climate change is hampering their ability to cultivate land, and vice versa. Likewise, land ownership or tenancy status is positively and significantly correlated with the perception that climate change is increasingly damaging the crops or vegetables. This implies that the perceptions differs accordingly the farmers are either farming on their own land, rented land or both (owned as well as rented). In case of other socio-economic characteristics and perceptions on climate change effects, no strong or significant association exists.

Adaptation Strategies of Small-scale Farmers:

In this study particularly two types of adaptation strategies that farmers undertake were assessed: autonomous adaptation strategies, and other (alternative) adaptation strategies. Adaptation that does not constitute a conscious response to climatic stimuli, but is triggered by ecological changes in natural systems and by market or welfare changes in human systems...also referred to as spontaneous adaptation[16], is generally known as autonomous adaptation. Adaptation that is the result of a deliberative policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return, to maintain, or to achieve a desired state[14] is autonomous adaptation strategies. The factors affecting farmers' autonomous adaptation strategies are revealed in tables 3:

Table 3: ***Farmer's Autonomous Adaptation Strategies***

Variables	**Autonomous Adaptation Strategies (Adaptive actions)**				
	Using different varieties of seed for same crop	Increasing use of irrigation	Planting drought resistant varieties	Changing Planting dates	Using pesticides/ insecticides/chemical fertilizers
Gender	0.163 0.185	0.139 0.258	0.034 0.785	0.086 0.486	0.079 0.520
Age(Years)	-0.344** 0.003	-0.141 0.901	-0.296** 0.010	-0.369** 0.001	-0.326** 0.005
Education	0.296** 0.008	-0.198 0.080	0.156 0.169	0.213 0.059	0.370** 0.001
Land Ownership (Tenancy of land)	0.096 0.414	-0.104 0.375	0.016 0.894	-0.048 0.685	0.029 0.806
Average Saving per Month	-0.016 0.888	-0.010 0.929	0.063 0.586	-0.081 0.484	0.097 0.405
Association with organizations/co-operatives	0.025 0.843	0.042 0.733	-0.104 0.400	0.060 0.629	-0.072 0.558
Training	0.166 0.181	-0.124 0.316	0.043 0.725	0.036 0.772	0.055 0.657

*** Correlation is significant at 0.01 level*

Table 3 indicates the farmers' autonomous adaptation strategies (in association with their socio-economic characteristics). The bivariate correlation indicated that age is negatively and significantly (at 0.01 level) related to farmers' adaptive strategies to climate change effects. This implies an interesting findings that the probability of adaptation significantly decreases with the age of the farmers which contradicted that as experience (age-wise) accumulates adaptation strategies is less likely to be on focus for farmers. It can be predicted that such farmers have less interest or less incentives in taking climate change adaptation measures. Perhaps aged farmers do not see the necessity to adapt to climate change effects. Moreover, these older farmers may be more 'set in their ways', interested in following traditional methods familiar to them rather than adopting innovative farming techniques while the younger farmers are more excited and willing to adopt new methods in their farming.

Further, it indicated that education is positive and significantly (at 0.01 level) related to autonomous adaptation strategies. From this statistics, it can be inferred that the likelihood of adaptation to climate change is much greater for those who have higher educational accomplishment than to less-educated or illiterate farmers. It is quite obvious that educated farmers who have more knowledge, a greater ability to understand and respond to anticipated changes, are better able to forecast future scenarios and, overall, have greater access to information and opportunities than others, which might encourage adaptation to climate change. This ability might have been affected by technological adoption by younger farmers as several studies found that education also positively and significantly affects the adoption of technology.

Challenging the 'gender role' in climate change adaptation, this research revealed no correlation and statistically significant data to show its relation with adaptive strategies. For instance a study by Bryan et al.[52] in Ethiopia showed that male-headed households had better opportunities to practice adaptation measures than the

female-headed households. Male headed households could be more likely to have access to technologies and climate change information than female-headed households. As a result, they were in a better position to practice diverse adaptation strategies than the female-headed ones. However, no such statistically significant evidence could be explained in case of farmers in Manohara river basin, Kathmandu, Nepal, even though the research area was equipped for accessing technologies and climate change information, just in case of dire need.

