Research Plan

On

Vulnerability Reduction for Small and Marginal Farmers in Uttarakhand, India

Submitted by

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Contents

1. Introduction

Every society is being impacted by the changing climate nowadays. The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) mentioned changing climate remains clearly influenced by humans, as evidenced by the greatest amount of anthropomorphic emissions of greenhouse gases (GHG) in the historical record, decreasing the amount of ice, and snow, increasing ocean floor, and increasing temperature of the oceans and surroundings. In addition, it has been noted that severe weather events are becoming more common (IPCC, 2014; Schmidhuber and Tubiello, 2007; UN, 2018).

For the reason that changing climatic patterns will affect crop yields and threaten the availability of food, marginalized people such as countryside poor and small-scale farmers in underdeveloped countries, there is a danger. This is particularly true for small-scale producers, who usually grow fewer crops and are least equipped to deal with their implications (Altieri et al., 2015; Antle, 1995; FAO, 2022; IPCC, 2014; Schmidhuber and Tubiello, 2007; UN, 2018; World Bank, 2013). Global warming has an impact on food availability in four ways: availability, access, utilization and stability (FAO, 2022).

The slowing economic development of countries and regions is also predicted to be a result of the changing climate. In the latest study of 134 nations, 1°C rise in the temperature has been estimated to considerably lower the gross domestic product (GDP) per person by 9% (World Bank, 2013). Frequent severe weather occurrences are a major problem for least-developed and developing countries. Efforts to reduce poverty in these nations are more challenging since budgeted resources are redirected to disaster assistance, resulting in the creation of new poverty and hunger hotspots (IPCC, 2014; Morton, 2007; World Bank, 2013).

Agriculture continues to be a major source of income in developing nations and the security of food, particularly in rural region (Baca et al., 2014). The amount of water needed for cultivation rises along with the temperature. Small-scale and rural farmers in developing nations are impacted by water shortages (Morton, 2007). The cycle of insect populations may potentially change due to global warming since temperature directly influences how they reproduce (Altieri et al., 2015).

Farming is a strategy that has developed throughout history, using insufficient machines and a little assistance from technology. Production of food for household consumption, and domestic

market retailing for family financial requirements are its main objectives. That practice is normally used among small and marginal farmers across the world (Bouroncle et al., 2017; Holland et al., 2017; Morton, 2007). Those marginal and smallholders rely upon rainfed agriculture, which makes their livelihoods highly vulnerable. In addition, these farmers are facing food insecurity and living below the poverty line. Therefore, climate change adaptation plans are urgently needed for their livelihood improvement (Holland et al., 2017; Morton, 2007).

Marginal and small-scale farmers are essential to the world's agricultural economy, particularly in developing nations (Fan and Rue, 2020). The world's farmland more than 80% is run under two hectares of land. As a result, this production contributes 80 % to Asia and Africa's food supply. (Lowder et al., 2016). Since only twelve species of plants but also five species of animals account for 75 % of total for the world's food production, making the world's agricultural sector particularly vulnerable to shocks, limited methods, who protect numerous conventional and weather patterns kinds and varieties, depend on biodiversity. Small holder farmers households make up one trillion of the sixty-five (65) million people living in developing countries that are solely reliant on agriculture and food sectors (Fan and Rue, 2020).

In developing nations, the proportion of women working in agriculture ranges from an average of 43% to nearly 50% in Sub-Saharan African and Eastern and Southeast Asia (FAO, 2012). Small-scale farmers already confront a number of threats to the productivity of agricultural crops, such as diseases and pest outbreaks, adverse weather, and economic fluctuations, which can have an impact on the households' availability of nourishment as well as cash (Morton, 2007; O'Brien et al., 2004). Furthermore, each and every declines throughout agriculture production could have a major adverse effect on small - scale farmers' availability of food, diet, income, and well-being because they frequently depend solely on agricultural production for their subsistence and generally have no assets and adaptability to resist scares (McDowell and Hess, 2012; Skoufias et al., 2011).

