A systematic review of Nepalese farmers' climate change adaptation strategies

Article *in* Climate Policy · September 2021

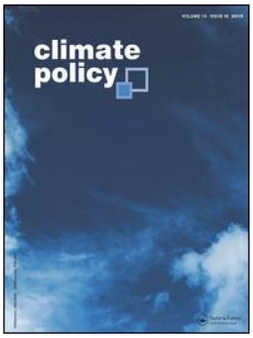
DOI: 10.1080/14693062.2021.1977600

Sushila Rijal
Prince of Songkla University

Popular Gentle
Charles Sturt University

Uttam Khanal
Agriculture Victoria

Clevo Wilson
Queensland University of Technology



Climate Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tcpo20

A systematic review of Nepalese farmers' climate change adaptation strategies

Sushila Rijal, Popular Gentle, Uttam Khanal, Clevo Wilson & Bhagawat Rimal

To cite this article: Sushila Rijal, Popular Gentle, Uttam Khanal, Clevo Wilson & Bhagawat Rimal (2021): A systematic review of Nepalese farmers' climate change adaptation strategies, Climate Policy, DOI: 10.1080/14693062.2021.1977600

To link to this article: https://doi.org/10.1080/14693062.2021.1977600

CLIMATE POLICY
https://doi.org/10.1080/14693062.2021.1977600

A systematic review of Nepalese farmers' climate change adaptation strategies

Sushila Rijal[a], Popular Gentle[b], Uttam Khanal[c], Clevo Wilson [d] and Bhagawat Rimal[e]

[a]Department of Environmental Management, Prince of Songkla University, Hat Yai, Thailand; [b]Institute for Land Water and Society, Charles Sturt University, Albury, Australia; [c]Agriculture Victoria, Department of Jobs, Precincts and Regions, Horsham, Australia; [d]School of Economics and Finance, Queensland University of Technology, Brisbane, Australia; [e]College of Applied Sciences, (CAS)-Nepal, Tribhuvan University, Kathmandu, Nepal

ABSTRACT

Given the increasing vulnerabilities and adverse effects of climate change, the development and implementation of adaptation strategies is essential. This is particularly so for Nepal where the agriculture sector – the mainstay of the country's economy – is highly vulnerable to climate change. As a country that loses much from climate change, local communities here have been adapting to climate change impacts using localized knowledge and practices. However, few studies have systematically reviewed the adaptation strategies of Nepalese farmers. We conduct such a review using the RepOrting Standards for Systematic Evidence Syntheses (ROSES) guidelines. The relevant literature is retrieved using Scopus, Web of Science and Google Scholar databases. The adaptation strategies of the Nepalese farmers are broadly categorized under seven themes and twenty-nine sub-themes: (a) access to financial resources and risk transfer; (b) diversification of livelihoods, income sources and agricultural practices; (c) spatial adaptation; (d) climate smart agriculture; (e) common pooling of resources and social action; (f) traditional and local knowledge; and (g) food and water storage and security. Diversification of livelihoods, income sources and agricultural practices are the most common adaptation strategies employed. All the strategies practiced are autonomous, have a short term orientation and reactive in nature rather than being sustainable and proactive. The outputs of this study explore the significance of the local adaptation strategies and to what extent they should be integrated into the mainstream of national and local level development plans. These findings of Nepal – are relevant to neighbouring countries such as Bhutan, Bangladesh and India.

Key policy insights:

- This study finds that locally practiced adaptation strategies have a short term and reactive focus rather than being sustainable and proactive solutions.
- Farmers are confronting weak institutions and financial and managerial difficulties in coping with climate change and adapting to its impacts; hence, local-level adaptation strategies alone cannot cope with the harsh impacts of climate change.
- The research findings indicate the urgency and need to integrate or mainstream local adaptation strategies into national and local level development planning to strengthen adaptation practice and make it sustainable.

ARTICLE HISTORY
Received 20 February 2021
Accepted 2 September 2021

KEYWORDS
Climate change adaptation; farming communities; Nepal; Systematic literature review

1. Introduction

Climate change has been recognized as a widespread phenomenon in the countries of South Asia (Ahmed et al., 2019; Rasul, 2021). This is particularly so for rural communities with subsistence-level farming where

CONTACT Sushila Rijal sushilarijal2001@gmail.com
Supplemental data for this article can be accessed at https://doi.org/10.1080/14693062.2021.1977600.

households have small land holding and are reliant on weather-dependent rain-fed agriculture (Bhandari, 2013; Howden et al., 2007; Jawid & Khadjavi, 2019; Khanal et al., 2019a; Suresh et al., 2021; Weerasekara et al., 2021). Countries highly dependent on climate-sensitive sectors such as agriculture (Pokhrel & Thapa, 2007) are therefore more vulnerable to the impacts of climate change. This is due to their poor adaptive capacities (Morton, 2007; Shrestha & Nepal, 2016), lack of institutional arrangements, the poor knowledge of farmers, higher exposure to extreme weather events and limited livelihood diversification options (Bhatta et al., 2017; Gentle et al., 2014; Morton, 2007). Increased temperature and erratic rainfall patterns have changed farming schedules, reduced water supply and availability, increased irrigation costs, increased spread of alien and invasive weeds, and increased prevalence of pest and diseases – all of which have produced a decline in agricultural production and productivity (Arunrat et al., 2017; IPCC, 2013). As well, more frequent landslides and flood events are eroding the fertile topsoil. Crops rely upon climatic factors such as moderate temperatures, adequate precipitation, humidity and solar radiation. Alterations to these factors directly impact crop yields. This in turn jeopardizes livelihoods, decreases farmers' food security and places additional socioeconomic pressure on poor communities (Bhandari, 2013).

In response to the above-mentioned climate change impacts, local farmers, governments, researchers and practitioners are exploring and adopting various adaptations strategies. Adaptation is defined as the 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC, 2007). Agricultural climate change adaptations involve the adjustment of agro-economic activities, processes and financial planning designed to combat the impacts imposed by climate change and variability (Khanal & Wilson, 2019). Adaptation strategies can be anticipatory, concurrent and reactive, and tend to minimize the harsh effects of climate change (IPCC, 2001). The nature and extent of adaptation varies according to socioeconomic context and location (Bhatta et al., 2015). The measures undertaken prior to exposure to climate change effects in order to combat possible future risks are anticipatory measures, whereas the reactive adaptations are the measures which are implemented as a response to already witnessed effects (Bhandari, 2013).

Despite its negligible contribution to global annual greenhouse gas emissions (0.05% annually) (Khadka & Pathak, 2016), Nepal is one of the countries experiencing highly adverse impacts of climate change (UNDRR, 2019) and is ranked 4th in the climate change vulnerability index (Eckstein et al., 2019). Climate-induced disasters (mainly hailstorms, avalanches, wind storms, cold waves, floods, landslides and erratic rainfall events) have been frequently witnessed in Nepal in recent years (MoHA, 2019a, 2019b), of which floods, landslides and glacial lake outburst floods (GLOF) in particular, result in very large socioeconomic and human losses (Khadka et al., 2018). Meanwhile, atmospheric warming (Shrestha & Nepal, 2016) is also being experienced. During 1971–2014, Nepal's average annual temperature increased by 0.056°C and the minimum annual temperature by 0.002°C per year (DHM, 2017), and mean temperature is expected to rise by 0.9–1.1°C during 2016–2045 to 1.3–1.8°C during 2036–2065 (MoFE, 2019a, 2019b). For example, the annual rainfall of Tarai has increased at an average of 0.49 mm per year since the 1960s (DHM, 2017). As the population of Nepal is predicted to reach 46 million by 2050 (UN, 2013), monsoonal precipitation is estimated to continue to increase by 15–20% (MoE, 2010) and flood hazards alone are projected to cause 82.9% of average annual damages. As well, the proportion of the population vulnerable to climate change impacts is expected to increase (UNISDR, 2015).