Furthermore, tenancy status of farmers indicated a negative correlation sign for most of the adaptation measures which infer that tenants are more likely to adapt their farming to perceived climate change compared to the self-operating farmers (owners). Increased likelihood of adaptation for tenants may be due to the reason that tenants are more conscious about their farm income compared to owners as the formers also has to pay the rent of land hence they will adapt more to climate change to keep their gross revenue above the total cost as compared to the farmers owning own land. The reason behind this signifier may be due to the reason that farmers with large landholdings are likely to have more capacity to try out and invest in climate risk coping strategies.

More surprisingly, there is no any correlation and statistically significant association between income, involvement with co-operatives, and trainings with adaptation strategies by farmers which is also in contrary with other studies. As an instance, Kim et al.[37] found that household income positively and significantly influences the adoption of adaptive to climate change while Gbetibouo[36] explained that wealthier farmers are more interested to adapt by changing planting practices, using irrigation, and altering the amount of land farmed. Further, Hasssan and Nhemachena[34] indicated that per capita income has a positive influence on farmers' decisions to take-up adaptation measures. As it was anticipated that farmers involved in cooperatives share knowledge and innovation ideas, discuss problems and challenges with others, and engage in collaborative decision making but these factors appeared weak and insignificant in this research. This clued for examining association (bivariate correlation) between such factors and other alternative adaptation strategies to climate change such as diversifying livelihoods, rigorous formation of networks such as by establishing cooperatives, and/or moving to non-farming activities by completely leaving the current farming activities.

Table 4: *Other Adaptation Strategies*

Variables	Other/Alternative Strategies (Adaptive actions)			
	Hoping to increase the farming by increasing the size of land or renting more land.	Diversifying livelihood (Starting a business, part time job)	Forming networks (co-operatives)	Moving to non-farming activities completely leaving the current farming activities
Gender	-0.103 0.401	0.164 0.182	-0.031 0.803	0.183 0.137
Age (Years)	0.130 0.257	0.208 0.070	0.049 0.668	.-227* 0.009
Education	-0.022 0.848	-0.294** 0.009	-0.067 0.555	-0.193 0.088
Land Ownership/Tenancy Status	-0.262* 0.026	-0.200 0.089	-0.063 0.593	-0.299* 0.011
Average Saving per Month	0.057 0.625	0.063 0.589	0.110 0.342	0.002 0.987
Association with organizations	-112 0.365	-0.078 0.527	-0.116 0.348	-0.023 0.841
Training	-0.175 0.156	0.025 0.841	0.043 0.725	-0.035 0.776

*** Correlation is significant at 0.01 level; * Correlation is significant at 0.05 level*

Table 4 shows the factors affecting farmers' alternative adaptive actions rather than autonomous. It revealed that age factor has negative correlation (r= -0.227*) but statistically significant at 0.05 level (p =0.009) implying that the younger the farmer the higher the chance for exiting farming activities. This is quite anticipatable because it is often believed that the younger individuals are more likely to change occupations and they prefer non-farm work more than older individuals, on the other hand, elderly farmers continue farming as long as they can contribute to the farm and they may have rare chances for off-farm employment. It is also found that education has a negative correlation with r= -0.294** and statistically significant at 0.01 level. It is implied that educated individuals may be more likely to leave farming probably because the earnings and benefits from agriculture are rather seasonal and relatively less rewarding than off-farm jobs.

Interestingly, adaptive actions showed no (significant) correlation with the gender factor. This appeared to be a very contradictory signifier because women's involvement in agriculture is significant in developing countries[27,28]; and women play a crucial role in the conservation of land, water, flora and fauna and in overall agricultural development[30]; moreover, some of the agricultural operations are gender specific[27,30]; while land preparation for crop cultivation, irrigation, and threshing of grains are predominantly performed by men, transplanting of rice, sowing, manure application, weeding, intercultural operations, and harvesting are primarily

done by women[29] as this scenario is not an exception to Nepal. Therefore, the gender composition of family labor may also affect the decision to livelihood transition and adaptive actions in contrast to this finding. Likewise, there is no any statistically significant correlation between income, involvement with co-operatives, trainings, and adaptation strategies by farmers.