Vulnerability Concept

The word "vulnerability" describes how susceptible an approach is to the adverse effects of changing climate and other socioeconomic challenges (Füssel, 2010). According to the third assessment report from the Intergovernmental Panel on Climate Change, susceptibility is

examined using three primary concepts: According to (Füssel and Klein 2006), (1) exposure is the length of time, (2) sensitivity is the extent which a disturbance has an effect on a system and whether it has a positive or negative effect (Gallopín, 2006), and (3) the capacity of a household, group, or organization to withstand, manage, or bounce back after a disruption (Smit and Wandel, 2006). In this circumstance, changing climate vulnerability may be evaluated by examining how these three factors interact (Di Falco, 2014).

Earlier vulnerability assessment methods focused on the physical hazard aspects of climate change to investigate specific climate change stresses (Antwi-Agyei et al., 2013; Singh and Nair, 2014). Such biophysical analyses came to the conclusion that Growers are prone to weather change as a result of the ongoing risks they confront resulting directly through natural climatic occurrences, particularly from weather extremes like drought and food shortages (Eakin and Luers, 2006). A "likelihood" approach called "physical and biological susceptibility evaluation" looks at how global warming impacts both physical and social ecosystems (Füssel and Klein, 2006). For modelling and analyzing biophysical factors that enhance sensitivity to global warming, numerous weather derivatives as well as forecasts have been developed within that field (Adger et al., 2007).

These analyses rely on biophysical datasets with a limited range of factors, like temperatures variation, quality of soil, and crop fluctuation. The amount of localized susceptibility to global warming, sustainability and adaptability is contextualized by complex social, economic, and environmental elements, which are misrepresented by a simple focus on biophysical variables (Hahn et al., 2009; Smit and Wandel, 2006).

Vulnerability of Small and Marginal Farmers

With an estimate 450–500 million small farmers globally, or 85 % of all grows, small - scale farmers make up a sizeable share of the global population (Wiggins et al., 2010). Additionally, according to estimates, smallholder farmers are responsible for feeding 50% of a globe's starving people and probably three-quarters of those in Africa (Sanchez and Swaminathan, 2009). Hence, the degree to which the global is able to eradicate worldwide lack of food, extreme poverty and attain the objectives set by the Sustainable Development Goals (SDGs) will largely depend on how small producers are doing.

Small producers in tropical regions already face a variety of risks to overall agricultural production, such as infectious disease and pest outbreaks, harsh weather, and marketplace disturbances, which regularly imperil the food and financial security of their households (Morton, 2007; O'Brien et al., 2004). Any decreases in crop production is able to significant effects on availability of food, nourishment, incomes, and prosperity for small-scale farmers because they often directly depend on their livelihoods from agriculture and insufficient natural resources and capacity to withstand disasters (McDowell and Hess, 2012). Small-scale farmers are projected to be severely impacted by global warming, which will make their risks even worse. Recent research, for instance, has found that the primary cereal crops grown by farm households, maize, and wheat will suffer adverse effects from even modest temperature increases (Morton, 2007).

The intensity and frequency of disease and pest outbreaks, floods and droughts and the possibility of low yields, poor soil fertility, and livestock death are all predicted to vary because of global warming (Katumo et al., 2022). Owing to the fact that the majority of the nations most affected by global warming will include substantial numbers of poor, small-scale farmers, (Hertel and Rosch, 2010), the world community now needs to concentrate its efforts on figuring out adaptation strategies that can lessen these farmers' climate change vulnerability and help them deal including its negative effects.

Small and Marginal Farmers Vulnerability in India

Due to the planned policies and improving technology of the Sustainable Agriculture, automation, specialization, and diversification of Southern Asia's agricultural practices occurred throughout the two decade of the twentieth century (Davis et al., 2019). In an effort to increase yields, income, or worker productivity, the adding an inorganic fertilizer, higher yielding cultivars, veterinary care, water management, and modernization caused modifications to the environment, and socio-economic situation. Although these initiatives resulted in higher yields and a growing economy (Jat et al., 2020), the benefits were not shared fairly. A few of the most populated regions of India is Bihar has been still suffering from malnutrition and starvation. Constant agricultural production caused soil degradation and resource depletion, which combined with a high level of agricultural fragmentation, insufficient facilities, and weak governance and marketplace made it difficult for small producers to survive (Aryal et al., 2018).