Agriculture is the mainstay of Nepal's economy contributing 27% to its GDP (MoF, 2019) – reflecting the 65.5% of the population engaged in agriculture for their livelihoods (MoALD, 2019). More than 86% of energy demand is derived from agricultural residue, forest, and animal waste (CBS, 2014). Despite its contribution, the agriculture sector has been under severe pressure due to climate change impacts in recent decades (Bandara & Cai, 2014; Karki & Gurung, 2012). Farming is mostly subsistence (Devkota et al., 2011; Shrestha & Nepal, 2016) with around 60% rain-fed (CBS, 2011; Chalise et al., 2015), and variation in climate has resulted in declining crop productivity. In 2005, crop production declined by 12.5% in eastern Nepal due to early monsoonal rainfall and large flooding events which destroyed crops in the western region. This resulted in a 30% decline in crop production (Pokhrel & Thapa, 2007; Regmi, 2007). The FAO (2009) reports a reduction in Nepalese wheat and barley production of 14.5% and 17.3%, respectively, due to the winter drought. Because of unfavourable climatic conditions, the area under rice production in Nepal declined by 7.2% in 2012 and 11.3% in 2013 (MoF, 2013). The monsoon calendar has shifted from mid-July to mid-August in Kathmandu

impacting paddy plantation. Unusual snowfall patterns in the mountain district of Darchula, the existence of mosquitoes in the mid-hill districts, receding snowfalls and retreating glaciers are other observable impacts which are the products of changed climatic conditions. Consequently, early ripening of crops, climatic zone shifts and increased prevalence of pest and diseases are also showing up as impacts of climate change (Malla,2009).

Adaptation strategies depend on socioeconomic and physical factors (Hussain et al., 2018). In Nepal, local communities have been adapting to climate change impacts through their localized adaptation strategies. These strategies are mostly local, reactive and generally *ad hoc* (Budhathoki & Zander, 2020; Nuorteva et al., 2010), mostly associated with disaster risk management and diversification (Gentle & Maraseni, 2012), and based on local indigenous knowledge (Maharjan & Maharjan, 2020). The National Adaptation Programme of Action (NAPA) (GoN, 2010), the Local Adaptation Programme of Action (LAPA) (GoN, 2011) and the Climate Change Policy, 2019 (GoN, 2019) are programmes being implemented through adaptation projects carried out by a number of institutional arrangements and local stakeholders (Regmi & Bhandari, 2013). In recent years, farmers are more concerned and informed about the impacts of climate change and are practicing adaptation through various mechanisms (Karki & Gurung, 2012). However, the existing experience, technology, knowledge and capacity are inadequate to meet the adaptation needs of farmers.

Climate change adaptation strategies are essential to address the vulnerabilities and adverse effects of climate change (Khadka et al., 2018). Implementation of appropriate strategic plans can minimize the adverse impacts of climate change in agriculture (Chhetri et al., 2012). Thus, investigating and evaluating adaptation practices at the local level are imperative to enhancing the coping capacity for climatic hazards and losses (Dhungana et al., 2020). Capturing reliable and accurate spatiotemporal data has been hindered due to the limited number of meteorological stations (Dixit, 2018). Due to topographical complexity and limited sub-district level data and research, simulating future climatic conditions and planning on a local scale becomes difficult and perception-based autonomous adaptation strategies have become imperative to combat the impacts (Vij et al., 2019). Understanding the past and current climate policy paradigms (Vij et al., 2018) and localized adaptation strategies is essential in order to shape, formulate and implement future effective climate policies.

How local people are adapting autonomously to the harsh impacts of climate change has been the topic of interest of various researchers with a number of studies investigating adaptation strategies at the local level (Chhetri et al., 2012; Dhakal et al., 2016; Gentle & Maraseni, 2012; Hussain et al., 2018; Khanal et al., 2019b; Manandhar et al., 2011; Prasain, 2018). However, such studies are based on a limited spatiotemporal framework. Moreover, the narrative reviews are neither comprehensive nor can ensure an absence of reviewer's bias. Hence, there is an absence of studies that encompass a national scenario in a broader temporal scale. Therefore, this study aims to comprehensively analyse the autonomous options that the Nepalese farmers have adapted to combat the impacts of climate change and variability in the last two decades (2000–2021). Through a comprehensive and organized systematic review accompanied by a robust methodology guided by a central research question, rigorous search strategy and screens, transparent and reliable results can be achieved. The results of this research can assist researchers and policy-makers in their understanding and exploration of how farmers in Nepal are coping and adapting to the impacts of climate change. They can also aid investigation into what extent farmers' adaptation strategies are effective and what are the areas which the government needs to contribute to. Given that adaptation planning has been initiated in Nepal at the local, regional and national level, comprehensive information on adaptation strategies generated through this study can contribute to more robust planning and implementation of adaptation programs.

1.1. Generating the research question

The research question is generated using the **P**opulation, **I**nterest and **Co**ntext (PICo) guideline adapted by various systematic review papers (Mohamad Shaffril et al., 2020). In this study, population refers to farming communities, interest relates to climate change adaptation interventions and context provides the research context in Nepal. The research question to be answered is: what are the major climate change adaptation strategies Nepalese farmers need to employ to overcome the adverse impacts of climate change?

Through this study, planners, policy-makers and researchers can acquire information about the fundamentals of local strategies used to adapt to the impacts of climate change and variability. The integration of local adaptation and knowledge are the basic inputs needed for the formulation of sustainable environmental and climate-related plans and strategic programs. Such information also helps to identify the existing gaps in current adaptation strategies.

2. Methodology

2.1. Review guideline – ROSES

The study is based on the RepOrting Standards for Systematic Evidence Syntheses (ROSES) review protocol which is recognized as an important tool for environmental management (Haddaway et al., 2018; Mohamad Shaffril et al., 2020). It is capable of guiding researchers through the process of accurately responding to research questions. A systematic search process comprises a process of identification, screening (defining inclusion and exclusion criteria) and eligibility assessment. It is followed by quality appraisal, data acquisition, abstraction and analysis (Ishtiaque et al., 2020).

2.2. Systematic literature retrieval and processing strategy

A systematic search strategy was adopted for the acquisition of data which includes the planned steps of research question formulation, identification, screening, eligibility, quality appraisal and data extraction (Figure 1). This is presented in detail in the sections below.

2.2.1. Identification

The appropriate data were identified by the use of synonyms, central key words and related terms (Okoli, 2015) generated on the basis of experts' suggestions and previous studies. The search process was mainly focused on Scopus and Web of Science, two of the most comprehensive databases for refereed published material on climate change and adaptation (Zhu & Liu, 2020). These databases are widely used as they are systematically managed and therefore appropriate for a systematic review process (Falagas et al., 2008) and for assembling high quality research papers in multiple disciplines including environmental management (Gusenbauer & Haddaway, 2020; Martín-Martín et al., 2018). In the search string, key and associated words were searched using the Boolean operator (OR, AND), field code function, truncation and phrase search (Table 1). Google Scholar, a publicly available database which contains scholarly journal articles of multiple disciplines (Gusenbauer, 2019; Orduña-Malea et al., 2017), was used as a supplementary database source (Haddaway et al., 2015). A total of 2083 articles were provisionally retrieved from these sources.

Table 1. Boolean database search from Web of Science and Scopus, and advance search in Google Scholar.

