LIVELIHOOD RESILIENCE OF FLOOD AFFECTED HOUSEHOLDS IN NORTH-WESTERN BANGLADESH

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CERTIFICATE

This is to certify that thesis entitled, "**LIVELIHOOD RESILIENCE OF FLOOD AFFECTED HOUSEHOLDS IN NORTH-WESTERN BANGLADESH**" submitted to the Faculty of **Agriculture,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURAL EXTENSION from DEPARTMENT OF AGRICULTURAL EXTENSION & INFORMATION SYSTEM**, embodies the result of a piece of bona fide research work carried out by **SUNIL CHANDRA SARKER, REGISTRATION NO. 15-06965** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

I wish his every success in life.

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DEDICATED

TO

MY BELOVED

PARENTS AND SISTERS

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LIST OF ABBREVIATIONS

AIS	Agriculture Information Service
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
BARI	Bangladesh Agricultural Research Institute
BRRI	Bangladesh Rice Research Institute
CARE	Cooperative for Assistance and Relief Everywhere
CI	Composite Indicator
DAE	Department of Agricultural Extension
DFID	Department for International Development
FAO	Food and Agriculture Organization
GIZ	German Cooperation for International Development
ICT	Information & Communication Technology
NGO	Non-Government Organisation
OECD	Organisation of Economic Cooperation and Development
PO	Private Organisation
PPCR	Pilot Program for Climate Resilience
SA	Sustainable Agriculture
SES	Social Ecological System
SDG	Sustainable Development Goals
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
WB	World Bank

ABSTRACT

Resilience, a long term capacity of a system to deal with change, has emerged as an integrated approach for achieving sustainable livelihood condition. The objective of the study was to select and describe the resilience indicators, to assess livelihood resilience of flood affected households, and to determine the key factors of livelihood resilience. Data were collected using interview schedule from a sample of 120 households of the total four villages of Sundargonj (Gaibandha) and Lalmonirhat Sadar (Lalmonirhat) upazilas. Households' livelihood resilience was conceptualized applying a climate resilience assessment framework of GIZ (German Cooperation for International Development) and analyzed developing a composite resilience index, which consists of three capacities and four dimensions. Correlation and multiple regression analysis were used to express results. Results show that (i) respondents had more absorptive capacity (46%) than adaptive (33%) and transformative (21%), (ii) in building capacities, social dimension had highest contribution, whereas institutional dimension was in a marginalized condition, and (iii) human capital, non-farm income generating activities, social capital, and infrastructure played a key role in improving livelihood resilience. This study concludes that households' adaptive and transformative capacities building are essential for improving livelihood resilience. Policy should emphasis on (i) investing (human and social) capital-centric approach for reducing flood vulnerability, (ii) facilitating non-agricultural income generating schemes (starting small business), and (iii) improving condition of local infrastructure like roads, bridge and culverts.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Bangladesh is the sixth most vulnerable country to floods in the world. Most of Bangladesh lies in the delta of 3 of the largest rivers in the world, the Ganges-Brahmaputra-Meghan basin – with globally the second highest water flow during the flood season. In most years between 30-50% of the country is affected by floods. These cause losses in agriculture, damages to households and livelihoods. However, every 4 to 5 years, there is a major flood that inundates 60% of the country and cause losses of life, substantial damage to infrastructure, housing, agriculture and livelihoods. In the last 25 years, Bangladesh has experienced six severe floods. In 2007, two successive floods inundated over 70% of the country, destroyed over 85,000 houses, affected almost 1 million households and destroyed 1.2 million acres of crops. Total estimated damage from these floods was over US$1 billion. Climate change is predicted to lead to heavier and more erratic rainfall, especially during the monsoon season. This is expected to result in higher river flows, causing over-topping and breaching of embankments and widespread flooding in rural and urban areas (PPCR, 2010).

Bangladesh, a low lying delta located between the Himalayas and the Bay of Bengal with a population of over 150 million, is one of the most climate vulnerable countries in the world. With over 1000 persons per sq. km. the country has one of the highest population densities in the world. With an average elevation of 4 to 5 meters above mean sea level, nearly a third of the country is susceptible to tidal inundation and nearly 70% of the country gets flooded during heavy monsoons. However, the country has made impressive economic and social progress in the past decade, despite frequent natural disasters and external shocks. Poverty declined from 57% of the population in 1990 to 40% in 2005. Broad-based private sector led growth and macroeconomic stability contributed to significant decline in rural and urban poverty. The average GDP growth over the last six years was over 5% (PPCR, 2010).

The rural infrastructure in Bangladesh, particularly the North Western part, is yet to be fully developed. Only 37% of the rural population in the country has access to all-weather roads compared with 60% in India and 61% in Pakistan. Road connectivity is weak, resulting in higher vehicle operation cost and the need for a significant upgrading of rural infrastructure. The main problems in fostering road connectivity are: (i) fast growing demand for road transport (6%); (ii) lack of funds for developing infrastructure; (iii) lack of enforcement of government's policies and regulations in road safety; (iv) inadequate maintenance funding; (v) lack of technical skills and capacity building of local government institutions; and (vi) vulnerability to extreme weather events. The absence of efficient rural transport and supporting infrastructure culminates in reduced accessibility for poor and women to resources and social services and is a serious impediment in fostering the economic and social development (PPCR, 2010). Households of Gaibandha and Lalmonirhat districts have been hampering every year by flood (PPCR, 2010). Thus, it is the burning need to assess and determine their livelihood resiliency.

1.2 Statement of the problem

Bangladesh is mainly comprised of the fertile alluvial flood plains of three large rivers (Ganges, Brahmaputra and Meghna) with over 90% of their catchments situated outside the country. These three rivers combine within the country to form the world's third largest river, the Lower Meghna, which drains into the Bay of Bengal via a constantly changing network of estuaries, tidal creeks and active deltaic coastline of the Bay (PPCR, 2010).

Every year thousands of households are hampered by flood and floods inundated all things of households of Gaibandha and Lalmonirhat district, destroyed houses, livelihood and thousands acres of crops. This study identifies and discuss of livelihood resilience against climatic hazards (flood) through the selective indicators such as human capital, social capital, access to ICTs'. The purpose of the study is to ascertain the nature of resilience livelihood of households. The study is also aimed to have an understanding of the selected indicators of resilience livelihood against flood. The purpose of the study is to have answer to the following questions-

1. Which indicators of households are related to resilience livelihood?

2. How to determine and describe the extent of use of indicators for resilience livelihood against flood?
3. What relationship exists between the selected indicators of the households of North Western Bangladesh and their effectiveness of resilience livelihood against flood?

1.3 Objectives of the Study

The present study was undertaken with the following objectives:

1. To determine and describe the following selected livelihood resilience indicators of the flood affected households:

- ✓ Human capital
- ✓ Social capital
- ✓ Access to ICTs'
- ✓ Annual family income
- ✓ Non-farm income generating activities
- ✓ Land productivity
- ✓ Climate Smart Agricultural practices & technologies
- ✓ Functional and response diversity
- ✓ Crop diversity
- ✓ Access to financial institutions
- ✓ Infrastructure
- ✓ Market access

2. To assess the livelihood resilience of the households, and

3. To determine the key factors of livelihood resilience of these households in North Western Bangladesh.

1.4 Scope and limitations of the study

The respondents of the study were exclusively selected from Sundargonj Upazila of Gaibandha district and Lalmonirhat sadar Upazila of Lalmonirhat district. But the findings may be applicable in other area of Bangladesh where the physical, socio-economic, and cultural conditions are alike with those of the study area. However, in order to conduct the research in a meaningful and manageable way it becomes necessary to impose certain limitations in regard to certain aspects of the study,

considering the time money and necessary resources available to the researcher. The study was conducted with the following limitations-

i) The study was conducted at Sundargonj Upazila of Gaibandha district and Lalmonirhat sadar Upazila of Lalmonirhat district.
ii) Population of the study was limited to the flood affected households.
iii) Households of selected study area have many variables but in this study only twelve variables were selected for investigation.
iv) Data furnished by the respondent households were considered to be valid and reliable.
v) Limited facts and figures collected by the investigator considering prevailing situation.
vi) Reluctance of the respondents to provide information was overcome through establishing rapport.

1.5 Assumptions of the Study

An assumption is the supposition that an apparent fact or principle is true in the light of the available evidence and, therefore, the assumption is taken as a fact or belief to be true. The following assumptions were made in conducting the study:

i. The respondents included the sample were capable to satisfy the queries made by the researcher.
ii. Data provided by the respondents were reliable.
iii. As the respondent households were the representative sample their views and opinion were also thought to be representative.
iv. As the study area and the respondents were known to the researcher the respondents' furnished unbiased information with no hesitation.
v. Selected indicators included in the study were known to the respondents.
vi. The findings of the study were expected to be useful for planning and execution of various extension programmes in order to develop household's livelihood.

1.6 Definitions of Related Terms

Resilience – is the long term capacity of a system to deal with change and continue to develop (Folke, 2010).

-Amount of change a system can undergo without changing state (IPCC, TAR, 2001 a).

-Resilience is a tendency to maintain integrity when subject to disturbance (UNDP, 2011).

-Resilience is the ability of a system to recover from the effect of an extreme load that may have caused harm (UKCIP, 2004).

-Resilience is the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures (UNDP, 2011).

-Resilience refers to three conditions that enable social or ecological systems to bounce back after a shock. The conditions are: ability to self-organize, ability to buffer disturbance and capacity for learning and adapting (FAO, 2010).

-For FAO, "resilience to shocks" is the ability to prevent and mitigate disasters and crises as well as to anticipate, absorb, accommodate or recover and adapt from them in a timely, efficient and sustainable manner. This includes protecting, restoring and improving livelihoods systems in the face of threats that impact agriculture, food and nutrition (and related public health) (FAO 2012).

Individual Resilience: a person's capacity to cope with changes and challenges and to 'bounce back' during difficult times.

General Resilience: refers to resilience of any and/or all parts of a system to all kinds of shocks and stresses (Folke et. al. 2010).

Livelihood: a means of keeping one alive. The meaning of the word also changed to mean support for a person's life. That naturally came to mean your job, which provides the monetary support to keep you going.

-Livelihood is the job or other source of income that gives you the money to buy the things you needs (British English).

-The definition of livelihood is the way you make your living and pay for the basic things you need in life. It is a way of earning money in order to live. It is the means of living, especially of earning enough money to feed oneself etc. In other word livelihood means of support or subsistence. A means of supporting one's existence, especially financially or vocationally; living: to earn a livelihood as a tenant household. The quality or state of being lively. Livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living (Carpenter et. al., 2012).

Livelihood Resilience- is capacity to build sustainable livelihoods and increasing their vulnerability and understanding the resilience of livelihood systems of the poor. Livelihoods are increasingly caught between major global transitions in both climate and social systems. The impact of dangerous climate change falls disproportionately on the livelihood systems of the poorest citizens, undermining their capacity to build sustainable livelihoods and increasing their vulnerability. Understanding the resilience of livelihood systems of the poor (through research) and enhancing them (through transformational action) must now be seen as a normative priority (Carpenter et. al., 2006).

Vulnerability – The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC TAR, 2001 b).

-Vulnerability is the extent to which a natural system or human society is unable to cope with the negative impacts of climate change, variability and extremes. It depends on changes in climate as well as the sensitivity and adaptive capacity of the system or society (Australian Greenhouse Office. 2003).

Climate Change – Refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC TAR, 2001 a).

– Refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land-use (IPCC TAR, 2001 b).

- A change of climate is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is added in addition to natural climate variability observed over comparable time periods. See also climate variability (UNFCCC, 1992).

Climate resilience: is the resilience of a system or part of a system to climate-related shocks and stresses. It is the ability to survive, recover from, and even thrive in changing climatic conditions (FAO 2012).

Climate Risk: The term 'risk' is often used in the context of climate change.

Risk is the probability that a situation will produce harm under specified conditions. It is a combination of two factors: the probability that an adverse event will occur; and the consequences of the adverse event. Risk encompasses impacts on human and natural systems, and arises from exposure and hazard. Hazard is determined by whether a particular situation or event has the potential to cause harmful effects (Australian Greenhouse Office. 2003).

-Climate risk is the result of interaction of physically defined hazards with the properties of the exposed systems – i.e., their sensitivity or (social) vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences – i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP, 2011).

Risk management: The implementation of strategies to avoid unacceptable consequences. In the context of climate change adaptation and mitigation are the two broad categories of action that might be taken to avoid unacceptable consequences (Australian Greenhouse Office. 2003).

CHAPT ER 2

LITERATURE REVIEW

This chapter deals with the review of past researches related to this investigation. The reviews are conveniently presented based on the objectives of the study. In spite of sincere effort adequate numbers of direct related literatures were not readily available for this study. However, the literatures of available studies have been briefly discussed in this chapter.

2.1 General Discussion on Resilience

The term ‘resilience’ is used widely in a variety of contexts, and its definition varies significantly. One context that is particularly relevant to the area of climate change adaptation is ecology, in which resilience refers to the ability of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes (Adger, 2006).

The concept of resilience has been applied to ‘social-ecological systems’, a term that recognizes the interdependence of human societies and ecological and other ‘natural’ systems. In this context, resilience has been described as referring to “the magnitude of the disturbance that can be absorbed before a system changes to a radically different state as well as the capacity to self-organise and the capacity for adaptation to emerging circumstances” (Adger, 2011).

Resilience thus refers to the ability of a natural, social, or coupled social-ecological system to withstand shocks and rebuild itself when necessary. However, building resilience in the context of development and poverty reduction requires more than simply enabling a social or socio-ecological system to revert to its previous state once a disturbance or shock has occurred. Development, adaptation, and resilience-building interventions, particularly those undertaken in the context of poverty or extreme poverty, seek to improve human well-being. In such contexts, interventions to build resilience should enable people not only to ‘bounce back’ aftershocks, but to improve their circumstances despite the occurrence of shocks. More generally, interventions to build resilience must recognise that socio-ecological systems are not static, but change and evolve even in the absence of stresses such as those associated with climate

change. Climate change further complicates this situation by necessitating adaptation that might involve the modification of existing systems, processes and behaviours, or their replacement with new ones that are better suited to changed conditions (Adger, 2011).

DFID uses a working definition of resilience as:
"The ability of countries, governments, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses, while continuing to develop and without compromising their long-term prospects" (DFID, 2006).

This definition acknowledges the need for development to have a transformative impact on people's lives, as well as enabling them to cope with stresses and shocks associated with climate variability and change, as well as other, non-climate related factors. The concept of resilience is closely related to that of vulnerability, which is related to the susceptibility of people or systems to harm when they are exposed to a disturbance or shock such as climate hazard. To a certain extent resilience may be viewed as the inverse of vulnerability. In the context of climate variability and change, resilience will depend on the capacity of people and systems to anticipate, plan for, cope with, recover from, and adapt to evolving climate hazards and their primary effects (e.g. on environmental systems and natural resources) (DFID, 2006).

Vulnerability, resilience can be specified as "resilience of what to what" (Carpenter *et al.*, 2001). However, focusing on specified resilience may cause the system to lose resilience in other ways (Cifdaloz *et al*., 2010). This is why general resilience can be described as being "about coping with uncertainty in all ways" (Folke *et al*., 2010).

As for vulnerability, resilience can be considered in various dimensions – biophysical, economic and social and at various scales. And as for vulnerability, the way the various dimensions and scales interact is crucial, precisely because of the importance of general resilience to cope with uncertainty. For instance, Karfakis *et al*. (2011) shows that increasing the level of education of households can be an efficient mean for reducing households' households' vulnerability to climate change.

2.2 Resilience of what to what?

Resilience of what?

It refers to the systems (human populations or social groups, communities, households, countries, institutions, regions, ecosystems, infrastructure, etc.) or process (governance, the delivery of services) whose resilience is being examined (DFID, 2006).

The desktop study assesses the ability of the lowland rice agro ecosystem of the Central Plain to continue to contribute to future human wellbeing by providing for their food, water, income and quality of life needs despite economic and environmental shocks and trends. The case study is human-centered – the consequences of rice production are judged only in terms of their direct or indirect impacts on human values. Indirect impacts result from loss of ecosystem functions, such as unintended eradication by pesticides of predators that could control crop pests. Values include use and non-use values. Some use values such as marketed rice or fish are monetary, others are not – rice eaten by farming households or fish caught in paddies for direct household consumption, for example. Non-use values include the intrinsic and existence values of ecosystems and their biota, such as the rich birdlife, and the unquantifiable values of the options that the system retains for potential use if the system transforms, such as land, water and biotic resources that could be put to other uses (World Bank, 2013).