These facts tend to lead to the inference that being male or female, rarely being associated with organizations (cooperatives), receiving less farming trainings, and making lower income with lower savings may be limiting farmers for up-taking alternative adaptation strategies. Alternative adaptation strategies, other than that of autonomous strategies may comprise, such as, diversifying their livelihood; choose other occupations; hoping to increase their farm size, or forming networks etc., in order to cope with the climate change effects sustainably. However, adoption of these strategies might have been affected by various adaptation barriers to farmers that directly or indirectly hampers their capabilities to deal with the changes in climatic conditions.

Barriers to Climate Change Adaptation:

These may encompass various limitations, including but not limited to, such as lack of money or savings or access to credit, access to land, infrastructural inputs such as sand dams, and climate information. For instance, small scale farmers may be lacking money, savings or access to credits for increasing their farm size by buying or renting more land to minimize the increasing consequences of climate change effects and sustain their livelihoods. Similarly, those who have enough savings to rent more land might not have access to (rent) land in urban context due to the reason that land values are higher and further being encroached by developmental activities, land plotting, and other high profit oriented businesses. To examine the association between such adaptation barriers for adaptive capacity and strategies, a bivariate correlation was performed and the result is depicted in the table 5:

Table 5: ***Adaptation Barriers and Alternative Adaptation Strategies***

Variables	**Other Strategies (Adaptive actions)**			
	Hoping to increase the farming by increasing the size of land or renting more land	Diversifying livelihood (Starting a business, part time job)	Forming networks (co-operatives)	Moving to non-farming activities completely
Lack of savings/access to credit	0.343** 0.002	0.279* 0.012	0.201 0.071	0.227* 0.045
Lack of access to land	0.368** 0.001	0.227* 0.041	0.369** 0.001	0.221 0.050
Lack of infrastructure /inputs	0.144 0.193	0.438** 0.000	0.216 0.053	0.335* 0.003
Lack of climate information	0.077 0.486	0.211 0.058	0.291* 0.009	0.221 0.050

*** Correlation is significant at 0.01 level; * Correlation is significant at 0.05 level*

Table 5 represents that almost all the barriers of adaptation strategies have positive correlation coefficient with statistically significant association at 0.01 and 0.05 level respectively. Lack of money /access to credit and savings hinders agricultural inputs thereby influencing farmers in diversifying their livelihood, moving to non-farming activities and willingness in renting more land. Other limitations such as access to land and infrastructure also influence the farmers in the same manner. Climate information via involvement with cooperatives may support small scale farmers on decision making such as in which option to invest in, when and how much to invest etc. In addition, flexible and proactive planning enabled by climate information may help vulnerable communities, service providers, and intermediaries to continuously adjust their plans as well as to maximize on opportunities. So, Climate information in above table shows positive correlation with statistically significance r=0.291* p=0.009 with forming network such as co-operatives.

Testing of Hypothesis:

$H1_1$: There is a significant relationship between farmers' well-being (satisfaction) and the chances of following adaptive strategies.

Wellbeing or satisfaction, in general, is operationalized as the fulfilment of one's (farmers) wishes, expectations, or needs, or the pleasure derived from their occupation. Hence farmers' wellbeing (satisfaction) with their occupation could probably reflect most of the (their) socio-economic characteristics included in this study. Thus, Chi-square test was performed to test this hypothesis.

Table 6: ***Chi-square Test for Level of Satisfaction and Adaptive Actions ($H1_1$)***

Non parametric Test	Chances of following adaptive strategies	P value	Level of Significance
Pearson Chi square Test	Hoping to increase the farming by increasing the size of land or renting more land.	**0.029**	**0.05**
	Diversifying livelihood (Starting a business, part time job etc.)	**0.008**	**0.05**
	Forming networks (co-operatives)	**0.002**	**0.05**
	Moving to non-farming activities completely leaving the current farming activities	**0.034**	**0.05**

Table 6 shows that there is a significant association between satisfaction level and farmer's chances of adapting strategies as $p<0.05$. Hence, we accepted alternative hypothesis i.e. there is a significant relationship between the level of satisfaction and farmer's chances of following adaptive strategies which signifies that the more satisfied a farmer is with his/her occupation (farming), the higher the probability for adapting climate change issues or devising adaptation strategies. This may be interpreted as the farmers who were less satisfied tend to follow lesser adaptation strategies, further implying that less satisfied farmer tend to exit farming practices taking alternative approaches rather than following adaptive strategies.