Database	Search string
Web of Science	TS=(('Climat* chang*' OR 'climat* variabilit*' OR 'climat* hazard*' OR 'climat* risk*' OR 'global warming* ' OR 'glacial* melt*' OR 'climat* extrem*' OR 'extrem* rainfall*' OR 'drought*' OR 'flood*' OR 'wildfire*' OR 'hot wave*' OR 'climat* uncertainit*' OR 'climat* disaster*' OR 'climat* impact*') AND ('Adapt* abilit*' OR 'adapt* strateg*' OR 'adapt*' OR ' adapt capacit*' OR 'adapt potential*' OR 'adapt *practice*' OR 'adapt* mechanism*' OR 'adapt* strength*' OR 'adapt* trend*' OR 'adapt* capabilit*') AND ('Cultivator*' OR 'agronomist*' OR 'harvester*' OR 'agriculturist*' OR 'peasant*' OR 'farm-hand*' OR 'farmer*' OR 'planter*' OR 'rancher*' OR 'pastoral*') AND (Nepal*))
Scopus	('climat* chang*' OR 'climat variabilit*' OR 'climat* hazard*' OR 'climat risk*' OR 'extrem heat*' OR 'global warming*' OR 'glacial melt*' OR 'extrem cold*' OR 'extrem* rainfall*' OR 'extreme* heat' OR 'drought*' OR 'flood*' OR 'wild fire*' OR 'hot wave*') AND ('Adapt* abilit*' OR 'adapt* strateg*' OR 'adapt*' OR 'adapt capacit*' OR 'adapt* potential*' OR 'adapt* practice*' OR 'adapt* mechanism*' OR 'adapt* strength*' OR 'adapt* trend*' OR 'adapt* capabilit*') AND (agronomist* OR harvester* OR agriculturist* OR peasant* OR farmer* OR planter* OR rancher* OR pastoral*) AND TITLE-ABS-KEY (adapt*) AND (nepal*)
Google Scholar	'climate change adaptation in Nepal'

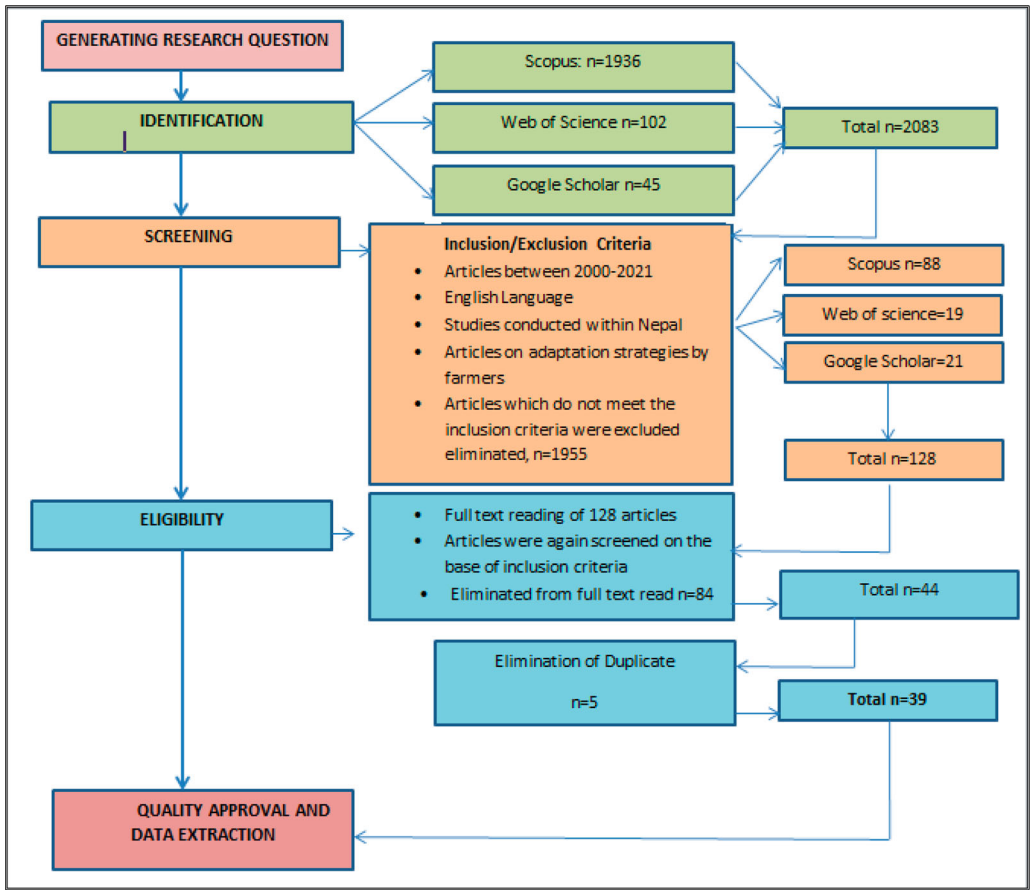


Figure 1. Flow diagram showing the steps of systematic search strategy.

2.2.2. Screening

The research question was placed at the centre while screening the data. As the impact of and adaptation to climate change and adaptation strategies have become more important in recent years, the journal articles on climate change adaptation between 2000 and 2021 were selected. In particular, the journal articles published relating to climate change adaptation in Nepal and in the English language were chosen. However, data before 2000, non-English language texts, conference proceedings and countries other than Nepal were excluded. Web of Science produced 19 articles, Scopus 88 articles, while 21 articles were retrieved from Google Scholar's search engine. All articles' abstracts were carefully examined to ensure the objective of the research was relevant to the research question of this study. A total of 87 articles were eliminated leaving a total of 41 eligible articles. The eliminated articles were found not eligible given they focused either on impacts, vulnerability, challenges or problems relating to climate change adaptation, did not relate to Nepal or related to other occupations apart from agriculture.

2.2.3. Eligibility

The endnotes of the remaining 41 articles were exported and compared to each other. Five of them were found to be duplicates and hence removed. Finally, 36 articles were selected for the systematic review and were further organized for analysis using endnote reference managing systems. All 36 articles were processed and manually observed for eligibility. The full texts of all 36 articles were then retrieved for quality appraisal.

2.2.4. Quality appraisal

A total of 36 articles were processed for quality appraisal. This was conducted to ensure the content quality of the selected literature (Mohamad Shaffril et al., 2020) and avoid bias (Ishtiaque et al., 2020). The selected articles were sent to two experts who were asked to categorize the quality of literature as: (a) high quality, (b) moderate quality, and (c) low quality in terms of content. The low quality literatures were to be excluded. Of the total 36 articles, experts identified 28 studies of high quality and 8 of moderate quality. Therefore, all 36 studies were eligible for final review and hence were extracted for analysis.

2.3. Analysis of data

We used the integrative review method to analyse the acquired data. This is an approach which synthesizes the previous literature and provides an inclusive understanding of the generated research question (Whittemore & Knafl, 2005). Synthesizing the literature thematically is a well-recognized approach for an integrative review (Flemming et al., 2019). The authors, in conducting the integrative review of the assembled literature, classified the central idea – i.e. adaptation strategies – into themes and sub-themes. In doing so, an in-depth analysis of the abstracts was carried out and the broad form of adaptation strategies (themes) and adaptation actions (sub-themes) were identified and grouped. The categorization of themes was developed by Gentle et al. (2018). The themes and sub-themes were cross-checked and verified by the corresponding author and the two co-authors to ensure the relevancy of the groupings. An inclusive and representative nomenclature was applied to the main group (theme). The factors of inclusion and consistency were duly focused in the process of generating themes and sub-themes. Then, classification of the literature according to spatial and temporal scales was the first step of analyses. This was followed by content analysis of individual studies to explore the impact of climate change on agriculture and farmer's autonomous adaptation strategies to combat their effects. Using the integrative review approach, adaptation strategies reported in all the studies were summarized through descriptive statistical analysis.

3. Results

3.1. Introducing the literature

Of the total 36 selected articles, seven were published in 2020, six in 2017, five in 2016 and 2018, three in 2013 and 2019, two in 2014 and 2021, one in 2011, 2012 and 2015. No literature was retrieved for the period 2000–2010.

Spatially, 36 articles incorporated the cases and contexts of 31 administrative districts: Chitwan (5), Rupandehi (4), Rasuwa (4), Mustang (2), Dhading (2), Lamjung (2), Kanchanpur (2), Banke (2), Sunsari (2), Sindhuli (2), Kavre, Saptari, Sarlahi, Bardiya, Nuwakot, Sindhupalchowk, Solukhumbu, Dolakha, Gorkha, Ramechhap, Bara, Ilam, Rautahat, Syangja, Jumla, Surkhet, Bhojpur, Kailali and Sankhuwasabha. Additionally, the selected articles incorporated Koshi Basin, Budhigandaki Basin, Kaligandaki Basin, four watersheds of western Nepal (Seti, Mohana, Bheri and Karnali), the Sindhukhola watershed, the Melamchi Valley (2), the Indrawati Basin (2), the Khaptad and Panchase regions. Meanwhile, three works dealt with the overall national scenario. Two studies were focused on the Hindu Kush region of the Himalayas: one study was simultaneously conducted in five other countries (China, India, Afghanistan, Bhutan and Pakistan) including Nepal (Upper Mustang region); and the other in Pakistan (upper Indus), Nepal (Koshi), India (Eastern Bramhaputra) and China (Salween and Mekong regions). Two other works had simultaneously reported about the cases of India (Bihar) and Nepal (Koshi Basin), and flood plains of India, Bangladesh and Nepal (Figure 2).