Resilience to what?

It is of a shock or stress (Disturbances) to which the system or process of interest is exposed. Disturbances can take many forms, and may be climatic, environmental, social, political, or economic in nature. In terms of climate variability and change, these disturbances will take the form of climate hazards and related phenomena (DFID, 2006).

The South East Asian Region's climate is changing as greenhouse gas emissions increase (World Bank, 2013). Average South-East Asian summer temperature is projected to rise at a rate that depends on the success or otherwise of attempts to reduce global emissions. The frequency of extreme heat events is projected to increase. Bangladesh has been identified among the countries where temperature rise is expected to constrain rice production, because the dry season temperatures are already at the upper threshold of tolerance for current rice varieties. Trends in

precipitation are unclear - predictions of whether annual averages will increase or decrease depend on which model is used (World Bank, 2013). The models generally agree, however, that the magnitude and frequency of extreme rainfall events will rise, perhaps contributing up to half of annual rainfall variability, even as the duration of dry periods increases. Potential impacts on rice production are flood damage to crops and infrastructure, and further yield reduction because drought is thought to enhance temperature sensitivity (Wassmann et al., 2009).

The focus of the study is on the resilience of the agro ecosystems' capacity to meet the health, wellbeing and livelihood needs of the populations dependent on them, now and into the future. When considering what these systems will need to be resilient to, there are several drivers and pressures contributing to both internal and external stresses and disturbances. Broadly, these include population demographics, climate variability (which results in climate shocks), climate change (a trend in both average levels of rainfall and temperature and in the pattern of climate shocks), ecological constraints, health, governance (especially regarding access to resources) and social-economic conditions (World Bank, 2013).

Figure-2.1: Severe flooding hampering households' livelihood in Gaibandha district

Figure-2.2: River erosion destroying habitat in Lalmonirhat district

2.3 DFID Resilience Framework

Elements of resilience

DFID has described resilience in terms of four elements:

1. Context
2. Disturbance
3. Capacity to deal with disturbance
4. Reaction to disturbance

Element 1: Context, which refers to the system or process whose resilience is being examined (i.e. 'resilience of what?'). Systems might include human populations or social groups, communities, households (and indeed individuals), countries, institutions, regions, ecosystems, infrastructure, etc. Processes might relate to governance or the delivery of services.

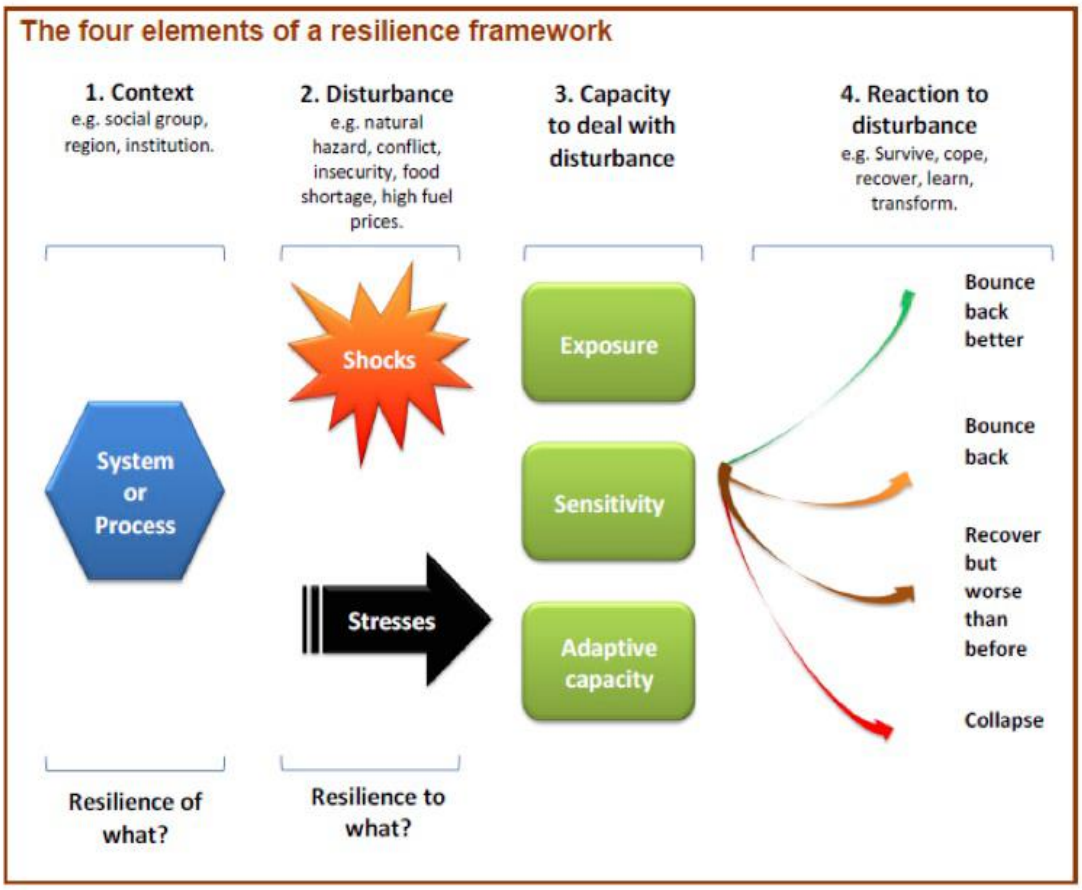


Figure-2.3: The four elements of resilience framework (DFID, 2011)

Element 2: Disturbance, in the form of a shock or stress to which the system or process of interest is exposed (i.e. 'resilience to what?'). Disturbances can take many forms, and may be climatic, environmental, social, political, or economic in nature. In terms of climate variability and change, these disturbances will take the form of climate hazards and related phenomena.

Element 3: Capacity to deal with disturbance, which depends on the degree to which the system or process in question is exposed to the disturbance, the sensitivity of the system or process to the disturbance, and the capacity of the system or process to adapt to changes associated with the disturbance. These dimensions describe sets of characteristics of a system or process that make it more or less likely to experience harm when exposed to a disturbance.

Element 4: Reaction to disturbance, in terms of whether the system or process continues to function as it did prior to the disturbance (bounce back), better than it did prior to the disturbance (bounce back better), worse than it did prior to the disturbance

(recover but worse than before, or not at all (collapse). A resilient system will bounce back or recover so that it functions in a way that is similar to or more efficient than the way it functioned before the disturbance, a non-resilient system will collapse or have its functioning significantly impaired as a result of the disturbance. Where recovery is only partial, collapse might occur after successive shocks, with the system or process becoming less resilient after each shock.

2.4 Resilience to Climate Change

FAO (2010) described that climate change is already contributing to physical transformations and threatening habitability in low latitudes and low lying coastal areas. Such impacts are a pressing concern given the scale and speed of global environmental changes, potential anthropogenic climate change in excess of 4°C, and their likely interaction to generate novel hazards. Livelihoods resilience challenges normative assumptions around resilience, allowing us to focus less on recovery from shocks and more on aspects of social transformation. This means asking difficult questions of adaptation strategies that may interpret resilience as a move to low-risk, low return activities that may in turn close potential pathways to commercialization, diversification and poverty reduction. It also challenges mainstream views of resilience that privilege the persistence of a system over its transformation and the reassembly of the same societal conditions which contributed to the original disruption. Resilience accepts that radically different livelihood strategies may be necessary and significant trade-offs may be involved. Adaptation can then be seen as a process of triage involving the things society values least, with adaptive responses equated to the relinquishing of certain values, development goals and even acceptance of conditions of poverty. Forms of adaptation that impoverish people build very powerful systems of negative resilience. In this way, adaptation is recast as a contested transformation, for example from traditional modes of agriculture to more precarious urban waged employment. Broader collectively held assumptions might also be challenged, such as those privileging economic production over other public and private goods, or placing economic profitability over ecological integrity.

2.4.1 The Resilience Perspective

Bahadur et.al.(2013) described that resilience is applied very differently in various disciplines. From a climate change perspective, an integrated social-ecological

understanding of resilience is most appropriate. Following this line of thought, our environment is constituted by social-ecological systems (SES), which encompass five main dimensions: a social, ecological, economic, physical and institutional dimension. The concept of resilience considers systems on various levels (e.g. households, communities, countries) as well as the interdependencies between these systems. Moreover, it regards risk, uncertainty and change as normal features of every SES.

In the broadest sense, resilience can be understood as the ability of a SES to deal with shocks and stresses. This ability depends on the capacities to absorb, adapt to and transform in the face of stressors threatening the system. Hence, it does not only include the responsive capacity to already known threats but also considers innovation, learning and anticipation to be prepared for projected impacts of a changing climate. Resilience possesses major commonalities with the concept of vulnerability. However, there is no consensus yet on the exact relationship between the two terms Resilience and vulnerability**.** Due to the multitude of definitions of both resilience and vulnerability, their mutual relationship is highly debated. A practical approach is to understand resilience and vulnerability as two distinct but overlapping concepts with a negative correlation. This means that systems with high resilience usually exhibit low vulnerability and vice versa (GIZ, 2015).

Although often used in the context of adaptation, the resilience perspective is not confined to the impacts of climate change. To the contrary, it considers a broad variety of disturbances (e.g. political or economic crises, violent conflicts, geophysical extreme events) as well as their effects on SES. 'Climate resilience' is thus a specific form of resilience, namely the ability to deal with climatic shocks and stresses.

2.4.2 Key characteristics of a climate-resilient system

Although many scientists and development practitioners have tried to answer this question, it is still highly debated which characteristics mainly determine whether a SES is climate-resilient or not. In addition, systems on different levels (e.g. fishermen's village vs. entire coastal region) also need different characteristics to be climate-resilient (Mitchell, 2013). Hence, a generic set of key characteristics cannot focus on one level only (e.g. community level) but needs to be applicable to SES on different levels.

Based on a review of numerous resilience concepts, Bahadur et al. (2013) synthesised a set of ten general characteristics of a resilient system. For the approach presented in this discussion paper, certain aspects of this set were revised and simplified, and it was combined with the results from a participatory process to develop a resilience framework in Vanuatu (VCAN, 2013). The resulting eight key characteristics of climate-resilient SES are as follows:

Satisfied basic needs: The population's basic needs such as shelter, sanitation, food, clean water or health care are satisfied.

High level of diversity: Different and partly interrelated forms of diversity exist within the SES such as biological and ecosystem diversity, livelihood diversity and a diverse natural resource base (GIZ, 2015).

Effective governance and institutions: Decentralised, flexible and inclusive organisational structures and policies are in place, which take into account the needs of the whole population including all minority groups (GIZ, 2015).

Equitably distributed financial assets: Financial assets as prerequisites for several strategies is to deal with adverse shocks and stresses are available and equitably distributed within the SES (GIZ, 2015).

Strong and inclusive social capital: A high amount of social capital based on mutual trust, norms and social networks exists, which facilitates strong cohesion and cooperation, emergency-support and consensus-building among all actors in the SES (GIZ, 2015).

Continuous social learning: Both individuals and organisations adopt a forward-looking perspective and engage in a continuous process of social learning to be able to anticipate future challenges and act accordingly (GIZ, 2015).

Preparedness for risk, uncertainty and change: The population accepts risk, uncertainty and change as regular elements of their daily lives, acknowledges the need for flexibility in this context, and actively plans for them instead of trying to return to a 'normal' situation GIZ, 2015).

Participation and access to relevant knowledge: The actions within the SES to deal with shocks and stresses exhibit a high degree of participation and ownership and are based on both traditional and scientific knowledge, which is made widely available to the public (GIZ, 2015).

2.5 Building Resilience

Gitz and Meybeck, (2012).To a great extent, increasing resilience can be achieved by reducing vulnerabilities and increasing adaptive capacity. This can be achieved by reducing exposure, reducing sensitivity and increasing adaptive capacity, for every type of risk. It can act in each domain, biophysical, economic and social. One way to achieve better resilience is to reduce transmission of shocks between types of risks, between scales and between domains and to organize compensation between scales (for instance transport of feed) or between domains (for instance safety nets) to avoid cumulative and long-term effects.

In this section we make an attempt to describe the bricks that can be used to build strategies for resilience (Gitz and Meybeck, 2012).

2.5.1 Three ways to build resilience

GIZ, (2015) identifies the following three ways to build resilience:

1. **Reduce exposure**. There is a fundamental difference between climatic and non-climatic shocks in this regard because most of the shocks on-farm can be reduced at the source, or limited in their extension, contrary to climatic shocks. Here the best example is probably the eradication of rinderpest, which has totally suppressed a major risk for livestock and those depending on it.
2. **Reduce the sensitivity of systems to shocks**. Sensitivity to drought can, for instance, be reduced by using flood-resistant varieties or keeping stocks of hay.
3. **Increase adaptive capacity**. This includes considering the modifications of a system taking into account all the potential shocks and changes altogether (to take into account compensating, cumulative or exacerbating effects).

Figure-2.4: Floating vegetable cultivation as a pragmatic strategy of livelihood in the study area

But all of this is not enough. To ensure resilience, the three ways of actions above have to be considered through time, and given uncertainties.

2.5.2 Building resilience through time

First, there is the need to build adaptive capacity not only to existing risks and shocks (coping capacity), but also to changes, in an evolving context (Fellmann, 2012).

Second, there is the need to consider that strengthening resilience, in real life, has to be done at the same time as the shock occurs, since they occur all the time. This

is where people can separate between ex-ante, during shock, and ex-post actions to build resilience:

1. **Before the shock**, by increasing, ex ante, the resilience of productive or livelihood systems to existing or emerging risks: for example, through putting in place systems for the early detection of emerging risks, or through the reduction or elimination of a specific risk.
2. **During the shock**, ensuring that affected agents (households, communities, small-scale food processors, and poor consumers) can benefit from continuing access to food and adequate diets, and keep their asset levels and means of livelihood, including by safety nets.
3. **After the shock**, helping systems to recover and build adaptive capacity. Actions can be pursued that progressively reduce the effect of the previous shock, reduce the exposure and sensitivity to future ones, and/or that increase the adaptive capacity of a system to future shocks in a changing context (adaptive capacity to changes). Restoration measures such as grassland restoration measures are a good example of this.

2.6 Why Livelihood Resilience against Climate Change (flood)?

Livelihood Resilience against Climate Change for the followings-

1. **Challenges** of resilience for adaptation
2. Livelihood resilience for **research and practice**
3. Livelihood resilience for **adaptation** futures

2.7 Key Challenges for Resilience

Applying the concept of resilience to climate change adaptation raises some complex challenges. Climate change is not exclusively an environmental problem that can be addressed purely in scientific, managerial or technical ways. Climate change is also crucially a conundrum of justice, with unequal contributions to the problem globally, disproportionate impacts upon poorer citizens, minority groups and future generations, and asymmetries in decision making power to determine appropriate responses (DFID, 2011).

The concept of resilience requires strengthening in three main ways.

First, people need to recognize its contested nature. When considering resilience as an 'end', it cannot be assumed that there is consensus around the nature of 'desired states'. Resilience is contingent on social values regarding what people deem important and how people ought to allocate resources to foster it. People may be perpetually locked into resilient but undesirable states of poverty and marginality. Instead, people need to ask 'resilience of what type, and for whom?' and ask who decides, on the basis of what value systems?

Second, people need to understand how values and ideologies translate into activities and institutions that characterize the political economy of climate change resilience. For example, resilience studies concerned with ecosystem services for human well-being need to focus more on whose needs are being met, on the politics of ecosystem management and distribution of benefits. This enables us to engage directly with power relations, differentiated access to resources, and issues of inequality that might otherwise be lost in resilience approaches. In particular, there are trade-offs in which the resilience of some peoples' livelihoods may result in the enhanced vulnerability of others' (for example, through downstream impacts of flood protection measures). These questions help to bring normative issues to the fore, and emphasize the distributional and political dimensions of the response options available to different actors.

Third, the (eco) systems focus of resilience thinking may lose sight of the people within those systems and their perspectives and differentiated vulnerability. Insights from sustainable livelihoods approaches and disaster prevention in particular have shown how vulnerability and impacts are contingent on place-based social and political-economic circumstances as well as on macro-level policies that drive wider ecological changes. The capacity to respond to shocks and stresses is determined by levels of on-the-ground social inequality, unequal access to resources, poverty, poor infrastructure, lack of representation, and inadequate systems of social security, early warning, and planning. These factors translate climate vagaries into disproportionate concentrations of suffering and loss.