The major source of stress, defined as weather patterns (Singh et al., 2020), is also adverse physical and biological conditions and socio-economic status disturbances (such as employment trends and price fluctuations), which have an effect on farming systems and possibly have an impact on production. Farming operations are frequently subject to unanticipated disruptions, such as flood disaster, declining of workers on farm, or the greatest latest epidemic, COVID-19. To respond to the unexpected situation of changing climate, adaptive capacity building is important to consider in agricultural production. The management of agriculture should be geared towards their adaptive ability, enabling beneficial but mostly undefined future outcomes, as cropping is subject to the characteristics of complex processes. It involves outlining the prerequisites for just an integrated approach that gains from disruptions and develops as a result of them (Darnhofer, 2020).

The goal of optimizing production systems promotes development in the direction of high yielding farm machinery, which is frequently based on investment resources, increasing the dependence of small-scale farmers, for example, on external inputs, equipment, and capital. These mechanisms become homogenized, optimized, as well as fragile like a result, since they degrade under less-than-ideal conditions. (Meynard et al., 2018). While there continues to be growing political and social pressure for these systems to be more robust (capable of enduring) and resilient (able to regain, or "rebound"), it is debatable whether existing system requires improvement or a complete overhaul (Rivera-Ferre et al., 2021).

"India Rural Development Report 2012-13", Rural Development Network of IDFC stated that the small and marginal farmers are more productive, principally when growing crops with limited labor. However, land holdings are too small to produce enough household income. The operating assets are divided into the following five size groups:

Sl. No	Category	Size-Class
A	Groups of Marginal Holder	Under 1.00 ha
B	Groups of Small Holder	Between 1.00 – 2.00 ha
C	Groups of Semi-Medium Holder	Between 2.00 – 4.00 ha
D	Groups of Medium Holder	Between 4.00 – 10.00 ha
E	Groups of Large Holder	Above 10.00 ha

Source; Ministry of Agriculture and Farmers Welfare, Government of India (2019)

In addition, the following table shows the average size of operating land holdings in India, divided per state.

Average Landholding of Across the Nation in India

Sl. No	State/UTs	Average size (hectare)
1	A & N Islands	1.78
2	Andhra Pradesh	0.94
3	Arunachal Pradesh	3.35
4	Assam	1.09
5	Bihar	0.39
6	Chandigarh	1.21
7	Chhattisgarh	1.25
8	D &N Haveli	1.38
9	Daman & Din	0.35
10	Delhi	1.39
11	Goa	0.81
12	Gujarat	1.88
13	Haryana	2.22
14	Himachal Pradesh	0.95
15	Jammu & Kashmir	0.59
16	Jharkhand	1.17
17	Karnataka	1.35
18	Kerala	0.18
19	Lakshadweep	0.26
20	Madhya Pradesh	1.57
21	Maharashtra	1.35
22	Manipur	1.14
23	Meghalaya	1.29
24	Mizoram	1.25
25	Nagaland	5.06
26	Odisha	0.95
27	Puducherry	0.62
28	Punjab	3.62
29	Rajasthan	2.73
30	Sikkim	1.13
31	Tamil Nadu	0.75
32	Telangana	1.00
33	Tripura	0.49
34	Uttar Pradesh	0.73
35	Uttarakhand	0.85
36	West Bengal	0.76
	All India	**1.08**

Source; Agriculture Census 2015-16

In summary, millions of people, particularly those who are small and marginal farmers in India, face serious challenges due to climate change in the areas of agriculture, food shortage, and

rural businesses. Small producers are likely to be impacted more negatively. Farmers, fishermen, and other people who depend on forests and have poor living conditions are suffering from the impact of climate change. The increasing failure of crops, livestock losses, and decreased availability of marine, fish farming, and forest products pose an immediate and escalating risk to rural populations, particularly those that live in already vulnerable ecosystems. They would negatively impact small farmers' incomes and the availability of food in general. Small-scale farmers must be the main focus of climate change-adaptive policies that also benefit the underprivileged. Small producers may profit from agriculture mitigation and adaptation approaches.

The study will support small and marginal farmers in India's rural areas, and will benefit reducing climate vulnerability in their farming through the use of climate-adaptive agricultural practices.