$H1_2$: Small scale farmers are suffering from capability losses due to climate change

The notion of Sen's Capability Approach was followed in order to examine this hypothesis, however, statistical testing appeared to be difficult due to the problems in capability measurements. As highlighted by Grasso[21], Sen himself suggested that at a practical level the most appropriate focus of attention should not always be the measurement of capabilities: "Some capabilities are harder to quantify than others and efforts to put them on a 'metric' might sometimes hide more than they disclose"[25]. Thus, testing this hypothesis statistically appeared difficult but rather required logical justification based on theoretical concepts of capability approach. Therefore, some findings were summarized to see if they can produce evidence for capability losses. Statements that may contradict the Capability Approach were indicated by negative (-) sign and that may support were indicated by positive (+) signal. Accordingly, an attempt was made to analyze and justify the capability related hypothesis.

Table 7: Findings' Signals (Positive/Negative) for Justifying the Hypothesis ($H1_2$)

Variables (Factors)	Statements of findings for justifying signals	Signal	
		+	-
Satisfaction/ Well-being factors	Majority of the farmers were satisfied (happy) with their occupation	+	
	Almost all farmers were somehow able to perceive and predict changes in climate	+	
	Most farmers tend to take adaptation decisions (moderate to very high importance)	+	
Effects	Climate change was hampering the ability to cultivate land (77.6%)		-
	Climate change was increasingly damaging the crops or vegetables (83.6%)		-
	Climate change was causing lower yields of crops or vegetables (80.6%)		-
	Climate change had increased risk of water shortage for harvesting (44.8%)		-
Autonomous Strategies	Most farmers were using different varieties of seed for same crop (74.6%)	+	
	Most farmers were increasing use of irrigation (61.2%)	+	
	Most farmers were planting drought resistant varieties (67.2%)	+	
	Majority of farmers were changing Planting dates (53.7%)	+	
	Most of the farmers were using pesticides/insecticides/chemical fertilizers 86.6%)	+	
Other Strategies	There were fifty-fifty chances of farmers for increasing the size of land	+	
	There were Low chances for farmers to diversify their livelihood (64.2%)		-
	Low chances for forming networks like cooperatives (67.2%)		-
	Low chances for exiting farming completely (74.6%)		-
Capability factors	There was lack of money /savings/access to credit (76.1%)		-
	There was lack of access to land (73.1%)		-
	There was lack of infrastructural inputs (64.2%)		-
	Farmers insisted that the more resources (money and materials) than available now would make them better able to cope with climate change effects (58.2%)		-
Age	Age of farmers indicated negative and significant (at 0.01 level) correlation with their autonomous adaptation strategies insisting that the younger the farmer more they tend to devise adaptation strategies.	+	
	Age of farmers indicated negative and statistically significant correlation (r= -227 at 0.05 level) implying that the younger the farmer the higher the chance for exiting farming activities by moving to non-farming activities.	+	
Education	Education indicated positive and significant (at 0.01 level) correlation with adaptation strategies implying higher the education better is the climate change adaptation strategies.	+	
	Education had a negative and statistically significant correlation (r= -0.294 at 0.01 level) implying the more educated a farmer is the more chances for diversifying livelihoods.		-
Gender	Gender wise, there seemed unequal distribution of the famers at the field level		-
	Indicated negative and significant correlation (r= -0.274 at 0.05 level) implying that male and female are likely to have opposite perceptions in case of climate change effects that hampers their ability to cultivate		-