2.8 Consequences of climate resilient livelihood and agricultural production in Bangladesh (OECD 2009)

1. Livelihoods-related project activities sustainable and resilient to climate change.
2. Project activities support diversification of livelihoods by target groups, particularly diversification to non-agricultural activities or more climate-resilient agricultural practices.
3. Project activities include facilitating access to climate information for risk analysis and planning.
4. Project activities facilitate efficient use of available resources, access to services, such as financial services or extension services which support adaptation.
5. The project aim to influence local plans and policies to support climate-resilient livelihoods strategies.
6. The agricultural practices promoted sustainable in the context of climate change.
7. The project support integration of adaptation into planning for land use management.
8. Project activities build capacity of stakeholders to access and use weather and climate information for agricultural planning and risk management.
9. The project will develop local capacity on longer-term adaptation beyond immediate coping mechanisms.
10. The project incorporates diversification to off-farm livelihoods strategies that may be less sensitive to climate hazards.

2.9 Indicators Selection

A set of indicators of livelihood resilience were selected based on literature (Pretty, 2008; Putnam, 1993; Roy *et.al*. 2015; FAO, 2010; Islam and Rahman, 2012; Rasul and Thapa, 2004).

2.9.1 Human capital

FAO (2013) described that Human capital is an essential constituent of social sustainability, which means the total capability residing within an individual, based on

his or her stock of knowledge, skills, experience, health and nutrition. Human capital is crucial for several reasons, mainly; it develops an educated and skilled generation of growers with up-to-date knowledge, technical skill, innovation and sound understanding of agricultural problems so that they can interact with innovative farming approaches and modern technologies to cope with agrarian risks, achieving food, fuel, environmental security and better livelihoods. Grower's human capital can be improved by increasing access to education, training programmes and services such as households' field schools, IPM club and extension activities. It was observed that household's human capital like leadership, motivational and organizational skills were significant to make resources available, accessible and valuable.

Mac Gillivary (2004) conducted that human capital is an essential constituent of social emerging problem. By building capacity it is easier to sustainability, which means the total capability residing reach to root of the problem and every single household can within an individual, based on his or her stock of play a significant role as a grower, leader as well as a knowledge, skills, experience, health and nutrition practitioner.

Nelson (2013) expressed that institutional, market and society's human capital are crucial for several reasons, mainly; it capacity development can act as a catalyst for managing develops an educated and skilled generation of growers and promoting individual and social wellbeing with up-to-date knowledge, technical skill and innovation.

2.9.2 Social Capital

FAO (2013) described that social capital is a fundamental ingredient for sustainable community. Its key elements are mutual interest, collaborations and partnerships embedded shared purposes, develop and nurture relationships and reciprocity through trust. It consists of two complementary components: structural (organizational networks) and cognitive (norms, values, attitudes and beliefs that emerge from community gathering) social capital. Mac Gillivary states that social capital is "creative trust and represents the stock of networks, stakeholder relationships and shared rules that help organizations and their surrounding communities work more effectively." Discussion with households revealed that social capital enhanced grower's physical and human capital substantially.

Trewevas (2002) conducted that social capital is a fundamental livelihoods. Grower's human capital can be improved by ingredient for sustainable community. Its key elements are increasing access to education, training programs and mutual interest, collaborations and partnerships, services such as households' field schools, IPM club and embedded shared purposes, develop and nurture extension activities. Tibbs (2011) said that it was observed that household's human relationships and reciprocity through trust.

UNDP (2011) observed that it consists of capital like leadership, motivational and organizational of two complementary components: structural skills were significant to make resources available, (organizational networks) and cognitive (norms, values, accessible and valuable.so the person who bears more social capital will be more knowledgable about resilient.

2.9.3 Access to ICTs

GIZ (2015) defined ICTs as technologies that facilitate communication and the processing and transferring of information by electronic means to those that need them. This definition encompasses the full range of ICTs from Radio, and Television to Telephone (Fixed and Mobile), Computers and the Internet. It can be said that if information on improved farming systems are made available for the womenfolk with effective communication system, their productivity in agriculture will fully be enhanced and the cumulative effect will reduce or alleviate rural poverty (Islam, 2012).

2.9.4 Annual family income

Roy R. (2015) stated that annual income refers to the total annual earnings of all family members of a respondent from agriculture, livestock, fisheries and other accessible sources (business, service, daily working etc.) during a year. Income is essential component of building resilience livelihood.

2.9.5 Non-farm income generating activities

Thomas et.al.(2013) described that the rural non-farm economy (RNFE) may be defined as comprising all those activities associated with waged work or self-employment in income generating activities (including income in-kind) that are not agricultural but which generate income (including remittances etc.) rural areas. In

some contexts rural non-farm activities are also important sources of local economic growth (e.g. tourism, mining, timber processing etc.). The promotion of diversification of activities may be an important component of poverty alleviation in rural areas. The rural non-farm economy is of great importance to the rural economy for its productive and employment effects, while the income it provides to rural households represents a substantial and growing share of rural incomes. Often this share is particularly high for the rural poor. There is evidence that these contributions are becoming increasingly significant for food security, poverty alleviation and farm sector competitiveness and productivity. In the light of increasing donor and developing country interest in the sharing of good practice for methodological approaches in analysis, policy intervention and support to the rural non-farm economy, people consider it timely to draw out the key emerging lessons from international experience to date. These have, where appropriate, been set in the context of current thinking on the topic and aim to add value to the debate through drawing on evidenced based work, new empirical data and consensus based dialogue.

Trewevas (2002) cited that non-farm income generation can help to overcome food insecurity when economic factors are a fundamental cause of food insecurity and when food is available in local markets but lack of money is the main difficulty faced by the vulnerable population.

Mac Gillivary (2004) conducted that the main thrust of the women's development activities would be to assist women in the sustainable establishment of income generating activities to be undertaken in or near the home. In some pilot villages this could be also one of the main objectives of the self-help female groups formed with the support of the Project through its reinforcement of group promotion activities.

Leeuwis (2004) expressed that it is essential to guarantee that women will have the control of the funds (saving funds, loans etc.) and the free disposal of them to implement IGAs. During the feasibility study project staff should be very careful on not raised expectations.

2.9.6 Land productivity

FAO (2010) stated that Agricultural land productivity is measured as the ratio of agricultural outputs to agricultural inputs. While individual products are usually

measured by weight, their varying densities make measuring overall agricultural output difficult. Therefore, output is usually measured as the market value of final output, which excludes intermediate products such as corn feed used in the meat industry. This output value may be compared to many different types of inputs such as labor and land. These are called partial measures of productivity. Agricultural productivity may also be measured by what is termed total factor productivity. This method of calculating agricultural productivity compares an index of agricultural inputs to an index of outputs. This measure of agricultural productivity was established to remedy the shortcomings of the partial measures of productivity; notably that it is often hard to identify the factors cause them to change. Changes in TFP are usually attributed to technological improvements. Increase in agricultural productivity is often linked with questions about sustainability and resilience livelihood. Changes in agricultural practices necessarily bring changes in demands on resources. This means that as regions implement measures to increase the productivity of their farm land, they must also find ways to ensure that future generations will also have the resources they will need to live and thrive.

2.9.7 Climate Smart Agriculture

FAO (2013) stated that Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible. CSA is an approach for developing agricultural strategies to secure sustainable food security under climate change. CSA provides the means to help stakeholders from local to national and international levels identify agricultural strategies suitable to their local conditions.

CSA is one of the 11 Corporate Areas for Resource Mobilization under the FAO's Strategic Objectives. It is in line with FAO's vision for Sustainable Food and Agriculture and supports FAO's goal to make agriculture, forestry and fisheries more productive and more sustainable". Transformations are needed in both commercial and subsistence agricultural systems, but with significant differences in priorities and capacity. In commercial systems, increasing efficiency and reducing emissions, as

well as other negative environmental impacts, are key concerns. In agriculture-based countries, where agriculture is critical for economic development (World Bank, 2008), transforming smallholder systems is not only important for food security but also for poverty reduction, as well as for aggregate growth and structural change. In the latter group of countries, increasing productivity to achieve food security is clearly a priority, which is projected to entail a significant increase in emissions from the agricultural sector in developing countries (IPCC, 2012). Achieving the needed levels of growth, but on a lower emissions trajectory will require a concerted effort to maximize synergies and minimize tradeoffs between productivity and mitigation. Ensuring that institutions and incentives are in place to achieve climate-smart transitions, as well as adequate financial resources, is thus essential to meeting these challenges. In this context mitigation finance can play a key function in leveraging other investments to support activities that generate synergies.

2.9.8 Functional and response diversity

Functional group composition and dynamics (functional redundancy), together with responsiveness to ecological change (response diversity), is fundamental to ecological functional integrity.

Holling (1996) deems that the control of ecosystem function is critical to an ecosystem's resilience when contending with change. As a determinant of ecological-resilience, functional response is based on the concept of functional groupings, which provide for a certain specific function, for example predators acting as consumers, their function being consumption (Elmqvis et.al. 2003). The responses to this exemplar of a specified ecological function encompass an array of predators, ranging from lions to large birds of prey, i.e. across scales. Response diversity is categorised "as the range of reactions to environmental change among species of the same function, which is critical to resilience, particularly during periods of ecosystem reorganisation" (Elmqvist, et.al. 2003).

Walker (2004) content that the more functionally similar species works within a functional group exits the "greater resilience in responding to environmental change, if those species differ in environmental responses".

Moreover, this can be considered functional redundancy, where in the reaction to a function fill ecological functional gaps (niches), occurring if other species are eliminated or their respective functional characteristics become suppressed.

2.9.9 Crop Diversity

GIZ (2015) stated that crop diversification is the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value-added crops with complementary marketing opportunities. Cropping system where a number of different crops are planted in the same general area and may be rotated from field to field, year after year. Among the agrarian societies in the world, Bangladesh stands between fourth and sixth positions in terms of her agricultural population. The livelihood of more than 62% of the rural population depends in one way or the other on agriculture, but it produces only about 22% of the Gross Domestic Product (GDP). The high population growth resulted in an increasing pressure on scarce land. The per capita land holding decreased from 0.42 acres in 1961 to 0.30 acres in 1971 and then to 0.17 acres in 2005.

Crop diversification through expansion of irrigation facilities, spread of modern technology and expansion of other support services is important for increasing agricultural production and for meeting the ever-changing demand of growing population (FAO, 2010).

More recently, crop sub-sector is gradually gaining importance, and it is now more diversified than in the last two decades due to the introduction of improved seed–fertilizer–irrigation technology.

2.9.10 Access to financial institution

FAO (2013) stated that access to financial institution is the ability of individuals or enterprises to obtain financial services, including credit, deposit, payment, insurance, and other risk management services. Accumulated evidence has shown that financial access promotes growth for enterprises through the provision of credit to both new and existing businesses. It benefits the economy in general by accelerating economic growth, intensifying competition, as well as boosting demand for labor. The incomes of those in the lower end of the income ladder will typically rise hence reducing

income inequality and poverty. The lack of financial access limits the range of services and credits for household and enterprises. Poor individuals and small enterprises need to rely on their personal wealth or internal resources to invest in their education and businesses, which limits their full potential and leading to the cycle of persistent inequality and diminished growth.

Ahmed (1977) study also indicated existence of a positive and significant relationship between access to finance and use of information sources in the adoption of three improved practices.

Rahman (2011) studied households' knowledge of improved practices in potato seed indicated a significant relationships between access to finance of improved practices.

Alam (1997) studied use of improved farm practices of rice cultivation by the households of Anwara thana of Chittagong district. The study indicated no significant relationships with their use of resilience in rice cultivation. He conducted a study on households' knowledge and adoption of modern sugarcane cultivation practices. He found that access to finance of the growers had significant relationships with their adoption of modern resilience in seed cultivation.

2.9.11 Infrastructure

Thomas et.al. (2013) described that infrastructure refers to the fundamental facilities and systems serving a country, city, or area, including the services and facilities necessary for its economy to function. It typically characteristics technical structures such as Established market, Deep tube well, Concrete roads, Concrete roads, School, Health center, Veterinary clinic, Input shops, Shelter house, Storage facilities, Embankment, roads, bridges, tunnels, water supply, sewers, electrical grids, telecommunications, and so forth, and can be defined as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions."

2.9.12 Market access

FAO (2013) stated that market access consists of the buying and selling ability for the households. Agreement with buyer and seller or direct involvement is in the

marketing. Market access for products stands for the totality of government-imposed conditions under which a product may enter a country under non-discriminatory conditions. It is often, but not exclusively, determined by border measures. Most Agreements have rules on market access that apply to both, agricultural products (Agreement on Agriculture) and to non-agricultural products (all other products). As you certainly imagine, there is a wide variety of measures which influence market access for products.

Islam (2012) showed that market access had the highest impact on agricultural extension engineers' knowledge and practice, followed by use of a sound filmstrip, a video film, a cassette and a pamphlet.

Bahadur et al. (2013) conducted a field study in Punjab, Pakistan, to assess the market access in the seed production by the households. The data show that majority (56.67%) of the respondents were aware of the existence system of seed processing in their area/village. None of the respondents acknowledged the seed system in the dissemination of rice crop recommendations including seed rate, seed treatments, time of sowing/transplanting, seed bed preparation, use of fertilizers, application of zinc sulfate, irrigation, weed control, application of plant protection measures and harvesting.

OECD (2009) in another study with Texas cotton seed growers, observed that 70 percent of cotton households received information about market access in cotton production from farm magazine followed by newspaper and country agricultural agent with 67 and 65 percent, respectively. These were again followed equally by radio, demonstration and field tours with 60 percent in each case. Other important sources of information used were television, friend and neighbors.

2.10 Conceptual Framework

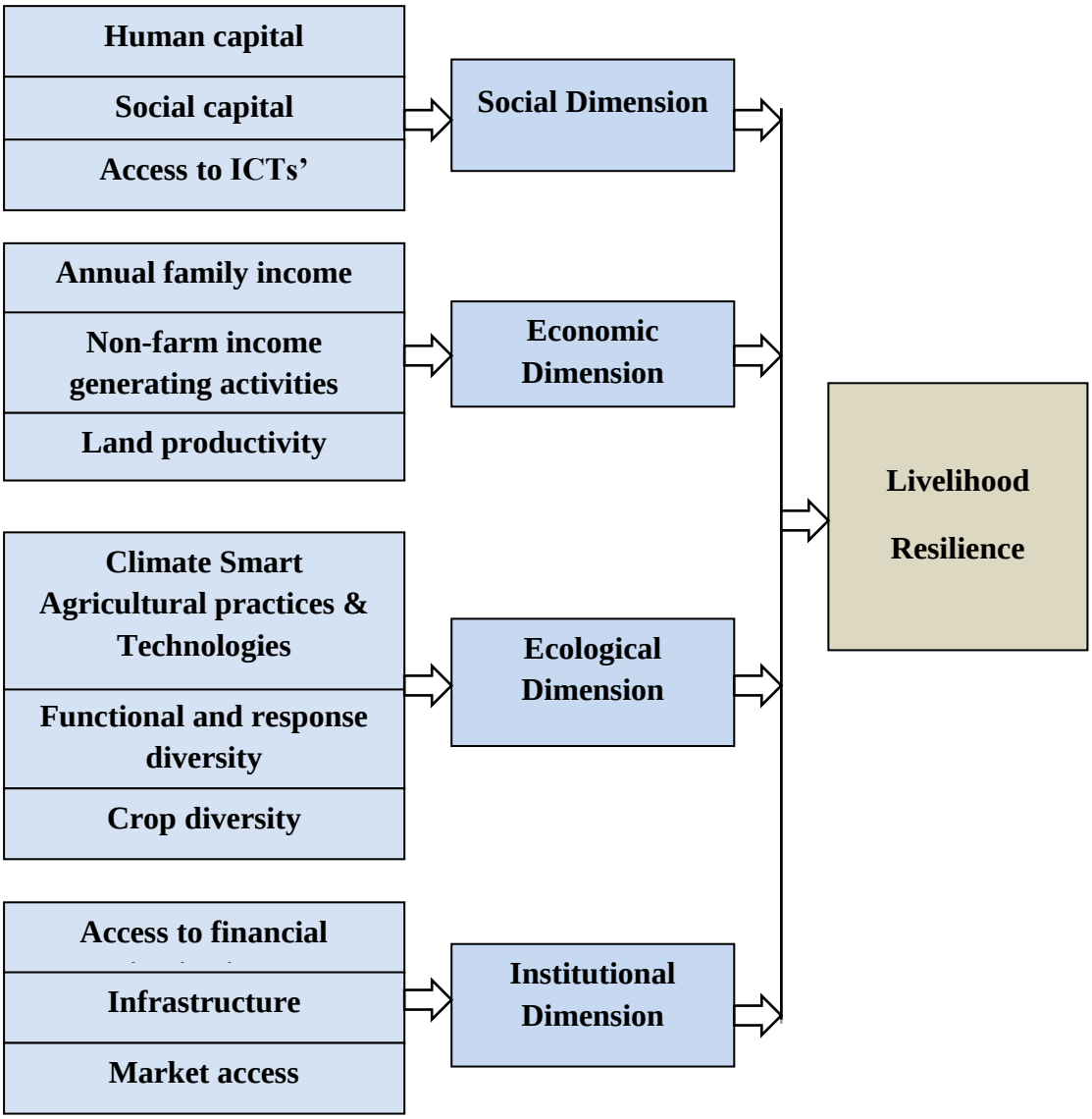


Figure-2.10: Livelihood resilience of flood affected households

CHAPTER 3

METHODOLOGY

Methodology plays an important role in a scientific research. Therefore, a researcher has to be careful in formulating methods and procedures in conducting research. Methodology should be such that enables the researcher to collect valid data and reliable information and to analyze that information to arrive at correct decision. The methods and procedures followed in this study are described in this chapter.