2. Literature Review and Research Gap

The overview of the literature explores two areas of study:

2.1 Climate Change and Vulnerability

2.2 Livelihood Vulnerability Index

2.1 Climate Change and Vulnerability

The Latin term vulnus, which meaning wound, is the root of the word "vulnerable." Due to Vulnus, the word vulnerable, which is the verb injure, and the Latin word vulnerabilis, which implies susceptible, were both derived (Kelly and Adger, 2000). The word "vulnerability" is now widely used in a range of study fields, such as people whose stay in poverty, and less development, availability of food, disaster planning, economic development, changing climate. Its topic and its recognition of those most vulnerable have been kindly characterized as ambiguous, which is of special significance. In some cases, the conceptual conflict in climate change research has become difficult. For better communication and collaboration among scholars from various domains, a standard terminology is required (Brooks, 2003; Fernández-Lozano et al., 2020; Füssel, 2007).

In addition, vulnerability refers to the analysis utilized to assess a group's or individual's vulnerability to a damaging circumstance brought on by a number of shocks and paths (Adger, 2006). As the consequences of climate change are increasingly being recognized, vulnerable has become a crucial idea in studies on changing climate. Assessments of vulnerability have been utilized to increase awareness, formulate policy, and track the effectiveness of mitigation measures (GIZ, 2014, 2013; Hinkel, 2011). The approach for measuring vulnerability must be chosen if one wants to construct an assessment of vulnerability (to inspire transformation in a community or update policymakers). According to empirical investigations, vulnerability is calculated using a variant of the fundamental formula: "Vulnerability = Risk + Response" either "Vulnerability = Baseline + Hazard + Response" (Moret, 2014).

The development of an approach to assess and determine the vulnerability of families in the research region is one of the key goals of this research. It is crucial to begin by defining a few terms that will be used in this vulnerability study because the literature of adaptation and vulnerability is expanding, and including broader ideas (Brooks, 2003). These concepts include vulnerability, capacity of adaptive, sensitivity, and exposure. The definitions given by (IPCC, 2014) shall be applied as follows in this study:

Vulnerability: The extent to which a approach is susceptible to the negative climate change consequences, particularly variations in temperatures and disasters. A system's sensitivity, adaptability, and exposure to certain types, intensities, and rates of climatic change all play a role in vulnerability.

Exposure: A system's risk to major changing climate, including nature, and degree.

Sensitivity: Sensitivity is the extent that an environment is impacted by climate-related events, either negatively or positively. The impact can be either direct (such as a change in agricultural yield by temperature changes) or indirect (such as sea level rising leads to flooding in coastal region).

Adaptive Capacity: The systems capacity, organizations, human beings, and other living things to adapt to possible damage, to respond to the impacts of changing climate (IPCC, 2014). According to empirical research, there are many

methods that may be employed when creating an assessment of vulnerability. Three ontological methods are listed by (Below et al., 2012): theory-driven, data-driven, and a mixture of empirical and theoretical. The theory-driven technique employs a review of the literature to choose the parameters being assessed, although this method introduces some degree of confusion regarding the validity of the selected variables.

The data-driven strategy chooses the variables to be assessed based on expert judgement or through the correlation of prior occurrences, however this technique does not evaluate the variables using a benchmark but instead restricts itself to expert judgment. In response to the weaknesses in the first two strategies, the third strategy was developed. One specific example is the Livelihood Vulnerability Index (LVI) recommended by the (Hahn et al., 2009).

2.2 Livelihood Vulnerability Index

Livelihoods are an environment with resources that provide a means of subsistence and that offer sufficient amounts of money and food. The meaning of "sustainable" describes the long-term development of natural resources without compromising those for future generations as well as the present. The land ownership availability, livestock, fishing, and hunting these activities are leading to providing a way of sustainable livelihoods, and higher income. The approach to sustainable livelihoods uses five kinds of assets to assist a household in withstand shocks: natural, social, financial, physical, and human capital (Hahn et al., 2009). However, the approach to sustainable livelihoods simply mentions adaptative capacity and sensitivity. This strategy can no longer be used because of climatic changes since it fails to adapt to the extensive ecosystem changes.

A new strategy is required to combine household adaptation and exposure. The LVI integrates techniques to calculate the changing climate effects are having on several communities by combining a number of variables such as exposure, adaptive capacity, and sensitivity. The socio-demo graphic profile, strategies of livelihoods, social groups, access to health, food and water, natural hazards, and climatic variability are the seven main components used by (Hahn et al., 2009). According to (Hahn et al., 2009), the LVI uses an equal weighted average method,

giving every sub-components the same weight. However, this weight of equaling is viewed foe example; a limitation because it is difficult to suppose that every the sub-components would have the same impact (Below et al., 2012).