Researchers have investigated how a change in climatic conditions has adversely impacted agriculture sectors. Some of the reported visible impacts of climate change are due to a rise in temperature, irregular precipitation, extreme weather events and increased natural hazards causing land desertification and degradation. Such events have several far-reaching consequences such as degradation of natural resources, pest attacks, delayed planting time, decreased crop yield and increased hazardous events. All of these have directly impacted the livelihoods of poor farming communities, which have been employing a range of corrective

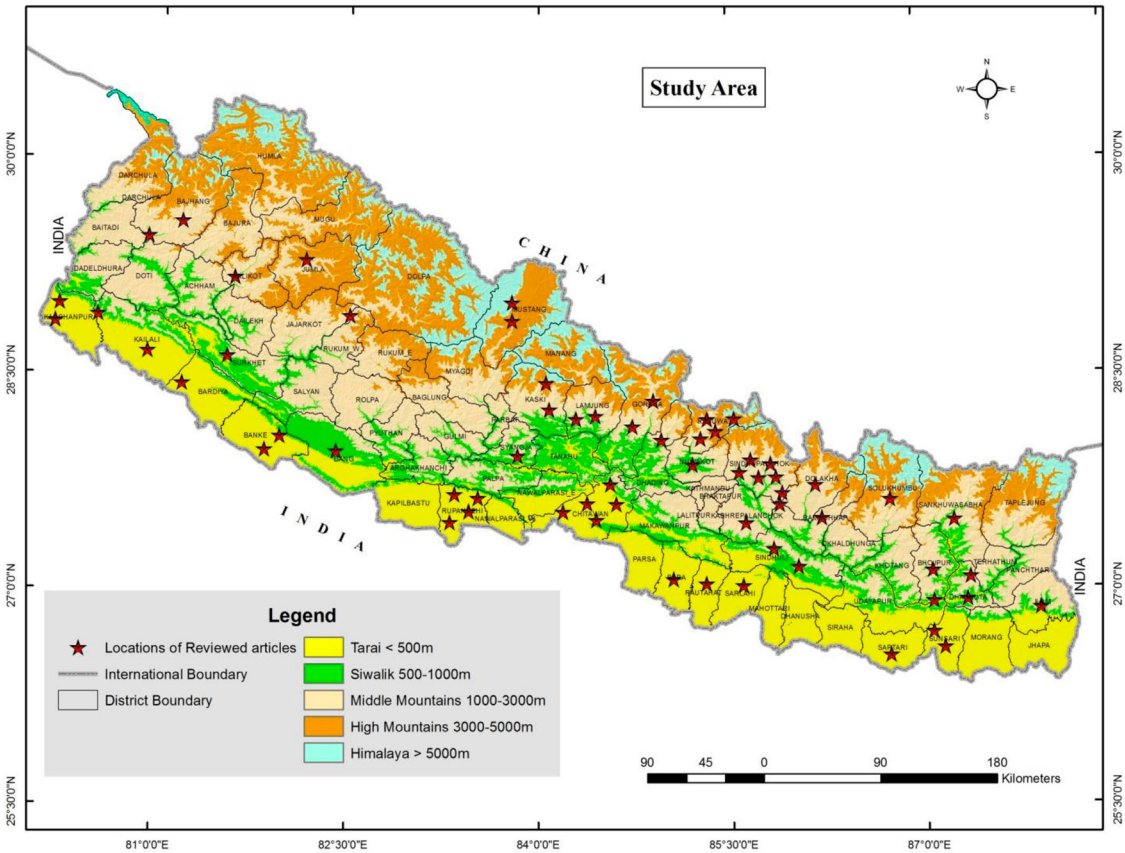


Figure 2. Physiographic map of Nepal indicating the locations of the reviewed 36 selected articles.

strategies such as diversification of livelihood practices, income sources and agricultural practices, adoption of spatial and technological practices, communal and collective efforts, and application of traditional and local knowledge. Such adaptation practices investigated in the selected literature are thematically presented in the section below.

3.2. Thematic categorization

In this analysis, the adaptation strategies identified were thematically categorized into 7 themes and 29 subsequent sub-themes. The adaptation priorities explored in the literature are presented in Table 2.[1]

3.3. Analysis of the adaptation strategies identified in the selected articles

The first theme- access to financial resource/credit and risk transfer are considered good means to adapt to the impact of climate change. In order to combat financial hardship and food scarcity during crop failures and emergencies, local people rely on immediate financial assistance from formal and informal institutions, while crop insurance is a longer term strategy to reimburse loss and damage from adverse climatic impacts.

Diversification of livelihoods, income sources and agricultural practices is the second theme in this article which includes other strategies farmers have incorporated to adapt to climate change. When sustaining a livelihood becomes difficult, people tend to become involved in multiple professions and ways of earning, farming and land utilization practices. Livelihood and income diversification related adaptation mechanisms include:

Table 2. Summary of the local adaptation strategies adopted by the farmers explored from the systematic review of the selected articles.

Themes	Sub-themes	Number of articles
Access to financial resource and risk transfer (AFR)	Access to formal and informal institutions (ACI)	7
	Farm and crop insurance (FI)	5
	Consumption of loans from money lenders (CL)	5
Diversification of livelihood, income sources and agricultural practices (DLIA)	Livelihood and income diversification (LID)	25
	Agricultural diversification (AD) (intercropping/mixed cropping/ quitting failed species)	23
	Land-use related diversification (LD)	11
	Change in crop calendar (CC)	14
Spatial adaptation (SA)	Internal/external migration (IEM)	9
	Seasonal migration (SM)	6
Climate smart agriculture (CSA)	Use of agro-chemicals (AC)	9
	Drought and flood tolerant crop species and varieties (DFC)	4
	Improved varieties introduce high yielding crops/breeds/shed (IV)	15
	Tunnel farming (TF)	4
	Alternative energy use (AE)	3
	Weather forecasting (WF)	7
	Improved/alternative irrigation (IAI)	14
	Agricultural and veterinary information (AV)	5
Common pooling of resource and social action (CRS)	Structural adaptation measures (water, irrigation, roads, embankments) (SAM)	9
	Measures for hazard controlling (MHC)	5
	Knowledge and experience sharing (KES)	2
	Kinship support (KS)	4
	Rotational resource use (RU)	5
	Social bonding (SB)	7
Traditional and local knowledge (TaLK)	Less water consumption (LWC)	2
	Organic farming (OF)	10
	Soil management practice mulching, contour farming, terracing and traditional sloping (SMP)	2
Food and water storage and security (FWS)	Food storage (FS)	4
	Water storage and management techniques (WMT)	17
	Agricultural residue storage (ARS)	2

wage and labour based income, selling livestock, milk and eggs, selling and/or mortgaging land, shifting to a skilled job, changes in eating habits and dropping off children from school, collection and sale of non-timber forest products (NTFP) such as medicinal herbs, and tourism-related activities. Similarly, diversification of agricultural practices includes changed farming practices, improved crop varieties, alternative cropping patterns and planting less water consuming species. Meanwhile, land-related diversification options refer to mulching, minimum tillage, terracing and sloping, changed land use, intercropping and mixed cropping. To combat the climate-induced hazards or minimize the effects, farmers typically make adjustments to the crop calendar. They continuously change the date and time of planting, weeding and application of agro-chemicals.

Another strategy, spatial adaptation, is categorized into two sub-themes: internal/external migration and seasonal movement of people and livestock. Spatial adaptation options are supportive of farmers during the failure of the subsistence peasant economy in rural Nepal. For example, studies have reported on labour migrations within the country, overseas and to Indian labour markets. People also migrate from hazard-prone areas and resettle in safer regions in order to avoid loss and damage from disaster events. The movement of livestock at various carefully chosen altitudes can control overgrazing and minimize the damage caused by overexploitation of resources.