3.1 Locale of the Study

Two villages of Sundarganj upazila under Gaibandha district and two villages of Lalmonirhat sadar upazila under Lalmonirhat district were selected as the study area. The study area consisted of total 4 unions. Chandipur and Kapashia of sundarganj upazila were selected covering 2 villages namely Bochagari and Lalchamar respectively; Rajpur and Harati of Lalmonirhat upazila were selected covering 2 villages namely Rajpur and Hiramanik respectively of by following simple random sampling technique. These 4 villages constituted the locale of the study. The following maps showing with the research area.

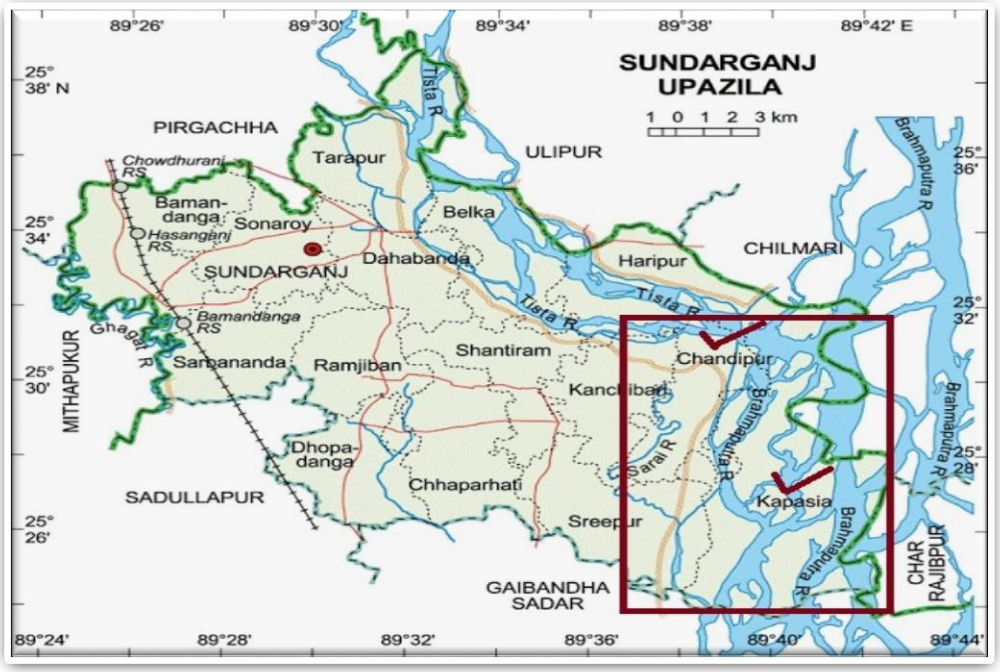


Figure 3.1: Map showing the study area of Sundarganj upazila

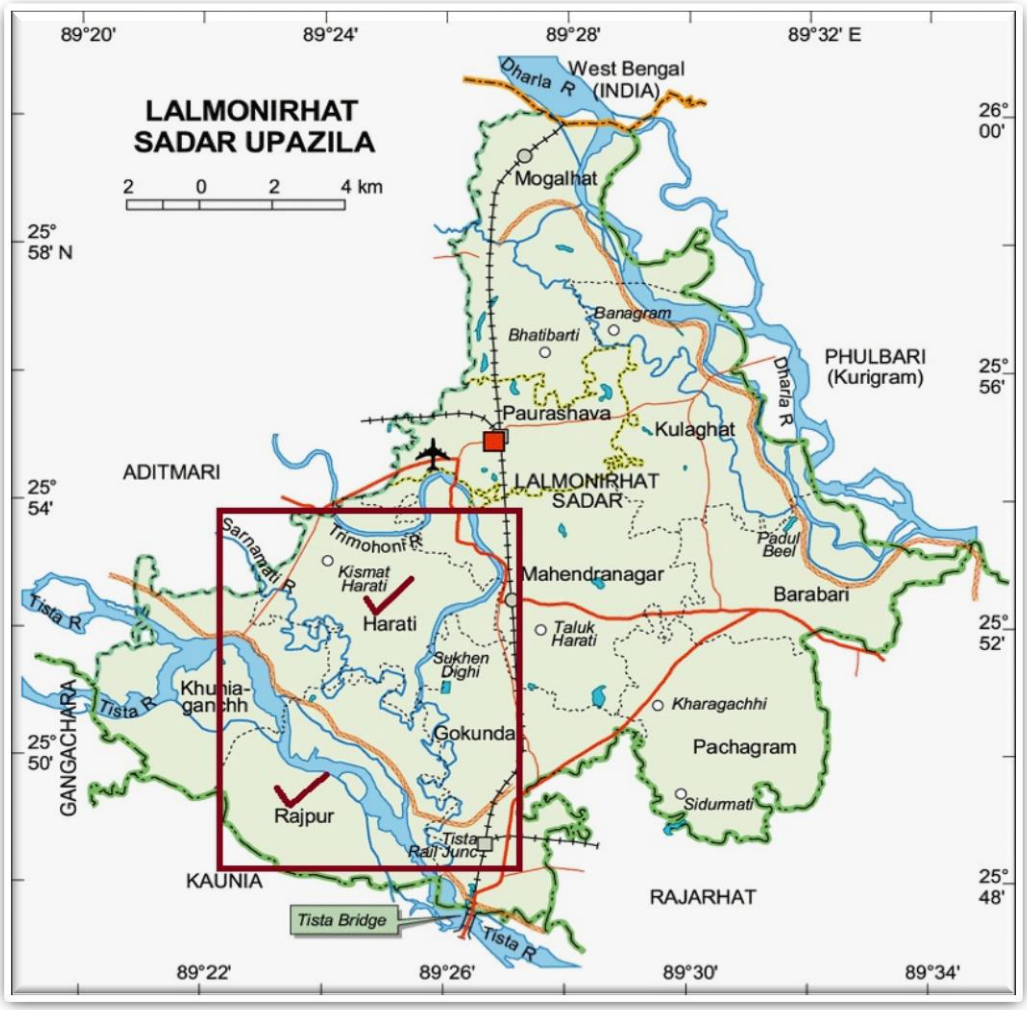


Figure 3.2: Map showing the study area of Lalmonirhat sadar upazila

3.2 Population and Sample Technique

Determination of sample size

There are several methods used for determining the sample size. Formula given by Yamane (1967) was used for the present study.

Here,

$$n = \frac{z^2 (1-P)\, N}{z^2\, P\,(1-P) + N\,(e)^2}$$

Where,

n = Sample size;

N, population size = 600;

e, The level of precision = 8%;

z = the value of the standard normal variable given the chosen confidence level (e.g., z = 1.96 with a confidence level of 95%) and

P, The proportion or degree of variability = 50%;

Here, the sample size (n) =120

The total number of farm families in the selected four villages of four unions under two districts was 600. Heads of the 600 farm families constituted the population for this study. Data were collected from the sample rather than whole population due to time and fund constraints. Therefore, 120 households were selected as the sample for this study. However, a reserve list of 10 households was also prepared. Households in the reserve list were used only when a respondent in the original list was not available. Distribution of population, sample size and reverse list are shown in Table 3.1.

Table 3.1: Distribution of Population and Samples with Reserve List

Name of the Village	Name of the Unions	Name of Upazila	Total Population	Sample Size	Reverse List
Bochagari	Chandipur	Sundargonj	400	80	8
Lalchamar	Kapashia				
Rajpur	Rajpur	Lalmonirhat Sadar	200	40	4
Hiramanik	Harati				
Total			600	120	12

3.3 Selection of indicators

According to GIZ's (German Cooperation of International Development) climate resilience assessment model the study selected 12 indicators in order to assess livelihood resilience of flood affected households. This model consists of 3 capacities and 4 dimensions. This model is presented in Figure 3.3.

Climate resilience matrix

		Capacities		
		Absorptive	Adaptive	Transformative
Dimensions	Social			
	Ecological			
	Economic			
	Institutional			

Figure 3.3: Climate resilience matrix (Source: GIZ, 2015)

Capacity:

Absorptive capacity: Ability of a system to prepare for, mitigate or recover from the impacts of negative events using predetermined coping responses in order to preserve and restore essential basic structures and functions (e.g. human life, housing, productive assets) (Béné *et al*., 2012, Cutter *et al*., 2008).

Examples: Early warning systems, savings, weather insurance schemes, trained disaster risk reduction teams, dyke systems in flood-prone areas (climate hazard-specific).

Adaptive capacity: Ability of a system to adjust, modify or change its characteristics and actions in order to better respond to existing and anticipated future climatic shocks and stresses and to take advantage of opportunities (Béné *et al*., 2012, Brooks, 2003, IPCC, 2012).

Examples: Adjusted planting behavior, climate change-related information and education events, improved natural resource management, diversification of early warning systems to reach a broader network of actors.

Transformative capacity: Ability of a system to fundamentally change its characteristics and actions when the existing conditions become untenable in the face of climatic shocks and stresses (Béné *et al*., 2012, Walker *et al*., 2004).

Examples: Livelihood transformation (e.g. from rice household to shrimp household), migration from rural to urban areas, change from fossil energy system to renewable energies.

Dimensions

It is possible to subdivide each capacity into the four dimensions that constitute a SES, namely the social, ecological, economic and institutional dimension.

Combining the three capacities with the four dimensions in a **climate resilience matrix** (Figure 3.3) represents a useful way of illustrating how multi-faceted the ability of a SES needs to be in order to deal with climatic shocks and stresses. In addition, it provides a good starting point for identifying factors contributing to the climate resilience of a system against observed and projected climate change risks and impacts.

Resilience livelihood against climate change (flood) was the main focus of the study. Effectiveness of the Resilience livelihood by increasing agricultural production and adopting capacities were also considered for the study. Reviewing related literature (e.g., Roy *et.al*, 2015; FAO, 2010; Islam and Rahman, 2012; Rasul and Thapa, 2004) 12 indicators were selected for the study.

i. Human capital
ii. Social capital
iii. Access to ICTs'
iv. Annual family income
v. Non-farm income generating activities
vi. Land productivity
vii. Climate Smart Agricultural practices & technologies
viii. Functional and response diversity
ix. Crop diversity
x. Access to financial institutions
xi. Infrastructure
xii. Market access

3.4 Measurement of Indicators

To keep the research within the manageable limit, 12 indicators were selected for the study. The measurement procedures of the selected indicators were as follows:

Human capital

Human capital comprised of knowledge, skill and capacity of households. The level of knowledge, skill and capacity about livelihood options were measured (see Appendix-B) by the following indications-

Response category	Score
Definitely	5
Probably	4
Probably not	3
Not sure	2
Definitely not	1

Total score is the measurement of human capital of a household. The scores obtained by all the items were added together to compute his human capital scores. These scores of a respondent could range from 15 to 75, where '15' indicates very low human capital and '75' indicates very high human capital.

Social capital

Social capital is measured by the two sub-sections (1) membership and frequency of contact (2) confidence of involvement benefits. As measurement of social capital membership indicate 1 point, otherwise No=0; and for number of contact weekly=3, monthly=2 and half yearly=1. And confidence of institutional benefit measurement (Appendix-B) as follows-

Response category	Score
A great deal	5
Quite a lot	4
No opinion	3
Not very much	2
Not at all	1

The scores obtained by all the items were added together to compute his social capital scores. These scores of a respondent could range from 0 to 52, where '0' indicates no social capital and '52' indicates very high social capital.

Access to ICTs'

ICTs' contact of a respondent was measured by his extent of contact for information with various media of communication (Appendix-A). Each Item indicated his extent of contact with each selected communication media by checking any one of the 3 responses namely, "Sustained access", "Intermittent access", "No access" (Appendix-B). Scores were assigned to the responses as follows:

Response category	Score
Sustained access	2
Intermittent access	1
No access	0

The scores obtained by all the 3 items were added together to compute his access to ICTs' scores. These scores of a respondent could range from 0 to 12, where '0' indicates no ICTs' access and '12' indicates very high access of ICTs'.

Annual family income

In calculating the annual income from agriculture of a respondent, income from different sources of farming were added together to obtain total annual income of a respondent. Income of a respondent was measured in term of Taka. A score of 1 was assigned for less than Tk.50, 000 income;' '2 for Tk.50,000 to Tk.1,00,000;' '3 for Tk.1,00,000 to Tk.1,50,000;' and '4 for over Tk.1,50,000' income.

Non-farm income generating activities

Non-farm income generating activities is measured as the involvement of the other non-agricultural income sources. Government job, private job, business, seasonal business, labour etc. are the non-agricultural income sources. A respondent get 1 point for each job involvement for livelihood. As 'involvement=1'; 'otherwise=0'; (Appendix-A).

Total scores range from 0 to 8 where '0' indicate no other income source and '8' indicates high income sources at all.

Land productivity

Measure of the physical yield of rice per unit area and yield data (HYV and local rice) was collected by survey (Rasul and Thapa, 2004) (Appendix-A). In the purpose of the study total yield of rice is at kilogram (kg) per decimal.

Climate Smart Agricultural practices & technologies

Climate Smart Agriculture is measured by the two sub-sections (1) practices and (2) technologies. As measurement of climate smart Agriculture of the followings (Appendix-B)-

Response category	Score
Adequately	4
Moderately	3
No opinion	2
Rarely	1
Never	0

The scores obtained by all the items were added together to compute his climate smart agriculture scores. These scores of a respondent could range from 0 to 40, where '0' indicates no climate smart agriculture and '40' indicates very high climate smart agriculture.

Functional and response diversity

As measurement of functional and response diversity, 'have=1', 'no=0'; and cultivation of each species indicate 1 point (Appendix-A). The scores obtained by all the items were added together to compute his functional and response diversity scores. These scores of a respondent could range from 0 to 13, where '0' indicates no functional and response diversity and '13' indicates very high functional and response diversity.

Crop diversity

Based on 'Velavan, C., Balaji, P. (2012)', crop diversity was measured by the following technique-

Herfindahl Index: Herfindahl index was used to study the extent of diversification in the state. Herfindahl index is defined as:

$$HI = \sum_{i=1}^{n} Pi^2$$

Pi = Proportion of area under i th crop

Pi = Ai /ΣAi

In which Ai=Area under ith crop and $\sum_{i=1}^{n}$Ai = Total cropped area

The value of HI index varies between 0 to 1. It is one in case of perfect specialization and zero in case of perfect diversification.

The study used Transformed HI=1-HI. THI score between 0 to 1, where 0 means perfect specialization and 1 refers to perfect diversification.

Access to financial institutions

Financial source of a respondent was measured by his extent of taking money from others for production (Appendix-A). Each type indicated his extent of taking money from others by checking any one of the 3 responses namely, "Sustained access", "Intermittent access", "No access". Scores were assigned to the responses as follows:

Responses category	Score
Sustained access	2
Intermittent access	1
No access	0

The scores obtained by all the 3 items were added together to compute his access to financial institutions scores. These scores of a respondent could range from 0 to 16, where '0' indicates no access to financial institutions and '16' indicates very high access of financial institutions.

Infrastructure

Infrastructure in the community of a respondent's locality was measured by the existence of buildings and access of households in this building for resilience livelihood. Each types of building indicated by the 2 responses namely, "existence=1", "otherwise=0" (Appendix-A and B).