Research Gap

In terms of concept, vulnerability occurs when an entity or a system of interest is exposed to an abnormal condition or a scenario with which it is not familiar. In light of this, it is reasonable to expect that any differences in climatical factors, such as precipitation, and high temperature, will increase vulnerability. Given the nature of agriculture in most India's areas, adaptation to rising temperatures and decreasing precipitation is more challenging. There is evidence that plants are sensitive to heat stress and one of the most important management strategies is irrigation (C A Rama Rao, B M K Raju, Adlul Islam and K V Rao, G Ravindra Chary, R Nagarjuna Kumar, M Prabhakar K Sammi Reddy, 2020).

Therefore, climate adaptative agriculture practices take the part of a vital part in dropping the number of small and marginal farmers' vulnerability. The literature gives multiple examples of adaptative agriculture methods such as intercropping, rotation of crop, drought and flood tolerance varieties, changing cropping patterns and many more. These practices are successful in plain areas. But in hilly areas, against the climate change through climate adaptative agriculture practices have met with limited success mainly due to the absence of access to credit, labor shortage poor human resource base, limited extension services, poor soil quality, and water management (ICAR, 2012).

An assessment of the research and development initiatives carried out by the Indian Council of Agricultural Research (ICAR) organization within the initial two years of the tenth Plan also found a number of weaknesses. Some of issues include (a) a lack of focus on the demands of rainfed areas, which make up more than 60% of farm land; (b) a bias towards certain crops, particularly rice and wheat; (c) lack of attention to opportunities and relevant areas (d) insufficient focus on newly developing issues, especially in marketing, postharvest technology, and environmental sustainability; (e) duplicated research works (f) limited responsibility, weak communication among private sector, extension workers, farmers and researchers, and extremely centralization of planning and supervision (ICAR, 2012).

Therefore, the study will introduce the best agricultural practices for the small and marginal farmers who are suffering from climate change in remote areas of India.

3. **Research Questions and Methodology**

RQ 1; What kinds of farming techniques are being practiced in the study villages?

Methodology for Research Question one

The adaptation technologies are "the application of technology to reduce the susceptibilities or strengthen the adaptive capacity of an environment to the impacts of climate change," definition by UNFCCC (UNFCCC, 2005).

To identify the application of farming techniques, reasons for low productivity and income, a preliminary study was conducted in the remote villages of Uttarakhand. The preliminary field study observed various types of crop grower farmers in the rural areas and People's Science Institute's (PSI) technical support. This would enable study on farming techniques such as the existing agriculture practices and determine the causes of crop failure in those areas. Four villages in the district of Bageshwar will be chosen for field study. These villages in Bageshwar are Palli, Walli, Kaptote and Ashon. The study will be chosen where the villages are limited agricultural extension services including farming techniques as well as.

Primary data will be collected based on household interviews with individual farmers in the villages. A detailed questionnaire is prepared after preliminary study to collect data in structured format. The livelihood vulnerability detail information will be collected with the help of a questionnaire survey form. Observations from filed surveys will help to identify the real causes of crop failure in selected villages.

RQ 2; What are the primary causes of small scale famers' livelihood vulnerability to changing climate and natural disasters?

Methodology for Research Question Two

Depending on the analysis's context, several vulnerabilities are proposed. The starting point of the outcome of susceptibility concepts is "endpoint" analysis, which focuses on how climate

change would affect production either using physical testing or using simulation model. This is also mentioned in vulnerability assessment first generation. Vulnerability assessments started to become more policy-oriented since their main goal was to explore ways to make the populations or systems under consideration less vulnerable.

The socio-economic approach to vulnerability assessment posits that the characteristics of the system are susceptible to the negative effects of an external shock (Adger and Kelly, 1999). In this situation, vulnerability is viewed as a prior condition (Jurgilevich et al., 2017) in terms of the people's health, education, wealth, etc., and the various assets of individuals are what cause variable vulnerability. The integrated method, which also considers the socioeconomic and environmental dimensions of vulnerability, combines both of these approaches.

In addition, the LVI makes use of a variety of indicators to evaluate the features of households' economic and social circumstances that affect their capacity for adaptation to change, as well as the characteristics of their current food security, water access, and health conditions that determine their sensitivity to the effects of climate change. There are two approaches: the first characterizes the LVI as a composite index made up of seven key components, and the second merges the seven components into the three components that the IPCC contributes to vulnerability: sensitivity, exposure, and adapting capacity. The study will use those two different approaches.