Climate smart technologies – the fourth theme in this work-include practices which are water-smart, weather-smart, nutrient-smart, energy-smart and knowledge-smart. Thus, they range from simple adjustment practices such as sowing, planting, irrigating, and using agro-chemicals, to harvesting and transforming agricultural productions (Poudel et al., 2017). Climate smart agricultural practices have been further classified under the following sub-themes in this analysis: use of agro-chemicals, improved varieties of seeds, new breeds and sheds, tunnel farming, alternative energy, weather forecasts technology, improved/alternative irrigation, and drought and flood tolerant species and varieties. Similarly, studies have also reported on farmer's

accessibility to technical support such as agricultural and veterinary information, weather forecasting systems and to a choice of alternative energies such as LPG gas, biogas and improved stoves in place of firewood. Farmers use chemical fertilizers, pesticides and insecticides in order to increase crop yields (Sujakhu et al., 2016b). Additionally, farmers are making use of productive inputs such as improved forage, vaccines, medicines (Dhakal et al., 2016), and varieties of higher yielding crops, breeds or sheds. Management of water resources is one of the crucial challenges raised by climate change (Iglesias & Garrote, 2015), where improved/alternative irrigation is the only option. Studies have reported that farmers – who are often exposed to water-stress and crop failure – use cost-effective plastic ponds to reduce water seepage. Additionally, concrete ponds and rainwater harvesting systems are also used to irrigate vegetable gardens using sprinkler systems (Sugden et al., 2014).

Common pooling of resource and social action is the next theme which incorporates five sub-themes: structural adaptation measures for hazard controlling, knowledge and experience sharing, kinship support, rotational resource use, and social bonding. To cope with disastrous events, people become collectively involved in hazard control and infrastructure development activities, such as collective action in bio-engineering mechanisms, the plantation in landslide and flood hazard prone areas, constructions of gabion walls, and dam construction on riverbanks for flood hazard control. Consequently, there is collective sharing of knowledge and experience, and rotational use of resources such as irrigation systems, water, pastures and grazing lands (Aryal et al., 2018; Bastakoti et al., 2017). Furthermore, during adverse situations, people seek kinship support for loans from friends and family circles which is noted to be an effective practice acting as a form of insurance during times of crop failure (Chhetri et al., 2013; Hussain et al., 2016; Sujakhu et al., 2016a; Aryal et al., 2018).

Similarly, traditional and local knowledge includes three sub themes: less water consumption, organic farming and traditional soil management. Studies have reported that people collect kitchen water for kitchen gardens and create deep irrigation around fields as techniques for water management (Adhikari et al., 2018; Biggs et al., 2013). As terracing can control topsoil erosion during periods of high rainfall and can maintain water storage during dry seasons, farmers use terrace management practices. Similarly, mulching, cover crops, and flood control are also practiced by farmers in the three ecological regions of Nepal (Mountain, Hill and Tarai) (Pradhan et al., 2015).

Finally, studies also report water storage, food storage and agricultural residue storage for future consumption during emergencies as important strategies. Rainwater collection, kitchen-waste-water collection, groundwater trenching, and plastic ponds are some of the water management techniques used to cater to water demand during the dry seasons.

4. Discussion

In this section, we further discuss what we found from the review of existing literature on climate change adaptations employed in Nepalese agriculture. Additionally, we present the research gaps and scope for future research, policy implications and make recommendations for adaptation strategies.

The livelihood options in practice primarily benefit those farmers who have access to financial resources and who can diversify their land and income resources through utilizing alternative options. For example, access to financial services and credit was found to be a coping strategy for farmers. However, access to formal institutions is limited to those who can provide collateral or financial assurance. Receiving remittance through overseas labour migration is an important source of income for the Nepalese economy, but extremely poor households who cannot invest in the minimal overseas travel costs do not stand to benefit from this option and therefore have to rely on local money lenders for emergency loans. Taking loans from money lenders at high interest rates pushes them towards indebtedness, thereby limiting their livelihood options and drawing them into a vicious circle of poverty. Moreover, land and agriculture related diversification as a livelihood option is viable only for farmers who possess their own land. Extremely poor landless households typically sustain themselves through income diversification options such as being paid a daily wage or off farm labour, changing food behaviour, dropping off children at school, and selling their belongings including food and grains. The loss of production – even in productive farm lands – due to high labour and production

costs and lack of productive farmland ownership by poor farmers accounts for share farming (sharing cost and production by both owners) being reported as a useful option for increasing crop yields (Gentle et al., 2018). Crop insurance in Nepal has very limited expansion potential due to multiple inhibiting factors such as lack of manpower, poor distribution networks and high transaction costs (Dhakal, 2019). The adaptation measures that are autonomous are conventional and do not overcome the inefficacy of such strategies, therefore their revitalization is seen as essential (Pathak, 2021).

Regarding spatial adaptation, farmers in hill and mountain areas typically migrate to city cores and their outskirts due to wider economic opportunities and the quest for a better quality of life (Rijal et al., 2020). Due to the failure of subsistence agriculture, farmers have migrated overseas by borrowing money from local lenders Yet others have shifted permanently to other rural areas due to water scarcity in the original region (Gentle et al., 2018). Despite its potential, national and local adaptation plans have not recognized the role of spatial adaptation options such as transhumant pastoralism and the traditional herders as a form of institutional support in continuing these age-old practices.

Most of the adaptation strategies are reactive in nature and have been implemented autonomously by farmers. Rather than following adaptation plans based on an analysis of potential hazards, assessing the implications on their livelihoods and using science-based adaptation measures, most of the responses are largely based on farmers' traditional and local knowledge (Regmi & Bhandari, 2013). This analysis shows that the adaptation practices in use are inadequate in comparison to increasing risks and the vulnerabilities that are commonly indicated as the limitations of autonomous adaptation. This analysis further reveals that although reactive and autonomous practices based on local knowledge and practice are important as survival strategies for farmers, such practices cannot be effective unless they are blended with modern knowledge, science and technology (Race et al., 2016). Studies also claim that unplanned and short term coping practices applied to address climate change impacts may not always be supportive; rather they may lead towards mal-adaptation (Brooks et al., 2009; Gentle et al., 2013). This has important policy implications in the context of ongoing adaptation planning in Nepal.

Given interlinking local adaptation practices with national level adaptation strategies is one of the major challenges of developing countries (Regmi et al., 2016), there is an urgent need to integrate and mainstream adaptation into development plans and thereby promote climate-smart development rather than implementing climate change adaptation and development as separate strands (Regmi & Bhandari, 2013). To understand, specify and implement policy, organizational structure has a crucial role so that the process-driven, rational and bureaucratic meta organizations can ensure legitimacy and effectiveness of local and national adaptation interlinkage (Chaudhury et al., 2016). We, therefore, suggest involving farmers and farming communities in the adaptation planning process for the effective design and implementation of climate change adaptation plans, programs and actions. This review shows that strengthening social capital in the form of local institutions such as agriculture groups and forest user groups is an important adaptation strategy (Aryal et al., 2018; Maharjan et al., 2017; Sujakhu et al., 2018). This in turn suggests that local government bodies and extension agencies need to create enabling environments for farmers to be organized and institutionalized. Additionally, location specific low cost technology, wider adaption know-how, structural development to combat hazards, weather-resilient crop varieties, better use of weather forecasting system and the need for technical knowledge to minimize the rampant use of fgchemical fertilizer and pesticides are imperative (ANPFa, 2011).

Studies have well-documented adaptation strategies. However, not all strategies are equally effective in adapting to different types of impacts imposed by climate change. Comprehensive appraisal of each adaptation option against specific climate change impacts would provide clear policy implications. Furthermore, given the distinct agro-ecological regions in Nepal, not all adaptation strategies are applicable in all the regions. Regional and local level analysis of adaptation strategies can have important implications relating to whether policies aimed at minimizing climate change impacts in one region can be applied to others. Moreover, some adaptation strategies identified are effective only in the short run. For example, climate-induced seasonal migration might not be a long-term solution, whereas common pooling of resources and social action could be a sustainable adaptation strategy. Studies have mostly focused on climate change impacts and adaptations at the production stage. However, climate change and variability have affected farmers throughout the food production channel starting from input supply to marketing of the final produce. There is also a need to properly document

and analyse various coping strategies adopted by farmers and turn them into local adaptation plans. Equally, the adaptation needs of farmers need to be integrated with local governments' planning processes to provide continuous support to farmers and help make the local investment market more robust. Furthermore, existing climate adaptation studies and programs have generally focused on the strategies combatting climate change at a general level. However, it is imperative to identify adaptation strategies that can be applied to specific types of disasters and natural hazards.