These total scores of a respondent could range from 0 to 20, where '0' indicates no infrastructure available in their community for resilience livelihood and '20' indicates very available infrastructure in their community for resilience livelihood.

Market access

In this study market access consists of two sections (1) buying and (2) selling. Market access measures the buying and selling of their products and getting all opportunities of agricultural market is defined. One respondent get 1 point for each 'yes' answer in buying of the agricultural inputs and selling of the products for resilience livelihood. Otherwise receives 0 score. Right answer for open question gets maximum 1 score.

Total marks range from 0 to 24 where ‘0’ indicate no market access and ‘24’ indicates high market access.

3.5 Instrument for Data Collection

In order to collect relevant information from the respondents, an interview questionnaire (Appendix-A) was used. The schedule was carefully designed keeping the objectives of the study in view. The schedule contained both open and closed questions.

3.6 Preparation of the survey schedule and pre-testing

The survey schedule was carefully prepared to record the required data of various aspect of the study. In order to collect desired information, a draft survey schedule initially was carefully prepared in conformity with the objectives of the study. Then it was pre-tested in the study area among some beneficiaries of the study area. Some parts of the draft schedules were improved, rearranged and modified in the light of actual and practical experiences gathered in pre-testing and then the final schedule was developed with logical sequence so that the respondents could give the accurate information sequentially.

3.7 Collection of Data

For the present study, data collection was started in January 1, 2017 and completed within 60 days. Collection of reasonable and reliable data from the field is not an easy task. After the schedule was finalized, the researcher himself collected necessary primary data through personal interview with individual household. Before starting the interview, each responded was given a brief description about the nature and purpose of the study. Then the questions were asked in the simple manner with explanation however necessary. The information supplied by the households was recorded directly on the interview schedules. The interviewees were requested to provide correct information as far as possible.

3.8 Compilation of Data

After completion of field survey all the data of the interview schedule were compiled. Local units were converted into standard unit. Appropriate scoring technique was followed to convert the qualitative data into quantitative forms. The responses of the individual respondent contained in the interview schedules were transferred to a

master sheet for entering the data in the computer. As soon as the data entered into the computer, it was then analyzed in accordance with the objectives of the study.

3.9 Methods of Analysis

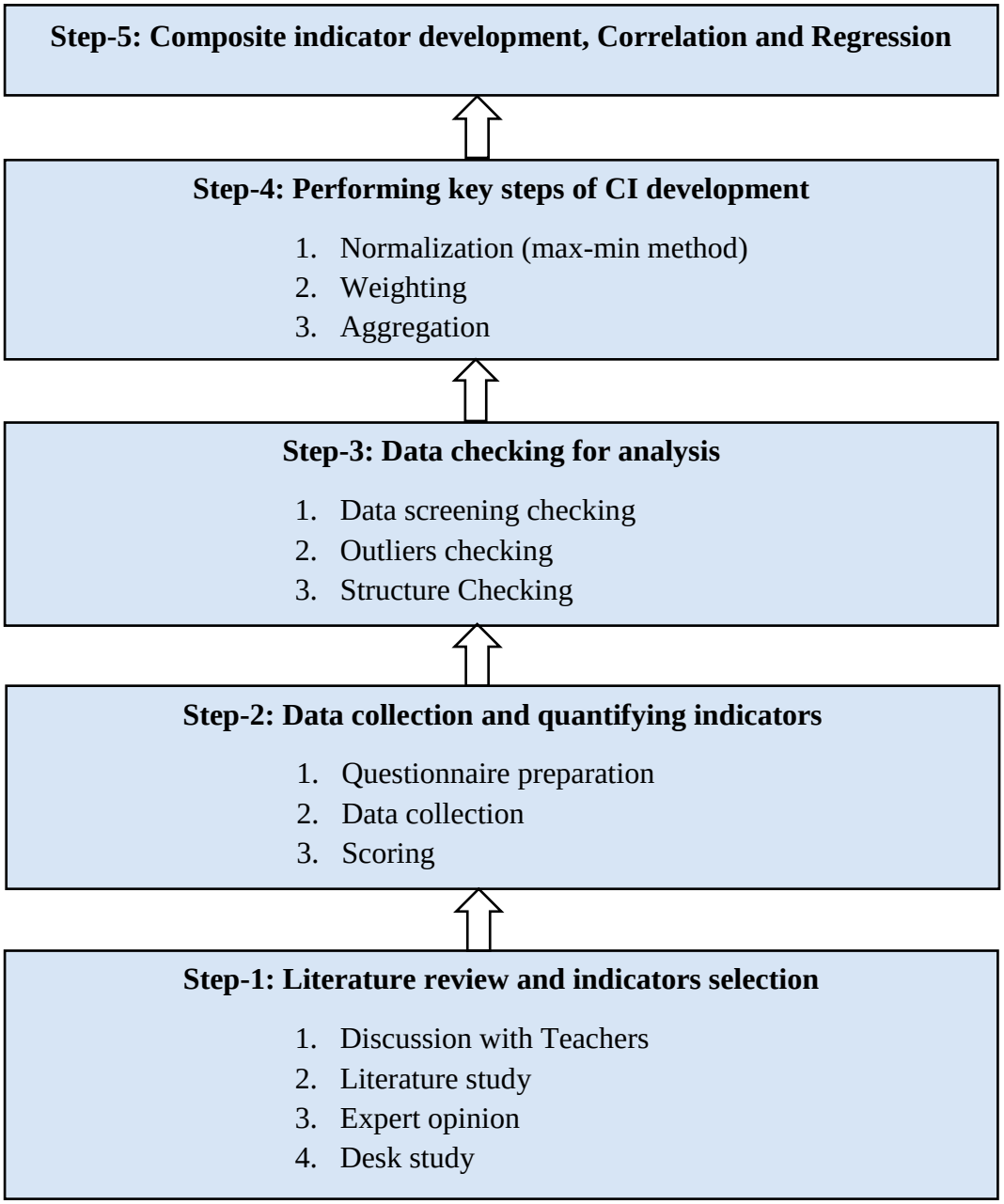
Data collected from the respondents were complied, tabulated and analyzed in accordance with the objectives of the study. Various statistical measures such as number, percentage distribution, average, and standard deviation were used in describing data. The categories and tables were used in describing data. The categories and tables were also used in presenting data for better understanding. For determining the relationship of the selected resilience indicators of the households with their use of resilience farming in increasing agricultural production, Pearson's Product Moment Coefficient of Correlation was (r) used. Five percent (0.05) level of probability was used. Data were analyzed by the software SPSS.

3.10 Development of Livelihood Resilience Index

3.10.1 Maintaining data quality

Following careful consideration, indicator values were quantified to get a data set with good quality. A good quality data is essential for constructing a meaningful and communicative CI. Adequate cares were taken for maintaining data quality, which was accomplished in two ways, namely applying data-screening tests and bivariate and multivariate analysis to examine the overall structure and suitability of the data set for subsequent methodological choices. Data screening was employed to ensure the data are useful, reliable, and valid for testing causal theory. The validity, interpretability, and explanatory power of the index largely depend on the quality of underlying data. Data screening tests such as detecting missing data, removing outliers, and identifying multicollinearity among the variables were conducted to ensure the data quality. Missing data were imputed by mean value substitution. Outlier has a strong impact on correlation structure and multivariate analysis. It needs particular care. The outliers were detected by observing z scores (>3.3) and graphing the data in a histogram. They were dealt by employing the next highest score plus one, and the mean plus two standard deviations (Field, 2009).

Conceptual framework of composite indicator development



(Adapted from Roy, 2015)

Figure-3.10: Methodology employed for the construction of the composite resilience index (CI)

Moreover, skewness and kurtosis were estimated to observe the normality of the variables, which is significant for employing regression analysis. The work of Field (2009) was followed for data-screening tests. Multicollinearity ($r > 0.80$) between the indicators creates a considerable problem such as double-counting (i.e. two or more indicators measure the same behaviour). To fix this problem two ways are suggested

in the literature: (i) to drop one of the variables from the analysis and (ii) the particular variables are simply averaged to produce a new variable (Field, 2009). Following data-screening tests, the correlation analysis was conducted to observe the interrelationships of the indicators. Correlation is a widely used statistical tool for confirming the mathematical design of index. The index is overwhelmed, confused and implicit in communicating when there is a poor interrelationship among the indicators (OECD, 2008). Correlation analysis showed that about 85% indicators had moderate to high correlation. The results also indicated that multicollinearity was not a problem among the indicators.

Multivariate analysis regression was employed to answer the two questions: (i) was the nested structure of the data set compared with the theoretical foundation well defined? and (ii) was the set of considered indicators sufficient to describe the phenomena? Moreover, this analysis helped to assess suitability of the data set and to guide subsequent methodological choices such as the weighting and aggregation.

Distribution of data:

There are two ways in which a distribution can deviate from normal:

(1) Lack of symmetry (called **skew**) and

(2) Pointiness (called **kurtosis**).

Skewed distributions are not symmetrical and instead the most frequent scores are clustered at one end of the scale.

In a normal distribution the values of skew and kurtosis are 0 (i.e. the tails of the distribution are as they should be). If a distribution has values of skew or kurtosis above or below 0 then this indicates a deviation from normal.

To check that a distribution of scores is normal, it is needed to look at the values of kurtosis and skewness. The values of skewness and kurtosis should be zero in a normal distribution. Positive values of skewness indicate a pile-up of scores on the left of the distribution, whereas negative values indicate a pile-up on the right. Positive values of kurtosis indicate a pointy and heavy-tailed distribution, whereas negative values indicate a flat and light-tailed distribution. The further the value is from zero, the more likely it is that the data are not normally distributed.

For this study the skew value is very close to zero (which is good) and kurtosis is a little negative. There is a skewness of around 1 (positive skew). So people can say about this study data set was normal which is expected (Table-4.3).

Normalisation of data

Generally, data of variables are incommensurate with each other, and has different measurement units. Therefore, normalisation is a good way to make them comparable. The method of normalisation should be determined based on data properties and the aim of the index. OECD (2008) described several normalisations methods such as ranking, max-min, etc. By considering the pros (e.g. simple) and cons (e.g. outlier) of various methods into consideration, this study used max-min normalisation methods.

$$li = \frac{x - min(x)}{max\ x - min(x)}$$

Where, *Ii* is the normalised value of the individual indicator, *x* is the raw value of individual indicator and *max (x)* and *min (x).*

Weighting

There is no consensus for the appropriate weighting method. Researchers are continuing to debate the suitable methods for weighting that reward greater weight of variables. There is a dichotomy between the participatory (subjective) and statistical (objective) method of weighting. A number of weighting methods exist. However, each method (e.g. budget allocation processes) has been reported to have limitations.

Equal weighting (EW) is the most widely used method, and has the risk of double counting (by combining variables with high degree of correlation) and ignores the statistical and empirical basis, implying a judgment on the weights being equal (Nardo et al., 2005). Babbie (1995) reported equal weighting should be the standard and the application of other weighting method desires a proper justification (Munda, 2005). From the policy perspective, public opinion-based weighting has been established. Although it is a legitimate choice, it is not unique and its arbitrary characteristic raises criticism. These methods are justifiable only when there is a well-defined basis for national policy (Munda, 2007). This study used equal weighting method.

Aggregation

Aggregation influences compensation among variables (Munda, 2008). Therefore, it is a very delicate part of the construction of an index that needs particular care. A number of aggregation methods exist, and the choice of a suitable method depends on the purpose of CI and the nature of the subject being measured. Aggregation

technique is strongly related to the method used to normalise the raw data (Nardo et al., 2005; OECD, 2008). The linear method is useful when indicators have the same measurement unit. Geometric aggregation is suitable when sub indicators are non-comparable and have strictly positive value in ratio-scale of measurement. Based on the data properties, this study used 'weighted arithmetic aggregation' to combine indicators within the dimensions with a view to minimize measurement error and capture inconsistencies.

$$CI = \frac{(I_1 * w_1 + I_2 * w_2 + \dots I_n * w_n)}{\sum_{1}^{n} w}$$

Where *CI* is the composite indicator, e.g., sensitivity, 'I' is an individual indicator of a dimension and *w* is the weight assigned to the indicator. If equal weighting applies, indicators are simply summed and divided by the number of indicators. Assigning a weight of 2 (or 3) to one or more indicators implies that these indicators are twice (or three times) more important than indicators which retain a weighting of 1.To enable meaningful aggregation of individual indicators, remember that all indicators of the three vulnerability components must be aligned in the same way. This means that a low or high score represents a 'low' or 'high' value in terms of resiliency.

CHAPTER 4

RESULTS AND DISCUSSION

Results and discussion is the focal point of the whole research work. The purpose of this chapter is to describe the findings of the present study. The quality of research exclusively depends upon how well the findings of the research are discussed and interpreted. So to make the results and discussion meaningful, acceptable and universal, the collected data were coded, categorized, tabulated, analyzed and statistically tested in accordance with the objectives of the study.

The study investigated livelihood resilience of the respondent households in the flood areas. This study explores the social capacities, ecologically balance, economic conditions and Infrastructural facilities of livelihood resilience.

In accordance with the objectives of the study, presentation of the findings has been made in four sections of this chapter.

Section 1: Selected indicators of the flood affected households

Section 2: Assessment of the effects of social, ecological, economical and infrastructural facilities of households on livelihood resilience.

Section 3: Relationship between the selected characteristics of the flood affected households and livelihood resilience

Section 4: Determination of key factors contributing livelihood resilience

4.1 Selected indicators of the households

There were various indicators of the respondent households that might have consequence on livelihood resilience of flood affected areas. But in this study, twelve characteristics of them were selected as independent variable.

In this section the selected indicators of the study such as i) Human capital ii) Social capital iii) Access to ICTs'; iv) Annual family income; v) Non-farm income generating activities; vi) Land productivity; vii) Climate Smart Agricultural practices &technologies; viii) Functional and response diversity; ix) Crop diversity; x) Access to financial institutions; xi) Infrastructure and xii) Market access have been discussed.

For categorization or frequency distribution of the indicators, descriptive statistics of the indicators was used. Based on the respondents, it was will classified into different categories by using this formula (Mean ± Standard Deviation).

The salient features of the individual indicators of the households are shown in table 4.1.

Table 4.1 Salient features of the respondent households according to selected indicators

Selected Indicators	Measuring Units	Possible Value	Observed Value		Skewness	Kurtosis
			Min	Max		
Human capital	Scores	15-75	10	68	-.214	-.015
Social capital	Scores	04-52	4	40	-.131	-.333
Access to ICTs'	Scores	0-12	0	15	-1.41	.310
Annual family income	Scores	0-04	0	6	.202	-.757
Non-farm income generating activities	Scores	0-08	0	5	-1.67	.612
Land productivity	Kilogram	-	20	55	.404	-.775
Climate Smart Agriculture	Scores	0-40	1	34	-.653	.546
Functional and response diversity	Scores	0-13	0	11	-.421	-.192
Crop diversity	Hectare	-	0	0.92	-.026	-.623
Access to financial institutions	Scores	0-16	0	16	-.653	.546
Infrastructure	Scores	0-20	0	20	-.653	.546
Market access	Scores	0-24	0	16	-.653	.546

4.1.1 Human capital

The human capital of the sample households ranged from 15 to 75 scores with an average of 43.73 and standard deviation of 15.37. The households were classified into three categories on the basis of human capital. Distribution of the households according to their human capital has been shown in the Table 4.1.1.

Table 4.1.1 Distribution of the respondent households according to their human capital

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low human capital (less than 28)	26	21.67	43.73	15.37
Medium human capital (28 to 59)	79	65.84		
High human capital (above 59)	15	12.5		
Total	120	100		

Data presented in table 4.1.1 indicates that the highest proportion (65.84 percent) had medium human capital of households compared to 21.67 percent low and 12.5 percent high human capital of households. It appears that above half (65.84 percent) of the respondents in the study area were medium human capital.

4.1.2 Social capital

The social capital of the sample households ranged from 4 to 52 scores with an average of 25.20 and standard deviation of 6.16. The households were classified into three categories on the basis of their social capital. Distribution of the households according to their social capital has been shown in the Table 4.1.2.

Table 4.1.2 Distribution of the respondent households according to their social capital

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low social capital (less than 19)	36	30	25.20	6.16
Medium social capital (19 to 31)	66	55		
High social capital (above 31)	18	15		
Total	120	100		

Data presented in table 4.1.2 indicates that the highest proportion (55 percent) had medium social capital of households compared to 30 percent low and 15 percent high social capital of households. It appears that above half (55 percent) of the respondents in the study area were medium social capital.