	land		
	There was no statistically significant data (no correlation) to show the relation between gender characteristics of farmers and adaptation strategies they follow.		-
Land owner-ship	Tenancy status of land for farming was mostly rented (55.2%), owned (25.4%), both (19.4%)		-
	There was negative and statistically significant correlation (r=-.227 at 0.05 level) implying that farmers with rented land have more chances to exit farm activities by moving to non-farming activities for adapting hazardous events of climate change.	+	
	There was a negative and statistically significant correlation (r=-0.249 at 0.05 level) implying that farmers with rented land is likely to perceive that climate change increasingly damaging the crops.		-
Savings	Average monthly savings from farming was mostly adequate to meet the ends and maintain current expenses.	+	
	There was a positive and statistically significant correlation (r=-0.233 at 0.05 level) implying that the lesser the savings lesser they perceive that climate change is hampering their ability to cultivate land.		-
Social capital related	Less farmers (only 25.4%) had association with organizations or cooperatives		-
	Farmers had less training access (7.5% only)		-
	There was easy access to market	+	
	There seemed no statistically significant correlation between savings, involvement with co-operatives, trainings and adaptation strategies		-
	There seemed no any statistically significant correlation between income, involvement with co-operatives, trainings access; and up-taking adaptation strategies by exiting from farming activities.		-
Total	Totaling of positive and negative signals to determines capability losses	**15**	**22**

Table 7 presents the summery of findings in this study that signaled mixed results: positive signs (15) as well as negative signs (22) in case of small-scale farmers' capability to follow climate change adaptation strategies. The result, however, showed more inclination toward the conclusion that small scale farmers are somehow suffering (or prone to suffer) from capability losses due to climate change impacts i.e. to accept alternative hypothesis.

V. Conclusion

The study concluded that small scale farmers are prone to suffer from capability losses due to climate change. Climate change is a reality to them and an unavoidable challenge that they (will) have to deal with overcoming days as they are experiencing a varied level of changes. Climate change effects are hampering their ability to cultivate the land, increasingly damaging their production, and causing lower yields of harvests. Knowingly or unknowingly, farmers are engaging in autonomous adaptation strategies. However, they are facing limitations to adopt other adaptive actions such as by expanding farming activities, diversifying livelihoods, forming networks to minimize effects, or even for moving to non-farming activities based on their individual and socio-economic conditions. These limitations are significantly associated with lack of access to credit, land, and other infrastructural inputs. Amongst all signifiers small scale farmers' wellbeing in terms of satisfaction with their farming occupation is significantly correlated (at 0.05 level) with the chances of devising adaptive strategies. Such influencing signifiers should be taken into prime considerations while developing additional intervention to enhance farmers' capabilities to better cope with climate change effects, thus improving their adaptation measures for maintaining a thriving relationship with the changing climate. Hence, alarming all the stakeholders and pressure groups, this research, recommends to focus specifically towards the weak existence of social capital bases among the farming communities which could appear fruitful for enhancement of farmers' capability aspects. Therefore, future research could be geared towards these policy interventions with the focus on wellbeing factors and capability enhancement of innocent farmers for their better adaptation and flourishment in the era of rapidly changing climate.