5. Conclusions

This study has revealed that the farming communities in Nepal have been adapting to the decline in agricultural production and its effects on their livelihoods through multiple coping strategies. However, these strategies are short term and reactive rather than sustainable and proactive, and they are inadequate in terms of the adaptation needs of farmers and local communities. Farmers are confronted with numerous difficulties in their adaptation, such as weak institutional and managerial capacity, limited access to finance, and risk transfer measures such as crop and livestock insurance. Due to a lack of access to formal financial institutions, poor farmers are depending on money lending which is leading to prolonged indebtedness and dependency of poorer farmers on the well-off. Weather related information is not accessible to most rural farmers and is not farmer-oriented. Even in areas of technological advancement, farmers have not benefitted as anticipated, due to a lack of climate awareness. Despite efforts in terms of national and local adaptation plans of action, there is very limited institutional, technical and financial support from the government to integrate and mainstream local adaptation plans into development plans and strategies. Overseas migration has been widespread with previously productive farm lands left barren or subject to reduced crop yields. Hence, proactive adaptation strategies are essential to cater to changing climatic conditions. Traditional local knowledge, therefore, needs to be integrated with modern scientific knowledge as a blended approach. Also imperative is building greater institutions within the government together with better development of technical, financial and longer term adaptation plans.

This study does have limitations. Given the geographical and resource base differences across the different ecological regions in Nepal, different adaptation strategies would be appropriate in a number of regions. Moreover, this study is solely based on a review of previous studies. The adaptation strategies identified via a systematic review such as this can be usefully further validated through field assessment so as to identify actual farm-based adaptations. As the outputs indicate the need of mainstreaming local adaptation strategies in local and national level plans to make the adaptation practices sustainable and proactive. Further research and analysis is therefore clearly warranted to explore region-specific adaptation strategies employing systematic review and field assessments.

Note

1. Detail of the reported adaptation strategies in the selected literature is presented in Supplementary Table 1 (S1). The summary of thematic results (in tabular form) is presented in Supplementary Table 2-a (S2-a). Similarly, detailed results by theme and spatial descriptions are presented in Supplementary Table 2-b (S2-b) (sections 3.2.1 to 3.2.7).

Acknowledgement

We would like to acknowledge the three anonymous reviewers for their time and effort to review our manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Clevo Wilson http://orcid.org/0000-0002-3885-0495

References

Adhikari, S., Baral, H., & Nitschke, C. (2018). Adaptation to climate change in panchase mountain ecological regions of Nepal. *Environments*, *5*(1), 1–18. https://doi.org/10.20448/journal.505.2018.51.1.7

Ahmed, A. U., Appadurai, A. N., & Neelormi, S. (2019). Status of climate change adaptation in South Asia region. In M. Alam, J. Lee, & P. Sawhney (Eds.), *Status of climate change adaptation in Asia and the pacific* (pp. 125–152). Springer International Publishing.

ANPFa. (2011). *Documentation of climate change impacts, community perceptions and adaptation practices in a rice farming community in Nepal*. All Nepal Peasants' Federation (ANPFa) in collaboration with Pesticide Action Network Asia and the Pacific.

Arunrat, N., Wang, C., Pumijumnong, N., Sereenonchai, S., & Cai, W. (2017). Farmers' intention and decision to adapt to climate change: A case study in the Yom and Nan basins, Phichit province of Thailand. *Journal of Cleaner Production*, *143*, 672–685. https://doi.org/10.1016/j.jclepro.2016.12.058

Aryal, S., Panthi, J., Dhakal, Y. R., Gaire, N. P., Karki, K., & Joshi, N. R. (2018). Historically evolved practices of the Himalayan transhumant pastoralists and their implications for climate change adaptation. *International Journal of Global Warming*, *14*(3), 356–371. https://doi.org/10.1504/IJGW.2018.090402

Bandara, J. S., & Cai, Y. (2014). The impact of climate change on food crop productivity, food prices and food security in South Asia. *Economic Analysis and Policy*, *44*(4), 451–465. https://doi.org/10.1016/j.eap.2014.09.005

Bastakoti, R. C., Bharati, L., Bhattarai, U., & Wahid, S. M. (2017). Agriculture under changing climate conditions and adaptation options in the Koshi Basin. *Climate and Development*, *9*(7), 634–648. https://doi.org/10.1080/17565529.2016.1223594

Bhandari, G. (2013). Assessment of climate change impacts and adaptation measures in the Kapilbastu district of Nepal. *Applied Ecology and Environmental Sciences*, *1*(5), 75–83. https://doi.org/10.12691/aees-1-5-2

Bhatta, G., Ojha, H., Aggarwal, P. K., Sulaiman, R., Sultana, P., Thapa, D., Mittal, N., Dahal, K., Thompson, P., & Ghimire, L. (2017). Agricultural innovation and adaptation to climate change: Empirical evidence from diverse agro-ecologies in South Asia. *Environment, Development and Sustainability*, *19*(2). https://doi.org/10.1007/s10668-015-9743-x

Bhatta, L. D., van Oort, B. E. H., Stork, N. E., & Baral, H. (2015). Ecosystem services and livelihoods in a changing climate: Understanding local adaptations in the Upper Koshi, Nepal. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *11*(2), 145–155. https://doi.org/10.1080/21513732.2015.1027793

Biggs, E. M., Tompkins, E. L., Allen, J., Moon, C., & Allen, R. (2013). Agricultural adaptation to climate change: Observations from the mid-hills of Nepal. *Climate and Development*, *5*(2), 165–173. https://doi.org/10.1080/17565529.2013.789791

Brooks, N., Grist, N., & Brown, K. (2009). Development futures in the context of climate change: Challenging the present and learning from the past. *Development Policy Review*, *27*(6), 741–765. https://doi.org/10.1111/j.1467-7679.2009.00468.x

Budhathoki, N. K., & Zander, K. K. (2020). Nepalese farmers' climate change perceptions, reality and farming strategies. *Climate and Development*, *12*(3), 204–215. https://doi.org/10.1080/17565529.2019.1612317

CBS. (2011). *Nepal living standard survey 2010/11*. *Statistical report*. Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal.

CBS. (2014). *Statistical pocket book of Nepal*. Central Bureau of Statistics, Government of Nepal.

Chalise, S., Maraseni, T. N., & Maroulis, J. (2015). Adapting to climate variability: The views of peasant farmers in Nepal. *International Journal of Global Warming*, *7*(3), 380–394. https://doi.org/10.1504/IJGW.2015.069369

Chaudhury, A. S., Ventresca, M. J., Thornton, T. F., Helfgott, A., Sova, C., Baral, P., Rasheed, T., & Ligthart, J. (2016). Emerging meta-organisations and adaptation to global climate change: Evidence from implementing adaptation in Nepal, Pakistan and Ghana. *Global Environmental Change*, *38*, 243–257. https://doi.org/10.1016/j.gloenvcha.2016.03.011

Chhetri, N., Chaudhary, P., Tiwari, P. R., & Yadaw, R. B. (2012). Institutional and technological innovation: Understanding agricultural adaptation to climate change in Nepal. *Applied Geography*, *33*, 142–150. https://doi.org/10.1016/j.apgeog.2011.10.006

Chhetri, N., Subedi, M., & Ghimire, S. (2013). Niche-based responses in addressing the climatic constraints to farm production: Analogues to climate-change adaptation in Nepal. *Climate and Development*, *5*(2), 174–181. https://doi.org/10.1080/17565529.2013.789790

Devkota, R. P., Bajracharya, B., Maraseni, T. N., Cockfield, G., & Upadhyay, B. P. (2011). The perception of Nepal's Tharu community in regard to climate change and its impacts on their livelihoods. *International Journal of Environmental Studies*, *68*(6), 937–946. https://doi.org/10.1080/00207233.2011.587282

Dhakal, N. H. (2019). Agricultural credit and insurance in Nepal: Coverage, issues, and opportunities. In G. Thapa, A. Kumar, & P. K. Joshi (Eds.), *Agricultural transformation in Nepal: Trends, prospects, and policy options* (pp. 529–572). Springer.