4.1.3 Access to ICTs'

The access to ICTs' of the sample households ranged from 0 to 12 scores with an average of 5.60 and standard deviation of 2.75. The households of the study area were classified into three categories on the basis of their access to ICTs'. Distribution of the households according to their access to ICTs' has been shown in the Table 4.1.3.

Table 4.1.3 Distribution of the respondent households according to their access to ICTs'

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low access (less than 3.0)	17	14.17	5.60	2.75
Intermittent access (3.0 to 8.0)	88	73.33		
High access (above 8.0)	15	12.5		

Total	120	100		

Data presented in table 4.1.1 indicates that the highest proportions (73.33 percent) had medium access to ICTs' of households compared to 14.17 percent low and 12.5 percent high access to ICTs' of households. It appears that about three-forth (73.33 percent) of the respondents in the study area were medium access to ICTs'.

4.1.4 Annual family income

The Annual family income of the sample households ranged from 0 to 4 scores with an average of 2.30 and standard deviation of 1.07. The households of the study area were classified into three categories on the basis of their Annual family income. Distribution of the households according to their Annual family income has been shown in the Table 4.1.4.

Table 4.1.4 Distribution of the respondent households according to their Annual family income

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low income (less than 2)	22	18.33	2.30	1.07
Medium income (2 to 4)	81	67.5		
High income (above 4)	17	14.17		
Total	120	100		

Data presented in table 4.1.4 indicates that the highest proportion (67.5 percent) had medium Annual family income of households compared to 18.33 percent low and 14.17 percent high Annual family income of households. It appears that above half (67.5 percent) of the respondents in the study area were medium Annual family income.

4.1.5 Non-farm income generating activities

The Non-farm income generating activities of the sample households ranged from 0 to 8 scores with an average of 1.25 and standard deviation of 1.12. The households of the study area were classified into three categories on the basis of their Non-farm income generating activities. Distribution of the households according to their Non-farm income generating activities has been shown in the Table 4.1.5.

Table 4.1.5 Distribution of the respondent households according to their Non-farm income generating activities

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low (less than 2)	52	43.33	1.25	1.12
Medium (2 to less 3)	57	47.5		
High (3& above)	11	9.17		
Total	120	100		

Data presented in table 4.1.5 indicates that the highest proportion (47.5 percent) had medium Non-farm income generating activities of households compared to 43.33 percent low and 9.17 percent high Non-farm income generating activities of households. It appears that about half (47.5 percent) of the respondents in the study area were medium Non-farm income generating activities.

4.1.6 Land productivity

The Land productivity of the sample households is measures by kilogram with an average of 36.84 and standard deviation of 4.79. The households of the study area were classified into three categories on the basis of their Land productivity. Distribution of the households according to their Land productivity has been shown in the Table 4.1.6.

Table 4.1.6 Distribution of the respondent households according to their Land productivity

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low (less than 31)	8	6.67	36.84	4.79
Medium (31 to 41)	99	82.5		
High (above 41)	13	10.83		
Total	120	100		

Data presented in table 4.1.6 indicates that the highest proportion (82.5 percent) had medium Land productivity of households compared to 6.67 percent low and 10.83 percent high Land productivity of households. It appears that most (82.5 percent) of the respondents in the study area were medium Land productivity.

4.1.7 Climate smart agricultural practices & technologies

The Climate smart agricultural practices & technologies of the sample households ranged from 0 to 40 scores with an average of 18.61 and standard deviation of 7.90. The households of the study area were classified into three categories on the basis of their Climate smart agricultural practices & technologies. Distribution of the households according to their Climate smart agricultural practices & technologies has been shown in the Table 4.1.7.

Table 4.1.7 Distribution of the respondent households according to their Climate smart agricultural practices & technologies

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low practice (less than 11)	26	21.67	18.61	7.90
Medium practice (11 to 27)	70	58.33		
Highly practice (above 27)	24	20		
Total	120	100		

Data presented in table 4.1.7 indicates that the highest proportion (58.33 percent) had medium Climate smart agricultural practices & technologies of households compared to 21.67 percent low and 20 percent high Climate smart agricultural practices & technologies of households. It appears that above half (58.33 percent) of the respondents in the study area were medium Climate smart agricultural practices & technologies.

4.1.8 Functional and response diversity

The Functional and response diversity of the sample households ranged from 0 to 13 scores with an average of 4.38 and standard deviation of 2.29. The households of the study area were classified into three categories on the basis of their Functional and response diversity. Distribution of the households according to their Functional and response diversity has been shown in the Table 4.1.8.

Table 4.1.8 Distribution of the respondent households according to their Functional and response diversity

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low diversity (less than 3)	33	27.5	4.39	2.29
Medium diversity (3 to 7)	64	54.17		
High diversity (above 7)	23	19.17		
Total	120	100		

Data presented in table 4.1.8 indicates that the highest proportion (54.15 percent) had medium Functional and response diversity of households compared to 27.5 percent low and 19.17 percent high Functional and response diversity of households. It appears that about half (54.15 percent) of the respondents in the study area were medium Functional and response diversity.

4.1.9 Crop diversity

The Crop diversity of the sample households is measured by hectare with an average of 0.41 and standard deviation of 0.23. The households of the study area were classified into three categories on the basis of their Crop diversity. Distribution of the households according to their Crop diversity has been shown in the Table 4.1.9.

Table 4.1.9 Distribution of the respondent households according to their Crop diversity

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low (less than 0.18)	18	15	0.41	0.23
Medium (0.18 to 0.61)	85	70.83		
High (above 0.61)	17	14.17		
Total	120	100		

Data presented in table 4.1.9 indicates that the highest proportion (70.83 percent) had medium Crop diversity of households compared to 18 percent low and 14.17 percent high Crop diversity of households. It appears that above half (70.83 percent) of the respondents in the study area were medium Crop diversity.

4.1.10 Access to financial institution

The Access to financial institution of the sample households ranged from 0 to 16 scores with an average of 5.32 and standard deviation of 2.40. The households of the study area were classified into three categories on the basis of their Access to financial institution. Distribution of the households according to their Access to financial institution has been shown in the Table 4.1.10.

Table 4.1.10 Distribution of the respondent households according to their Access to financial institution

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low financial access (less than 7)	76	63.33	5.32	2.40
Medium financial access (7 to 8)	14	11.67		
High financial access (above 8)	30	25		
Total	120	100		

Data presented in table 4.1.10 indicates that the highest proportion (63.33 percent) had low Access to financial institution of households compared to 11.67 percent medium and 25 percent high Access to financial institution of households. It appears that above half (63.33 percent) of the respondents in the study area were low Access to financial institution.

4.1.11 Infrastructure

The infrastructure of the sample households ranged from 0 to 20 scores with an average of 10.37 and standard deviation of 3.65. The households of the study area were classified into three categories on the basis of their infrastructure. Distribution of the households according to their infrastructure has been shown in the Table 4.1.11.

Table 4.1.11 Distribution of the respondent households according to their Infrastructure

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low (less than 7)	24	20	10.37	3.65
Medium (7 to less 14)	71	59.12		
High (above 14)	25	20.83		
Total	120	100		

Data presented in table 4.1.11 indicates that the highest proportion (59.12 percent) had medium infrastructure of households compared to 20 percent low and 20.83 percent high infrastructure of households. It appears that above half (59.12 percent) of the respondents in the study area were medium infrastructure.

4.1.12 Market access

The market access of the sample households ranged from 0 to 24 scores with an average of 5.32 and standard deviation of 3.84. The households of the study area were classified into three categories on the basis of their market access. Distribution of the households according to their market access has been shown in the Table 4.1.12.

Table 4.1.12 Distribution of the respondent households according to their Market access

Categories	Households		Mean	Standard deviation
	Number	Percentage		
Low access(less than 4)	42	35	5.32	3.84
Medium access(4 to 8)	57	57.5		
Highly access (above 8)	21	27.5		
Total	120	100		

Data presented in table 4.1.12 indicates that the highest proportion (57.5 percent) had medium market access of households compared to 35 percent low and 27.5 percent high market access of households. It appears that above half (57.5 percent) of the respondents in the study area were medium market access.

4.2 Presenting and interpreting results of Resilience Index

Results can be presented on three ways: presenting overall livelihood resilience result as well as the results presenting capacity and dimension wise.

The result indicates that households had more absorptive capacity than the adaptive and transformative capacity. About 50% households had absorptive capacity, where only one-fifth percent of households had transformative capacity.

4.2.1 Capacity wise resilience index:

Capacity	Index
Absorptive	46
Adaptive	33
Transformative	21

Households' Capacities of Resilience Livelihood

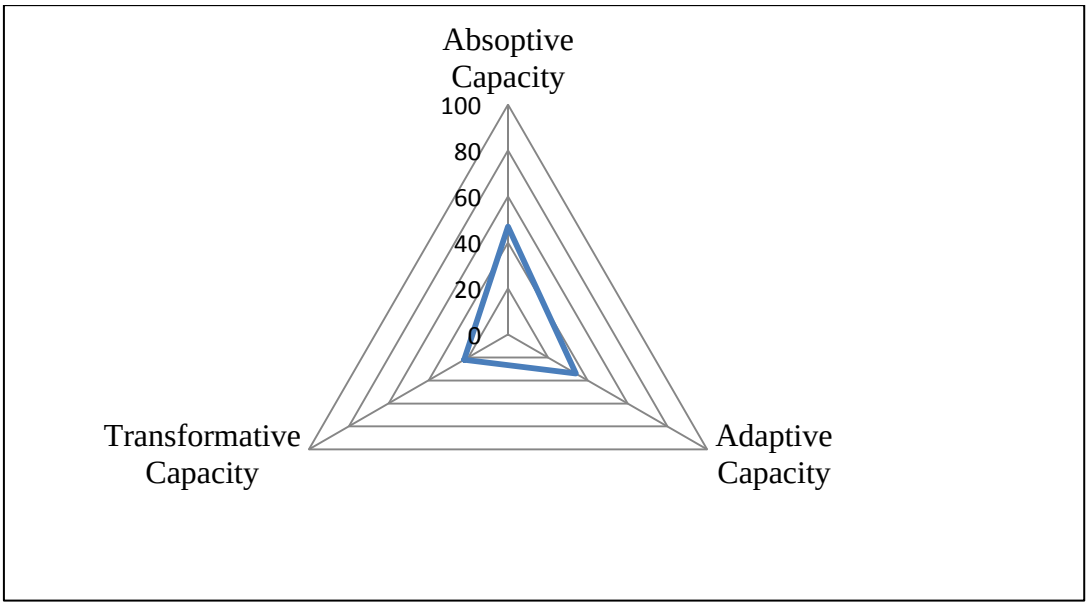


Fig. 4.2.1 Capacities of households in building livelihood resilience.

The result shows that highest percent (46%) had absorptive capacity, where only 21% of households had transformative capacity. Adaptive capacity showed in middle position between absorptive and transformative capacity. It means households possess more absorptive capacity than other. Respondents had least transformative capacity and one third had adaptive capacity for improving livelihood resiliency of flood

affected households.

Absorptive Capacity

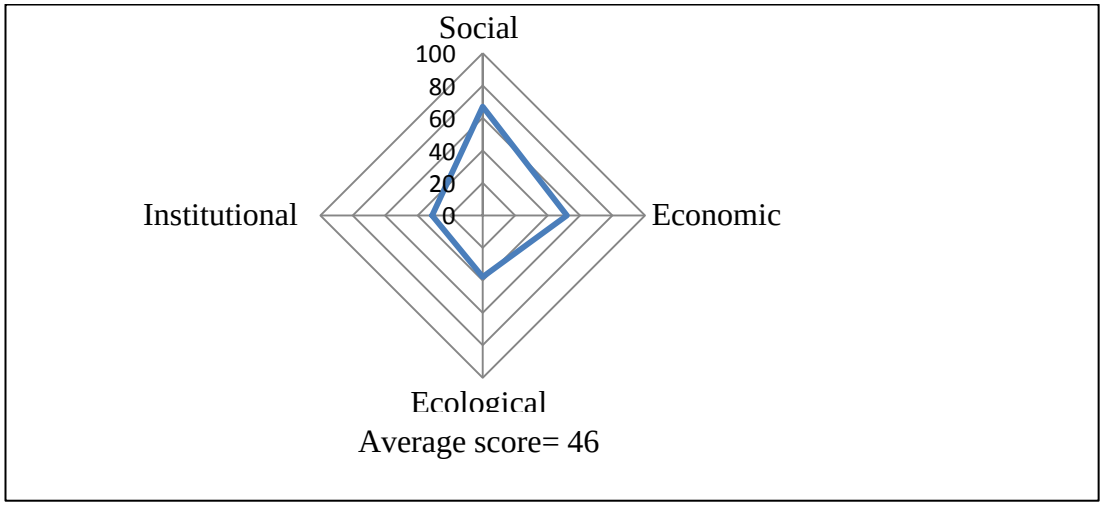


Fig 4.2.2 Different indicators of absorptive capacity in resilience livelihood

The above figure indicates that social dimension influenced high portion of absorptive capacity of households than next 3 dimensions. Economic dimension was second contributor for attaining absorptive capacity. Ecological and institutional dimension had lowest part for developing absorptive capacity of flood affected households. Human capital (knowledge, skill and capacity) of households is increasing day by day; organizational involvement; NGOs' activities and increasing of access to ICT and for above reasons, social dimension of households was increased which had enhanced absorptive capacity.

Adaptive Capacity

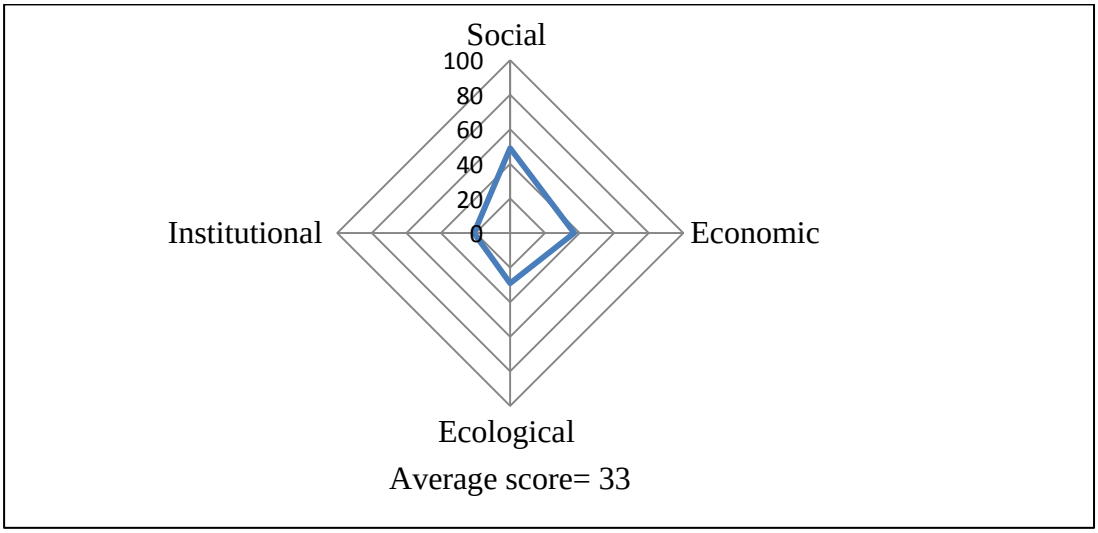


Fig 4.2.3 Different indicators of adaptive capacity in resilience livelihood

The above figure indicates that adaptive capacity of household highly influenced by human capital and social capital. Economic dimension was second contributor for influencing adaptive capacity. Ecological and institutional dimension had poor contribution for developing adaptive capacity of flood affected households.