The parameters are as follows;

Major Component	Sub-component	Parameters
Adaptative Capacity	Socio-demographic Profile	HH Leaders' education, Age of HH Head, Ratio of Dependency, Skilled Members, Literacy Rate, Highest qualification in the family, house condition.
	Livelihood Strategies	HH member working outside/migrant worker, Receipt of loan from government and Private organization, solar plates for power supply, Battery/engine power supply, existing agricultural practices
	Social Networks	head community in last 12 months, average of distance to nearest market, agricultural extension service farmers to farmers
Sensitivity	Health	Average travel time to medical institutions, chronically ill members of family, miss employment or education center due to illness, malaria infection, corona infection, insufficient mosquito nets, without, sanitary toilet

	Food	Rely on family farm for food, they have not safe food in last 12 months, they have not safe seed in last 12 months, rely on non-cash food items, Average HH Food expenditure, Average numbers of HH struggle with find food
	Water	flooding problem on their farm, without a private source of water, difficulties with drainage water, travelling time to get the clean water through resources of water (minutes)
Exposure	Natural hazard (in Previous 10 years)	non-receive of early warming information, HH members injured because of recent natural hazards, recent natural disasters that resulted in the deaths of HH members, natural disasters causing livestock loss, natural disasters causing assets loss, monthly precipitation (last 10 years), land degradation, soil erosion

The index will be built using primary research data from household surveys. Additionally, it offers a structure for collecting and combining information at the district level to make plans for adaptive strategy and rural development. The method helps to reduce the risk of using secondary data.

RQ 3: How do small and marginal farmers see the existing agricultural practices?

Methodology for Research Question Three

To identify the vulnerability of their livelihood due to the existing agricultural practices, the study will analyze both quantitative and qualitative methods by using both primary and secondary data sources. The livelihood data sources will be grouped and implied. SPSS Version and Microsoft Excel will be used to organize a database. A descriptive statistics approach includes (e.g., percentage, mean, standard deviation, maximum, and minimum).

Ordinary Least Squares (OLS) regression analysis will be employ (Seetha et al., 2018), where the dependent variable (e.g; existing agricultural practices, adaptative measurement, barrier of adaptive measure, natural disasters and changing climate, drinking(clean) water and public health, socio demographic profile) will select livelihood indicators and the independent variables (e.g; income, education, family size, land holding size, dependency ration, migration) will include the extent and type of adaptive practices, sensitivity, and exposure.

The Meteorological Centre at Dehradun, Uttarakhand, will be used to collect the temperature and rainfall data for the last twenty years.

4. **Research Objectives**

The study aims to look at these goals in accordance with a review of the literature and a preliminary study in rural areas:

RO1: To study the existing agricultural practices of small and marginal farmers in rural areas.

RO2: To assess the vulnerability of small and marginal farmers and study the socio-economic impact of climate adaptive agricultural methods in rural areas.

RO3: To recommend the best agricultural practices for small and marginal farmers in rural areas based on vulnerability analysis.

5. **Sampling**

For the determination of sample size, the simple random sampling will be used by conducting household survey. For the determination of sample size, the study will be used Yamane (1967:886).

7. Conclusion

The research aims to introduce best agricultural adaptation practices that policymakers, funding agencies can use to help people adapt to climate change by vulnerability reduction and construct resilience, and hence, help meet sustainable development goal 1; end poverty, and goal number 13 for climate action , then related to their target 1.5 and 13.1.

In conclusion, many developing and low-income nations still depend severely on crop growing for their livelihoods and food security, particularly in their rural areas. The need for irrigation water rises along with the temperature. The study will determine the factors that contribute to crop failure in present agricultural practices, which can help small and marginal farmers. The study's second component focuses on the susceptibility of the livelihood index technique to evaluate the socioeconomic vulnerability of small and marginal farmers in rural regions. This research aims to give non-governmental organizations, administrators, and professionals from health sector useful tools to assess climate risk at the district level. The research will also make

recommendations for the best agricultural practices for climate adaptation based on vulnerability assessments. In addition, this research will support vulnerable rural farmers with a sustainable livelihood.

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