Dhakal, S., Sedhain, G. K., & Dhakal, S. C. (2016). Climate change impact and adaptation practices in agriculture: A case study of Rautahat district, Nepal. *Climate*, *4*(4). https://doi.org/10.3390/cli4040063

DHM. (2017). *Observed climate trend analysis (1971–2014)*. Department of Hydrology and Meterology, Government of Nepal.

Dhungana, N., Silwal, N., Upadhaya, S., Khadka, C., Regmi, S. K., Joshi, D., & Adhikari, S. (2020). Rural coping and adaptation strategies for climate change by Himalayan communities in Nepal. *Journal of Mountain Science*, *17*(6), 1462–1474. https://doi.org/10.1007/s11629-019-5616-3

Dixit, A. (2018). *Climate change in Nepal: Impacts and adaptive strategies*. World Resources Report. http://www.wri.org/ourwork-/project/world-resources-report/climate-change-in-nepalimpacts-and-adaptive-strategies

Eckstein, D., Marie-Lena, H., & Maik, W. (2019). *Global climate risk index, 2019, who suffers most from extreme weather events? Weather-related loss events in 2017 and 1998 to 2017*. Germanwatch.

Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: Strengths and weaknesses. *The FASEB Journal*, *22*(2), 338–342. https://doi.org/10.1096/fj.07-9492LSF

Flemming, K., Booth, A., Garside, R., Tunçalp, Ö, & Noyes, J. (2019). Qualitative evidence synthesis for complex interventions and guideline development: Clarification of the purpose, designs and relevant methods. *BMJ Global Health*, *4*(Suppl. 1), e000882. https://doi.org/10.1136/bmjgh-2018-000882

Gentle, P., & Maraseni, T. N. (2012). Climate change, poverty and livelihoods: Adaptation practices by rural mountain communities in Nepal. *Environmental Science & Policy*, *21*, 24–34. https://doi.org/10.1016/j.envsci.2012.03.007

Gentle, P., Thwaites, R., Race, D., & Alexander, K. (2013). Changing role of local institutions to enable individual and collective actions for adapting to climate change.

Gentle, P., Thwaites, R., Race, D., & Alexander, K. (2014). Differential impacts of climate change on communities in the middle hills region of Nepal. *Natural Hazards*, *74*(2), 815–836. https://doi.org/10.1007/s11069-014-1218-0

Gentle, P., Thwaites, R., Race, D., Alexander, K., & Maraseni, T. (2018). Household and community responses to impacts of climate change in the rural hills of Nepal. *Climatic Change*, *147*(1-2), 267–282. https://doi.org/10.1007/s10584-017-2124-8

GoN. (2010). *National Adaptation Programme of Action (NAPA)*. Ministry of Environment, Government of Nepal.

GoN. (2011). *National framework on local adaptation plans for action (LAPA)*. Government of Nepal.

GoN. (2019). *National climate change policy*. Ministry of Health and Population (MoHP).

Gusenbauer, M. (2019). Google Scholar to overshadow them all? Comparing the sizes of 12 academic search engines and bibliographic databases. *Scientometrics*, *118*(1), 177–214. https://doi.org/10.1007/s11192-018-2958-5

Gusenbauer, M., & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research Synthesis Methods*, *11*(2), 181–217. https://doi.org/10.1002/jrsm.1378

Haddaway, N. R., Collins, A. M., Coughlin, D., & Kirk, S. (2015). The role of Google Scholar in evidence reviews and its applicability to grey literature searching. *PLoS One*, *10*(9), e0138237. https://doi.org/10.1371/journal.pone.0138237

Haddaway, N. R., Macura, B., Whaley, P., & Pullin, A. S. (2018). ROSES reporting standards for systematic evidence syntheses: Pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environmental Evidence*, *7*(1), 7. https://doi.org/10.1186/s13750-018-0121-7

Howden, S. M., Soussana, J.-F., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences*, *104*(50), 19691–19696. https://doi.org/10.1073/pnas.0701890104

Hussain, A., Rasul, G., Mahapatra, B., & Tuladhar, S. (2016). Household food security in the face of climate change in the Hindu-Kush Himalayan region. *Food Security*, *8*(5), 921–937. https://doi.org/10.1007/s12571-016-0607-5

Hussain, A., Rasul, G., Mahapatra, B., Wahid, S., & Tuladhar, S. (2018). Climate change-induced hazards and local adaptations in agriculture: A study from Koshi River Basin, Nepal. *Natural Hazards*, *91*(3), 1365–1383. https://doi.org/10.1007/s11069-018-3187-1

Iglesias, A., & Garrote, L. (2015). Adaptation strategies for agricultural water management under climate change in Europe. *Agricultural Water Management*, *155*, 113–124. https://doi.org/10.1016/j.agwat.2015.03.014

IPCC. (2001). Overview of impacts, adaptation and vulnerability too climate change.

IPCC. (2007). *Intergovernmental panel on climate change (IPCC) Assessment of adaptation practices, options, constraints and capacity*. Cambridge University Press.

IPCC. (2013). *The physical science basis. Working group I contribution to the IPCC fifth assessment report. Intergovernmental panel on climate change (IPCC) climate change*. Cambridge University Press.

Ishtiaque, A., Masrur, A., Rabby, Y. W., Jerin, T., & Dewan, A. (2020). Remote sensing-based research for monitoring progress towards SDG 15 in Bangladesh: A review. *Remote Sensing*, *12*(4). https://doi.org/10.3390/rs12040691

Jawid, A., & Khadjavi, M. (2019). Adaptation to climate change in Afghanistan: Evidence on the impact of external interventions. *Economic Analysis and Policy*, *64*, 64–82. https://doi.org/10.1016/j.eap.2019.07.010

Karki, R., & Gurung, A. (2012). An overview of climate change and its impact on agriculture: A review from least developing country, Nepal. *International Journal of Ecosystem*, *2*(2), 19–24. https://doi.org/10.5923/j.ije.20120202.03

Khadka, C., Aryal, K. P., Edwards-Jonášová, M., Upadhyaya, A., Dhungana, N., Cudlin, P., & Vacik, H. (2018). Evaluating participatory techniques for adaptation to climate change: Nepal case study. *Forest Policy and Economics*, *97*, 73–82. https://doi.org/10.1016/j.forpol.2018.08.017

Khadka, D., & Pathak, D. (2016). Climate change projection for the marsyangdi river basin, Nepal using statistical downscaling of GCM and its implications in geodisasters. *Geoenvironmental Disasters*, *3*(1), 15. https://doi.org/10.1186/s40677-016-0050-0

Khanal, U., & Wilson, C. (2019). Derivation of a climate change adaptation index and assessing determinants and barriers to adaptation among farming households in Nepal. *Environmental Science & Policy*, *101*, 156–165. https://doi.org/10.1016/j.envsci.2019.08.006

Khanal, U., Wilson, C., Hoang, V.-N., & Lee, B. (2019a). Impact of community-based organizations on climate change adaptation in agriculture: Empirical evidence from Nepal. *Environment Development and Sustainability*, *21*(2), 621–635. https://doi.org/10.1007/s10668-017-0050-6

Khanal, U., Wilson, C., Hoang, V.-N., & Lee, B. L. (2019b). Autonomous adaptations to climate change and rice productivity: A case study of the Tanahun district, Nepal. *Climate and Development*, *11*(7), 555–563. https://doi.org/10.1080/17565529.2018.1469965

Maharjan, S. K., & Maharjan, K. L. (2020). Exploring perceptions and influences of local stakeholders on climate change adaptation in Central and Western Tarai, Nepal. *Climate and Development*, *12*(6), 575–589. https://doi.org/10.1080/17565529.2019.1664377

Maharjan, S. K., Maharjan, K. L., Tiwari, U., & Sen, N. P. (2017). Participatory vulnerability assessment of climate vulnerabilities and impacts in Madi Valley of Chitwan district, Nepal. *Cogent Food & Agriculture*, *3*(1). https://doi.org/10.1080/23311932.2017.1310078

Malla, G. (2009). Climate change and its impact on Nepalese agriculture. *The Journal of Agricultur and Environment*, *9*, 62–71. https://doi.org/10.3126/aej.v9i0.2119

Manandhar, S., Vogt, D. S., Perret, S. R., & Kazama, F. (2011). Adapting cropping systems to climate change in Nepal: A cross-regional study of farmers' perception and practices. *Regional Environmental Change*, *11*(2), 335–348. https://doi.org/10.1007/s10113-010-0137-1

Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & Delgado López-Cózar, E. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of Informetrics*, *12*(4), 1160–1177. https://doi.org/10.1016/j.joi.2018.09.002

MoALD. (2019). *Krishi Diary*. Ministry of Agriculture and Livestock Development, Government of Nepal.