Transformative Capacity

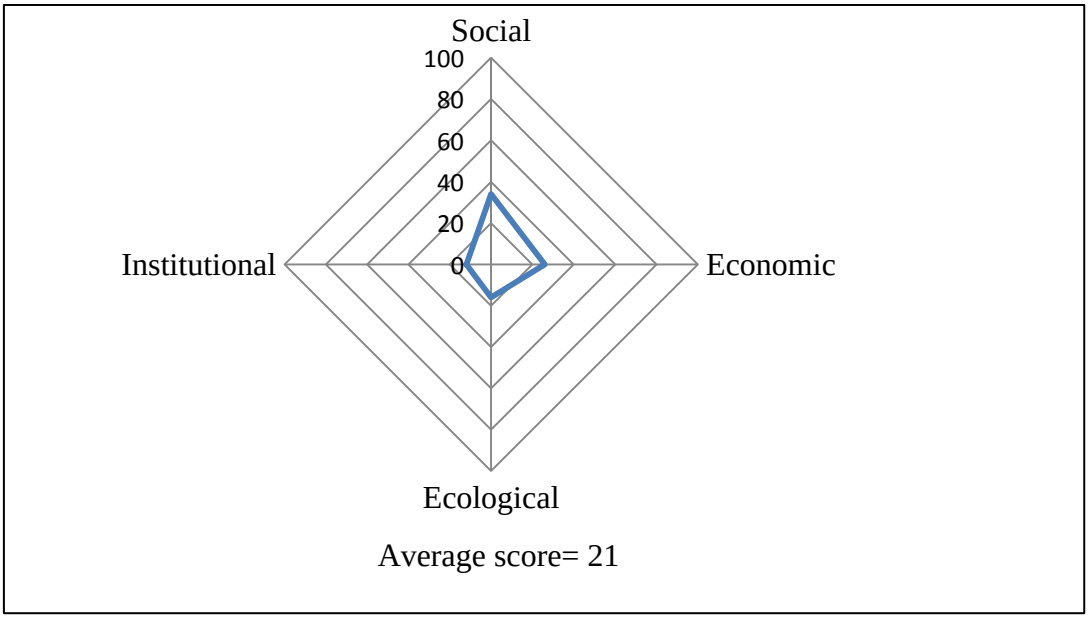


Fig 4.2.4 Different indicators of transformative capacity in resilience livelihood

The above figure shows that transformative capacity is developed by the influence of social dimension with high percentage than ecological and institutional dimensions. Economic dimension gets second position for developing transformative capacity of flood affected households.

From the above three figures it is clear that flood affected households' institutional and ecological conditions are in a marginalized position, where interventions for improvement are required.

4.3 Livelihood resilience assessment

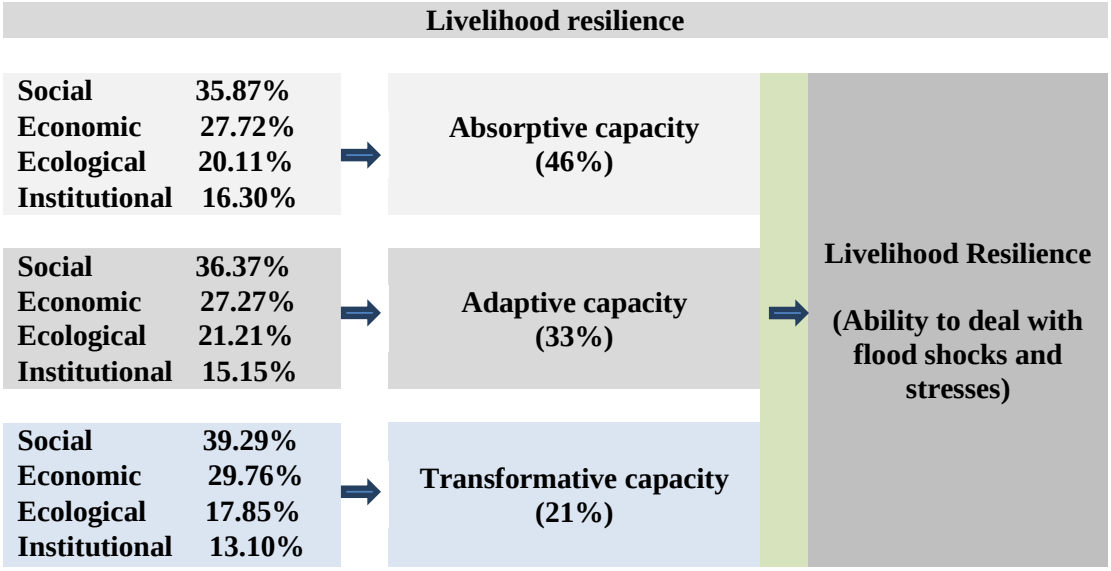


Figure 4.3: Livelihood resilience index

In the above result it can be found that the absorptive capacity had contributed more in building livelihood resilience of flood-affected households. 33% contribution was come from adaptive capacity. Transformative capacity contributed least, i.e. 21% in improving households' livelihood resilient. Dimensions had followed a trend in forming capacities. It is clear that they had marginalized condition in ecological and institutional dimensions, which required authority's attention in building flood-affected households' livelihood resilient. Social dimension was in relatively well positioned. Economic dimension was contributed around 30% in improving three capacities.

4.4 Pearson's correlation coefficients between the selected indicators and livelihood resilience index as well as their underlying dimensions

In the above table, human capital, social capital, annual family income, non-farm income generating activities, and infrastructure shows more significant relationship.

Table 4.4 Pearson's correlation coefficients between the selected indicators and livelihood resilience index as well as their underlying dimensions

Dimension	Indicators	Correlation with	
		Resilience Index	Dimensions
Social	Human capital	.478**	.432**
	Social capital	.402**	.398**
	Access to ICTs'	.101*	.143*
Economic	Annual family income	.212**	.201**
	Non-farm income generating activities	.238**	.223**
	Land productivity	.140*	.113*
Ecological	Climate Smart Agricultural practices & technologies	.213**	.210**
	Functional and response diversity	.207**	.109*
	Crop diversity	.010	.014
Institutional	Access to financial institutions	.103*	.100
	Infrastructure	.290**	.123*
	Market access	.011	.015

** 5% level of significant and * 1% level of significant

4.4.1 The relationship between human capital and livelihood resilience index

In Table 4.4, a coefficient of $r = .478$, $p < .05$ indicates that the human capital & livelihood resilience have positive and highly significant relationships, so as the scores of human capital increases, the scores of livelihood resilience increases by a proportionate amount.

4.4.2 The relationship between social capital and livelihood resilience index

Table 4.4 shows that social capital is positively related to the livelihood resilience, with a coefficient of $r = .402$, which is significant at $p < .05$. This coefficient value indicates as the scores of livelihood resilience increases, the scores obtained in the social capital.

4.4.3 The relationship between non-farm income generating activities and livelihood resilience index

Table 4.4 shows non-farm income generating activities was positively correlated to the livelihood resilience, $r = .238$, $p < .05$. This means that as the scores of non-farm income generating activities increases, the livelihood resilience enhances.

4.4.4 The relationship between infrastructure and livelihood resilience index

In Table 4.4, a coefficient of $r = .290$, $p < .05$ indicates that the infrastructure & livelihood resilience have positive and highly significant relationships, so as the scores of infrastructure improves, the scores of livelihood resilience improves by a proportionate amount.

4.4.5 The relationship between annual family income and livelihood resilience index

In Table 4.5, a coefficient of $r = .212$, $p < .05$ indicates that the annual family income and livelihood resilience have positive and highly significant relationships, so as the scores of annual family income improves, the scores of livelihood resilience improves by a proportionate amount.

4.5 Pearson's correlation coefficients for the livelihood resilience index and its dimensions

Pearson's correlation analysis has been done to show the relationship among the dimensions and the livelihood resilience index. The correlation coefficients of the analysis are shown below table 4.5

Table 4.5: Pearson's correlation coefficients for the livelihood resilience index and its dimensions

	Dimensions			
	Social	Economic	Ecological	Institutional
Livelihood Resilience Index	.284**	.260**	.211**	.174*
Dimensions				
Social	1			
Economic	.323**	1		
Ecological	.284**	.240**	1	
Institutional	.260**	.217**	.077	1

** 5% level of significant and * 1% level of significant

A coefficient of +1 indicates that the two variables are perfectly positively correlated, so as one variable increases, the other increases by a proporsonate amount. Conversely, a coefficient of -1 indicates a perfect negative relationship: if one variable increases, the other decreases by a proportionate amount. To determine the relationship between indicators and index among the households, the computed correlation coefficient (r) between the two dimensions of the indicators gives direction.

Based on the above observations in Table 4.5, the researcher said conclusion that resilience index to dimension and capacity had significant relationship in the study. This means that the more capacity of the households the more livelihood resilience. A coefficient of *r* value, $p < .05$ indicates that resilience indicators, CI and dimensions have positive and highly significant relationships, so as capacity increases, the CI and dimensions increases by a proporsonate amount.

4.5.1 The relationship between social dimension and livelihood resilience index

In Table 4.5, a coefficient of $r = .284$, $p < .05$ indicates that the social dimension & livelihood resilience have positive and highly significant relationships, so as the scores of social dimension increases, the scores of livelihood resilience increases by a proportionate amount.

4.5.2 The relationship between economic dimension and livelihood resilience index

Table 4.5 shows that economic dimension is positively related to the livelihood resilience, with a coefficient of $r = .260$, which is significant at $p < .05$. This coefficient value indicates as the scores of livelihood resilience increases, the scores obtained in the economic dimension.

4.5.3 The relationship between ecological dimension and livelihood resilience index

In Table 4.5, a coefficient of $r = .211$, $p < .05$ indicates that the ecological dimension & livelihood resilience have positive and highly significant relationships, so as the scores of ecological dimension increases, the scores of livelihood resilience increases by a proportionate amount.

4.5.4 The relationship between institutional dimension and livelihood resilience index

In Table 4.5, a coefficient of $r = .174$, $p < .05$ indicates that the institutional dimension & livelihood resilience have positive and highly significant relationships, so as the scores of institutional dimension increases, the scores of livelihood resilience increases by a proportionate amount.

4.5.5 The relationship between social dimension and economic dimension

Table 4.5 indicates that social dimension is positively related to the economic dimension, with a coefficient of $r = .323$, which is significant at $p < .05$. This coefficient value explains as the scores of social dimension increases, the scores obtained in the economic dimension.

4.6 Reporting of Multiple Regression outputs

Table-4.6 Summary of regression analysis

Variables	B	SEB	β
Hunan capital	0.082	0.010	.278**
Social capital	0.199	0.0321	.224**
Access to ICTs'	0.1760	0.0420	.117*
Annual family Income	0.120	0.0101	.123*
Non-farm income generating activities	0.170	0.0092	.251**
Land productivity	0.127	0.045	.106
Climate smart agriculture	0.120	0.0101	.123*
Functional & response diversity	0.170	0.021	.105
Crop diversity	0.111	0.010	.109
Access to financial institution	0.170	0.021	.115
Infrastructure,	0.150	0.012	.220**
Market access	0.190	0.031	.091

R^2 = 0.781 (Adjusted value 0.779); * P < 0.01; ** P < 0.05

* Significance at 1% and ** Significance at 5%

Standard errors are used to determine whether or not the *b*-value differs significantly from zero.

The value of R^2 is 0.781, which tells us that twelve variables can account for 78.1% of the variation in livelihood resilience. There might be many factors that can explain this variation, but this model, which includes only twelve variables, can explain approximately 78.1% of it. This means that 21.9% of the variation in livelihood resilience cannot be explained by twelve variables alone. Therefore, there must be other variables that have an influence also.

Table 4.6 shows that there is a significant contribution of households' human capital, social capital, access to ICT, annual family income, climate smart agriculture, non-farm income generating activities and infrastructure. Based on standardized coefficients (β), human capital, social capital, non-farm income generating activities and infrastructure were the most important contributing factors (significant at the 5% level of significance).

The *b*-values and their significance are important statistics to look at; however, the standardized versions of the *b*-values are in many ways easier to interpret (because they are not dependent on the units of measurement of the variables). The standardized beta values are provided by SPSS (labeled as Beta, β**1**) and they tell that the number of standard deviations that the outcome will change as a result of one standard deviation change in the variable. The standardized beta values are all measured in standard deviation units and so are directly comparable: therefore, they provide a better insight into the 'importance' of a variable in the model.

Human capital (*standardized β* = .278): This value indicates that as human capital increases by one standard deviation, livelihood resilience increase by 0.278 standard deviations.

Social capital (*standardized β* = .224): This value indicates that as the number of Social capital increases by 1 standard deviation, livelihood resilience increase by 0.224 standard deviations.

Access to ICTs' (*standardized β* = .117): This value indicates that as Access to ICTs' increases by one standard deviation, livelihood resilience increase by 0.117 standard deviations.

Non-firm income generating activities (*standardized β* = .251): This value indicates that as Non-firm income generating activities increases by 1 standard deviation, livelihood resilience increase by 0.251 standard deviations.

Infrastructure (*standardized β* = .220): This value indicates that as Infrastructure increases by one standard deviation, livelihood resilience increase by 0.220 standard deviations.

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents summary of major findings, conclusion and recommendation of the study.

5.1 Summary of Findings

The major findings of the study are summarized below:

5.1.1 Findings of Selected Indicators of the households

Findings in respect of the 12 selected livelihood resilience indicators of the households are summarized below:

Human capital

Human capital scores of the respondents ranged from 13 to 36.More than half (70.1 percent) of the households had medium, 16.9 percent had low and 13 percent had high Human capital.

Social capital

Social capital scores of the households ranged from 20 to 48. The highest proportion (59.7 percent) of the households had medium Social capital while 27.9 percent had high Social capital and 12.3 percent had low Social capital.

Access to ICTs'

Access to ICTs' scores of the households ranged from 20 to 48 and the highest proportion (65.6 percent) of the respondents had medium Access to ICTs', 23.4 percent of the respondents had high and 11 percent of the respondents had low Access to ICTs' respectively.

Climate Smart Agricultural practices & technologies

Climate Smart Agricultural practices & technologies (CSA) scores of the households ranged from 4 to 23. About 59.7 percent of the respondents showed medium CSA,

21.4 percent showed low CSA and 18.8 percent showed high Climate Smart Agricultural practices & technologies.

Functional and response diversity

Functional and response diversity scores of the households ranged from 24 to 66 and more than half (51.9 percent) of the respondents were medium Functional and response diversity compared to 32.5 percent of the respondents belonged to the low Functional and response diversity categories and 15.6 percent were in the high Functional and response diversity category.

Crop diversity

Crop diversity scores of the households ranged from 24 to 66 and more than half (51.9 percent) of the respondents were medium Crop diversity compared to 32.5 percent of the respondents belonged to the low Crop diversity categories and 15.6 percent were in the high Crop diversity category.

Annual family income

Annual family income scores of the respondents were ranged from 2 to 12 and half (55.8 percent) of the respondents had medium family income, 27.9 percent had small family income and 16.2 percent had high family income.

Non-farm income generating activities

Non-farm income generating activities scores of the households ranged from 0.6 to 6.43. More than half (65.6 percent) of the respondents were small Non-farm income generating activities, 24.7 percent had medium Non-farm income generating activities, 6.5 percent had high Non-farm income generating activities.

Land productivity

Land productivity scores of the households ranged from 88 to 999 and more than half (68.8 percent) of the households had medium Land productivity compared to 15.6 percent under low and 15.6 percent under high Land productivity.

Access to financial institutions

Access to financial institutions scores of the respondents ranged from 14 to 38 and majority (68.8 percent) of the households had medium Access to financial institutions, 20.1 percent had high Access to financial institutions and 11 percent had low Access to financial institutions.

Infrastructure

Infrastructural facilities scores of the respondents ranged from 3 to 47. Majority (70.8 percent) of the households had medium Infrastructural facilities, 18.2 percent had low Infrastructural facilities and 11 percent had high Infrastructural facilities.

Market access

Market access scores of the respondents ranged from 3 to 47. Majority (70.8 percent) of the households had medium Market access, 18.2 percent had low Market access and 11 percent had high Market access.

5.1.2 Finding of presenting and interpreting results of resilience index

The result of Presenting and interpreting results of Resilience Index showed that the absorptive capacity shows high index value (46%). On the other hand adaptive capacity give medium index value (33%) and low is transformative capacity (21%) contribution in resilient livelihood. Social dimension play a vital role in total livelihood resilience of flood affected households. Results have presented on three ways: presenting overall livelihood resilience result as well as the results presenting capacity and dimension wise.

5.1.3 Capacity wise resilience index

Capacity	Index
Absorptive	46
Adaptive	33
Transformative	21

The result indicates that households have more absorptive capacity than the adaptive and transformative capacity. About 50% have absorptive capacity, where only one-fifth percent of households have transformative capacity.

4.1.4 The relationship between indicator and livelihood resilience index

The relationship between human capital, social capital, non-farm income generating activities, infrastructure and annual family income with livelihood resilience of flood affected households was positive and highly significant.

5.1.5 The relationship between dimension and livelihood resilience index

The relationship between social dimension, economic dimension, ecological dimension and institutional dimension with livelihood resilience of flood affected households was positive and highly significant.