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Annexure

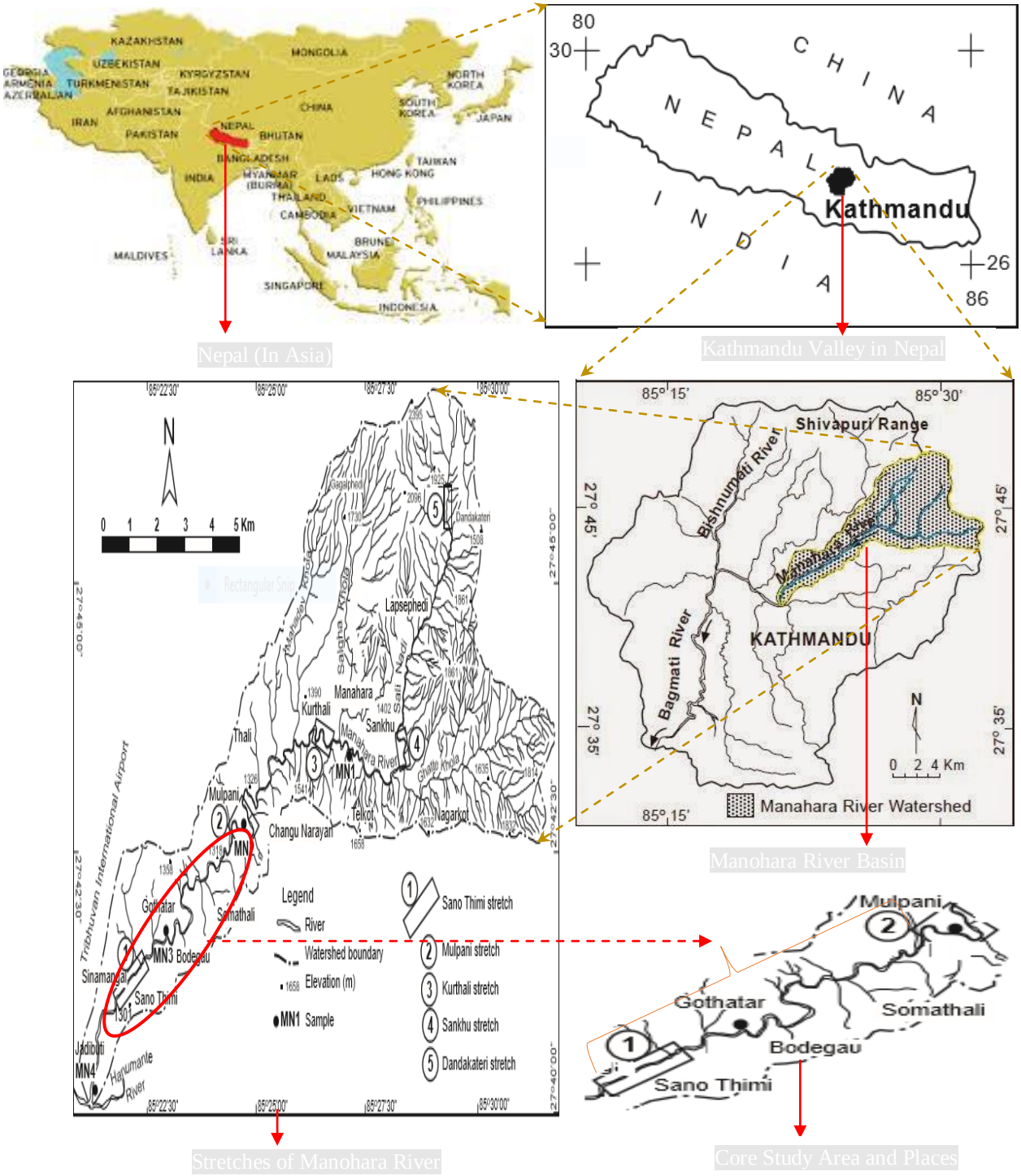
Annex I

Variable Matrix: Measuring indicators with operational definition

Variables		Indicators	Measuring Indicators insisting their operational definition
Dependent	Climate Change Adaptation	Perception of climate change and adaptation decisions	Climate change [(precipitation/rainfall; temperature) and their consequences (water source; flood; drought)] perceptions to be assessed by using the indicators (increase, decrease, unusual changes, no change, including being unknown of the changes)
Intervening	Capability	Ability to cultivate land and sustain livelihoods	(Lack or availability of) climate information, market access, money (cost to tackle with the fertilizers/pesticides/boreholes etc.) for adopting impacts.
	Uptake of Strategies	Technical changes in farming practice	Using different varieties of same crop; Changing planting dates, increasing the use of irrigation, adapt by moving to non-farming activities; , crop diversification, resource conservation, and cultivation of stress tolerant crop varieties
Independent	Individual Characteristics	Gender	Measured through attributes (Male/Female)
		Age	Number of years (current)
	Socio-economic Characteristics	Capital	Physical Capital: Control over land (own or rented) Economic or financial capital: savings from Income Social Capital: networks or associations e.g. cooperatives
		Education	Informal (also indigenous knowledge) and formal education

Annex II

Map(s) of Study Area: Manohara River Basin, Kathmandu Valley, Nepal



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