MoE. (2010). *National adaptation programme of action (NAPA) to climate change*. Ministry of Environment, Government of Nepal.

MoF. (2013). *Economic survey: fiscal year 2012/2013*. Ministry of Finance.

MoF. (2019). *Economic Survey 2018/2019*. Ministry of Finance, Government of Nepal.

MoFE. (2019a). *Climate change scenarios for Nepal, national adaptation plan*. Ministry of Forest and Environment, Government of Nepal.

MoHA. (2019b). *Nepal disaster report*. Ministry of Home Affaris, Government of Nepal (GoN).

Mohamed Shaffril, H. A., Ahmad, N., Samsuddin, S. F., Samah, A. A., & Hamdan, M. E. (2020). Systematic literature review on adaptation towards climate change impacts among indigenous people in the Asia Pacific regions. *Journal of Cleaner Production*, *258*, 120595. https://doi.org/10.1016/j.jclepro.2020.120595

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19680–19685. https://doi.org/10.1073/pnas.0701855104

Nuorteva, P., Keskinen, M., & Olli, V. (2010). Water, livelihoods and climate change adaptation in the Tonle Sap Lake area, Cambodia: Learning from the past to understand the future. *Journal of Water and Climate Change*, *1*(1). https://doi.org/10.2166/wcc.2010.010

Okoli, C. (2015). A guide to conducting a standalone systematic literature review. *Communications of the Association for Information Systems*, *37*, 43. https://doi.org/10.17705/1CAIS.03743

Orduña-Malea, E., Ayllón, J. M., Martín-Martín, A., & López-Cózar, E. D. (2017). The lost academic home: institutional affiliation links in Google Scholar Citations. ArXiv abs/1804.07268.

Pathak, S. (2021). Determinants of flood adaptation: Parametric and semiparametric assessment. *Journal of Flood Risk Management*, *14*(2). https://doi.org/10.1111/jfr3.12699

Pokhrel, D. M., & Thapa, G. B. (2007). Are marketing intermediaries exploiting mountain farmers in Nepal? A study based on market price, marketing margin and income distribution analyses. *Agricultural Systems*, *94*(2), 151–164. https://doi.org/10.1016/j.agsy.2006.08.004

Poudel, B., Khanal, R. C., Khatri-Chhetri, A., & Chaudhari, P. (2017). Climate-smart agriculture in Nepal: Champion technologies and their pathways for scaling up.

Pradhan, N. S., Sijapati, S., & Bajracharya, S. R. (2015). Farmers' responses to climate change impact on water availability: Insights from the Indrawati Basin in Nepal. *International Journal of Water Resources Development*, *31*(2), 269–283. https://doi.org/10.1080/07900627.2015.1033514

Prasain, S. (2018). Climate change adaptation measure on agricultural communities of Dhye in Upper Mustang, Nepal. *Climatic Change*, *148*(1-2), 279–291. https://doi.org/10.1007/s10584-018-2187-1

Race, D., Mathew, S., Campbell, M., & Hampton, K. (2016). Understanding climate adaptation investments for communities living in desert Australia: Experiences of indigenous communities. *Climatic Change*, *139*(3-4), 461–475. https://doi.org/10.1007/s10584-016-1800-4

Rasul, G. (2021). Twin challenges of COVID-19 pandemic and climate change for agriculture and food security in South Asia. *Environmental Challenges*, *2*, 100027. https://doi.org/10.1016/j.envc.2021.100027

Regmi, B. R., & Bhandari, D. (2013). Climate change adaptation in Nepal: Exploring ways to overcome the barriers. *Journal of Forest and Livelihood*, *11*(1), 43–61. https://doi.org/10.3126/jfl.v11i1.8612

Regmi, B. R., Star, C., & Leal Filho, W. (2016). Effectiveness of the local adaptation plan of action to support climate change adaptation in Nepal. *Mitigation and Adaptation Strategies for Global Change*, *21*(3), 461–478. https://doi.org/10.1007/s11027-014-9610-3

Regmi, H. (2007). Effect of unusual weather on cereal crop production and household food security. *Journal of Agriculture and Environment*, *8*, 20–29. https://doi.org/10.3126/aej.v8i0.723

Rijal, S., Rimal, B., Stork, N., & Sharma, H. P. (2020). Quantifying the drivers of urban expansion in Nepal. *Environmental Monitoring and Assessment*, *192*(10), 633. https://doi.org/10.1007/s10661-020-08544-3

Shrestha, R. P., & Nepal, N. (2016). An assessment by subsistence farmers of the risks to food security attributable to climate change in Makwanpur, Nepal. *Food Security*, *8*(2), 415–425. https://doi.org/10.1007/s12571-016-0554-1

Sugden, F., Shrestha, L., Bharati, L., Gurung, P., Maharjan, L. D., Janmaat, J., Price, J., Sherpa, T., Bhattarai, U., Koirala, S., & Timilsina, B. (2014). *Climate change, out-migration and agrarian stress: The potential for upscaling small-scale water storage in Nepal*. International Water Management Institute (Research Report 159): 30.

Sujakhu, N. M., Ranjitkar, S., Niraula, R. R., Pokharel, B. K., Schmidt-Vogt, D., & Xu, J. (2016). Farmers' perceptions of and adaptations to changing climate in the Melamchi Valley of Nepal. *Mountain Research and Development*, *36*(1), 15–30. https://doi.org/10.1659/MRD-JOURNAL-D-15-00032.1

Sujakhu, N. M., Ranjitkar, S., Niraula, R. R., Salim, M. A., Nizami, A., Schmidt-Vogt, D., & Xu, J. (2018). Determinants of livelihood vulnerability in farming communities in two sites in the Asian Highlands. *Water International*, *43*(2), 165–182. https://doi.org/10.1080/02508060.2017.1416445

Suresh, K., Khanal, U., Wilson, C., Managi, S., Quayle, A., & Santhirakumar, S. (2021). An economic analysis of agricultural adaptation to climate change impacts in Sri Lanka: An endogenous switching regression analysis. *Land Use Policy*, *109*, 105601. https://doi.org/10.1016/j.landusepol.2021.105601

UN. (2013). *World population prospects the 2012 revision*.

UNDRR. (2019). *Disaster risk reduction in Nepal, status report*. UN Office for Disaster Risk Reduction, Regional Office for Asia and Pacific.

UNISDR. (2015). *Global assessment report on disaster risk reduction 2015*.

Vij, S., Biesbroek, R., Groot, A., & Termeer, K. (2018). Changing climate policy paradigms in Bangladesh and Nepal. *Environmental Science & Policy*, *81*, 77–85. https://doi.org/10.1016/j.envsci.2017.12.010

Vij, S., Biesbroek, R., Groot, A., Termeer, K., & Parajuli, B. P. (2019). Power interplay between actors: Using material and ideational resources to shape local adaptation plans of action (LAPAs) in Nepal. *Climate Policy*, *19*(5), 571–584. https://doi.org/10.1080/14693062.2018.1534723

Weerasekara, S., Wilson, C., Lee, B., Hoang, V. N., Managi, S., & Rajapaksa, D. (2021). The impacts of climate induced disasters on the economy: Winners and losers in Sri Lanka. *Ecological Economics*, *185*, 107043. https://doi.org/10.1016/j.ecolecon.2021.107043

Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. *Journal of Advanced Nursing*, *52*(5), 546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Zhu, J., & Liu, W. (2020). A tale of two databases: The use of Web of Science and Scopus in academic papers. *Scientometrics*, *123*(1), 321–335. doi:10.1007/s11192-020-03387-8