5.1.6 The relationship between social dimensions and economic dimension

The relationship between social dimensions and economic dimension of flood affected households was positive and highly significant.

5.1.7 Presenting of reporting of multiple regression of Livelihood Resilience

Human capital (*standardized* β = .278): This value indicates that as human capital increases by one standard deviation, livelihood resilience increase by 0.278 standard deviations.

Social capital (*standardized* β = .224): This value indicates that as the number of Social capital increases by 1 standard deviation, livelihood resilience increase by 0.224 standard deviations.

Non-firm income generating activities (*standardized* β = .251): This value indicates that as Non-firm income generating activities increases by 1 standard deviation, livelihood resilience increase by 0.251 standard deviations.

Infrastructure (*standardized* β = .220): This value indicates that as Infrastructure increases by one standard deviation, livelihood resilience increase by 0.220 standard deviations.

5.1.8 Contribution of the selected indicators of the households' for improving livelihood resiliency

Out of the twelve independent variables, four variables namely human capital, social capital, non-farm income generation activities and infrastructure have significant contribution to building livelihood resilience as indicated by regression analysis. These four contributory factors combinedly explained the most contribution.

5.2 Conclusions

Findings of the present study and the logical interpretation of other relevant facts prompted the researcher to draw the following conclusions:

1. The findings indicate that human capital of the respondents had highest contribution to building livelihood resilience. It may be concluded that the respondents having more human capital were highest livelihood resiliency against flood.
2. The findings indicate that social capital of the respondents had second highest contribution to the livelihood resilience capacity against flood. It may be concluded that the respondents having more social capital were highest livelihood resilience capacity against flood.
3. The findings indicate that level of access to Non-farm income generating activities had a significant contribution to the livelihood resilience capacity against flood. It may be concluded that access to Non-firm income generating activities of the respondents had influence on the livelihood resilience.
4. The findings indicate that households had more absorptive capacity (46%) than adaptive capacity (33%) and transformative capacity (21%).
5. The findings show that households' social and economic conditions were comparatively better than the ecological and institutional aspects.
6. Regression results indicate that market access, land productivity show less contribution to improve households' livelihood resiliency.

5.3 Recommendations for policy implications

On the basis of experience, observation and conclusions drawn from the findings of the study following recommendations are made:

1. The study has shown that the human capital play vital role to enhance livelihood resilience. For sustainability of household livelihood resilience at a more increased level, authority may arrange motivational campaigning about livelihood resilience.
2. The findings of this study have indicated that human capital of the respondents had highest contribution to the flood affected households for improving livelihood resiliency. Therefore, it may be recommended that authority may provide training to the beneficiaries for increasing their human capital.

3. The findings indicate that social capital of the households had a significant contribution to the effectiveness of livelihood resilience. Therefore, it may be recommended that the local authority should attempt the households about social capital for increasing their livelihood resilience.
4. The findings indicate that access to Non-firm income generating activities had a significant contribution to the effectiveness of livelihood resilience. Therefore, it may be recommended that agricultural authority should insure the households about new working sectors for increasing their livelihood resilience.
5. Infrastructural facilities influenced significantly to the livelihood resilience of the flood affected households. So, proper steps should be taken to increase Infrastructural facilities in the flood affected areas.
6. An interdisciplinary (crops, livestock, fisheries etc.) technical expertization for strengthening the livelihood resilience within the framework of livelihood resilience system need to be emphasized for achieving full potential out of it.
7. There should be appointed more manpower and technical expertise at union level. Therefore, more number of common interest groups will be trained and information transfer will be easier than present situation.
8. Households faced many constraints in utilization of resilient agricultural practices technologies. Therefore, it may be concluded that emphasis should be given to minimize these problems.

5.4 Recommendations for future studies

Considering the scope and limitations of the study, the following recommendations are made for further study:

1. The present study was conducted two unions named Chandipur & Kapasia of Sundargonj upazila under Gaibandha district and two unions named Harati & Rajpur union of Lalmonirhat sadar upazila under Lalmonirhat district. So, similar attempts may be taken in other parts of the country to verify the results.
2. The study was undertaken to explore the contribution of 12 indicators of the households on effectiveness of livelihood resilience. But there are many other indicators of the households which may influence them regarding effectiveness of livelihood resilience. So, it is recommended that further study should be conducted involving other unexplored indicators of the households.

3. In this study effectiveness of livelihood resilience have been studied on four dimensions (social, economic, ecological and Institutional) of livelihood resilience. In further study, other dimensions may be included.
4. Only four variables namely human capital, social capital, infrastructure and non-farm income generation activities had significant contribution to the effectiveness of livelihood resilience. Hence, further investigation is necessary to find out such relationships between the concern variables to authentic the present study.
5. In the present study land productivity, market access showed no contribution to the effectiveness of livelihood resilience. In this connection further research is necessary to justify the results.
6. All constraints affect the livelihood of the households. There is need for undertaking research on the various problems faced by the households which affect their livelihood.
7. From the above research it is clear that flood affected households' institutional and ecological conditions are in a marginalized position, where interventions for improvement are required.

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APPENDICES

Appendix–A:

Questionnaire

English version of the interview questionnaire

Department of Agricultural Extension and Information System

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar

Dhaka-1207

An interview questionnaire on the study of

Livelihood Resilience of Flood Affected Households in North Western Bangladesh

Respondent Questionnaire: Flood affected households

Date: ..... Serial No. : .....

Name of the respondent:.....

Village: .... Upazila/Thana: ..... District:.....

(Please answer the following questions. Your information will be used only for academic purpose)

1. Human Capital:

Statement	Definitely	Probably	Probably not	Not sure	Definitely not
Knowledge					
Flood resistant variety of paddy gives sustainable production					
Biological control of pest is significant					
IPM is good for economic					
Mixed cropping enhances soil nutrient availability					
Deep urea placement is reduced N_2 loss					
Skill					
Flood increases weed infestation					
Floating cultivation					

minimizes production loss					
Quality water is base for good health					
Plant sources are important sources of compost fertilizer					
Non farming income is very effective during flood.					
Capacity					
Education is unique for resilience Crop production					
Training helps to adopt environmentally friendly farming practices					
Organization participation assists for getting updated information					
Extension service is key for maximum production					
Financial capacity is urgent for adopting innovation					

2. Social capital:

A. How many organizations are you a member of and its frequency of contact?

Name of organization	Member		Number of contact		
	Yes	No	Week	Month	Six months
Households group(e.g. Deep tube well)					
NGOs					
Mosque/Market/School committee					
Cooperative (Credit/financial)					
Club (e.g., youth, village, IPM)					
Religious group					
Neighborhood/village association					
Political group					

B. How much confidence do you have in the following institution?

Institution	A great deal	Quite a lot	No opinion	Not very much	None at all
Upazila agricultural extension organization					
Local administration (Union parishad)					
Other Govt. organization (e.g., BRDB, Social Welfare)					
Input business community/ Numbers of community					

3. Access to ICTs':

Item	Sustained Access	Intermittent Access	No Access
Mobile Phone/Smart Phone			
Television			
Radio			
Dish connection/ Internet connection			
Computer/Tab			
Digital Information Centre(DIC)			

4. Annual Family Income:

Which of the following categories best describes your household's family income?

a. Under 50,000 BDT [ ]
b. 50,001 to 100,000 BDT [ ]
c. 100,001 to 150,000 BDT [ ]
d. Over 150,000 BDT [ ]

5. Non-farm income generating activities:

Do you have any income source other than agriculture? Yes [ ] No [ ]

If Yes, then answer the following.....

a. Government Job [ ]
b. Private job [ ]
c. Business [ ]
d. Seasonal job [ ]
e. Labor to mill/factory/other house [ ]
f. Brick field [ ]
g. Weaving factory [ ]

6. Land productivity:

Yield of-

1. Modern varieties (Kg/decimal) [ ]
2. Local varieties (Kg/decimal) [ ]

7. Use of climate smart agricultural practices and technologies:

Do you use the following resource-conserving practices and technologies?

	Adequately	Moderately	No opinion	Rarely	Never
Practices					
Integrated farming system					
Crop residue as fertilizer					
Legume crop/pulse crop					
Homestead farming					
Mixed cropping					
Technologies					
Floating cultivation					
ICM					
Deep placement of Guti urea					

Cultivation of flood resistant crop varieties					
Using modern machineries					

8. Functional and Response diversity:

Please answer the following questions.

Do you have any animal?	Yes	No	If Yes, which species?	1. Cow 2. Goat 3. Buffalo	
Do you have any breed?	Yes	No	If Yes, which species?	1. Chicken 2. Duck	
Do you practice aquaculture?	Yes	No	If Yes, do you have pond?	Yes	No
Do you practice Apiculture?	Yes	No	If Yes, do you have own?	Yes	No
Do you practice horticulture?	Yes	No	If Yes, do you have garden?	Yes	No

9. Crop diversification:

Please mention the name of crops with area you grown in the last 5 years.

Name of the crop	Cultivated area (Decimal)	Name of the crop	Cultivated area (Decimal)
Rice		Pulse	
Wheat		Maize	
Jute		Sugarcane	
Potato		Oil seed	
Vegetables		Sweet potato	
Kaon		Groundnut	

10. Access to financial institutions:

Types	Sustained access	Intermittent access	No access
Family members			
Friends/ Neighbors			
Cooperative			
Government programme(PKSF)			
NGO's/Microfinance			
Loan company			
Local Leader			
Remittances			

11. Infrastructure:

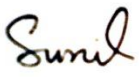
Types	Do you have following buildings in your locality?		Do you have access to following buildings in your locality?	
Established market	Yes	No	Yes	No
Deep tube well	Yes	No	Yes	No
Concrete roads	Yes	No	Yes	No

School	Yes	No	Yes	No
Health center	Yes	No	Yes	No
Veterinary clinic	Yes	No	Yes	No
Input shops	Yes	No	Yes	No
Shelter house	Yes	No	Yes	No
Storage facilities	Yes	No	Yes	No
Embankment	Yes	No	Yes	No

12. Market access:

Buying				
Do you buy directly from product?	Yes	No	If yes, for which product? (Max 2)	
Do you have any vegetal product? Which you can only access from one available seller?	Yes	No	If yes, which crops?	
Are there animal produces, Which you can only access from one available seller?	Yes	No	If yes, which product?	
Do you have any agreement or binding documents with the seller/provider?	Yes	No	If yes, describes your contract or agreement with the buyer.	
Selling				
Last year did you sell any of your crops/livestock?	Yes	No	If yes, which ones? (e.g. chicken, sorghum, millet)	
Do you sell or trade some of those products directly to consumers?	Yes	No	If yes, for which products?	
Do you have any product with only one available buyer?	Yes	No	If yes, which products?	
Do you have any agreement or binding documents with the buyer?	Yes	No	If yes, please elaborate: what kind of agreement?	

Thank you for your information, time, and patience.



Sunil

……..……..

Signature of the interviewer

(Appendix-B) Indicators definition and measurement, including objective of the dimension

Dimension and objective	Indicator	Definition and measurement	Source
Social: to enhance the quality of life of society at large	Human capital	Explores and measures household's knowledge, skills, and capacities for innovation in conventional and modern farming systems. For each category: 5 = 'definitely'; 4 = 'probably'; 3 = 'probably not'; 2 = 'not sure' and 1 = 'definitely not'	Pretty (2008)
	Social capital	Involvement in organisations, number of contacts, and confidence level in these organisations; 1 = 'involvement in organisation'; and 0 = 'otherwise'. 3 = 'weekly contact'; 2 = 'monthly contact'; 1 = 'contact every six months'; and 0 = 'no contact'. Confidence level: 5 = 'a great deal'; 4 = 'quite a lot'; 3 = 'no opinion'; 2 = 'not very much'; and 1 = 'none at all'	Putnam (1993)
	Access to ICTs'	Measuring access to ICTs, 2= 'Sustained access'; 1= 'Intermittent access'; 0= 'No access'.	Roy *et.al.* (2015)
Ecological: to maintain and improve the natural resource base	Uses of climate smart agriculture	As measurement of CSAPTech; 4= 'Adequately'; 3= 'Moderately'; 2= 'No opinion'; 1= 'Rarely'; 0= 'Never'.	FAO (2010)
	Functional and response diversity	Measuring 'Functional and response diversity'; '1' for one suitable answer and 'Yes'=1 ; 'No'=0;	FAO (2010)
	Crop diversification	Measuring as the total number of crops and the proportion of acreage of the crop to total cropped area in the last year, using Herfindahl Index (HI) and Transformed Herfindahl Index (THI)=1-HI	Islam and Rahman (2012)
Economic: to achieve economic viability	Annual family income	As measurement of Annual family income; 4= 'Over Tk. 150000'; 3= 'Tk. 100001 to Tk. 150000'; 2= 'Tk. 50001 to Tk. 100000'; and 1= 'Under Tk. 50000';	Roy *et.al.* (2015)
	Non-farm income generating activities	One non-agricultural income source=1	FAO (2010)
	Land productivity	Measure of the physical yield of rice per unit area and yield data (HYV and local rice) was collected by survey	Rasul and Thapa (2004)
Institutional: to sustain production	Access to financial institutions	Measuring access to financial institutions, 2= 'Sustained access'; 1= 'Intermittent access'; 0= 'No access'.	Roy *et.al.* (2015)
	Infrastructure	If one type of infrastructure present in locality, it indicate 1 point with 'Yes' otherwise 'No' and 'Yes'=1 & 'No'=0;	FAO (2010)
	Market access	As measurement of Market access; 1 point for one yes answer and correct answer receives maximum 1 score	FAO (2010)

Appendix–C:

Correlation Matrix

Coefficient of correlation of different indicators of Livelihood resilience

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	1												
X2	.233**	1											
X3	.201*	.174*	1										
X4	.254**	.091	.172*	1									
X5	.197*	.106	.179*	.104	1								
X6	.410**	..014	.096	.017	.034	1							
X7	.169*	.175*	.216**	.323**	.484**	.069	1						
X8	.191*	.108	.086	.050	.329**	-.033	.493**	1					
X9	.024	.041	.170*	.071	.156*	.111	.141*	.064	1				
X10	.244	.080	.197*	.155*	.130	-.035	.162*	.075	.059	1			
X11	.052	.351**	.158*	.257**	.363**	-.029	.544**	.161*	.152*	.343**	1		
X12	.230	.124	.108	.043	.414**	.076	.323**	.332**	-.016	.106	.222**	1	
X13	.242**	.290**	.320**	.173*	.224*	.238**	.242**	.213	.324**	.334**	.210*	.279**	1

**Correlation is significant at the 0.01 level (2- tailed)

* Correlation is significant at the 0.05 level (2 -tailed)

Where X1= Human capital, X2= Social capital, X3= Access to ICTs', X4= Annual family income, X5= Non-farm income generation activities= X6 Land productivity, X7= Climate smart Agriculture, X8= Functional and response diversity, X9= Crop diversification, X10= Access to financial institution, X11= Infrastructure, X12= Market access and X13= Livelihood resilience index.

Appendix-D

Dependent variable for regression analysis

(Based on resilience index values of 120 respondents)

Value	Value	Value
18.69889	31.45394	38.15624
28.54448	57.32019	46.01798
49.45748	51.69667	29.98424
50.45210	34.61762	49.53686
43.02400	42.68598	79.62371
35.41599	33.95214	48.31943
44.53798	43.95567	30.23596
55.96804	30.98886	44.02924
63.14152	49.66723	41.54290
55.59431	45.53588	51.04302
38.85553	76.05437	47.75213
56.22403	41.24932	44.83694
57.47021	38.20367	65.99501
39.22297	42.93833	55.96458
52.59091	36.81675	55.78603
49.39837	57.00876	50.43388
34.53718	23.13184	55.86408
49.45432	37.72014	51.66126
39.76087	28.44680	39.11113
26.92280	42.63795	45.66909
35.31544	46.50580	49.60743
28.89263	62.24761	60.14783
31.19135	56.38607	60.14783
30.91462	68.90003	32.28639
33.56204	37.90100	39.34860
18.48159	29.01184	46.48493
22.68834	23.11207	32.05092
37.02977	30.17279	18.16317
42.85351	28.78603	40.48587
69.25435	59.58869	38.99026
59.31171	63.35205	45.64383
35.09974	37.64560	39.72532
26.54943	25.52650	44.68651
38.37250	37.67588	41.33026
37.22829	44.76793	25.56849
40.68576	73.53991	54.55691
42.28581	41.18666	52.17039
59.87361	62.11882	44.44045
59.28493	56.41645	42.70156
59.90358	63.15004	51.37730