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Evaluating participatory techniques for adaptation to climate change: Nepal case study

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ABSTRACT

The community-based climate change adaptation plan of action (CAPA) ensures a bottom-up planning process to minimize climate impacts on the livelihood of vulnerable people and provides adaptation actions for increasing resilience capacity in Nepal. This paper mainly examines the role of participatory tools and techniques with the potential to identify the level of vulnerability and likely adaptation measures to increase the forest resilience capacities of communities where CAPA has been prepared (i.e. CAPA group). In total, 13 participatory qualitative tools were evaluated against 15 criteria for identifying their performance in nine CAPA groups representing three geo-graphical regions of Nepal. Multivariate analyses of the participatory tools and their performance allowed for selecting the most similar and dissimilar CAPA groups. The results indicated how CAPA groups are evaluating the likelihood of climate change impact, determining the vulnerability of specific ecosystem services and understanding the possible local adaptation measures. Many methods do not offer conditions for exploiting new innovative opportunities, assessing scenarios or identifying ecosystem services in the CAPA process. Tools are required that consider qualitative and quantitative evaluation methods, measure vulnerability and ecosystem functions and services. Although many issues related to local conditions and vulnerabilities have not been tapped adequately, it is difficult to generalize individual case study results within the different geographical contexts of Nepal. The integration of adaptation planning in local institutions, in order to deal with different ecosystem-based adaptation options, along with identification of climate change scenarios, impacts, trade-offs, synergies and the sensitivity of management problems, is highly recommended.

1. Introduction

Formulating climate change adaptation plans has recently emerged as a popular development agenda to deal with the vulnerabilities and adverse impacts of climate change in human and natural systems. The formulation of a climate change adaptation plan is an important approach to address the negative impacts of climate change wherein identifying adaptation measures and prioritizing adaptation options are essential. Implementing adaptation practices for reducing vulnerability has become a high priority for policy makers and development organizations. An adaptation plan is typically required more for the current and short-term time scales of a vulnerability assessment and identifying adaptation strategies, and is more localized, such as at the household or community levels. Adaptation is necessary to deal with adverse climatic stresses and hazards and to uses opportunities such as innovations, which can be both to current, actual or projected conditions (Smit et al., 1999). Some of the critical factors limiting the adaptive capacity of developing countries to climate change include limited access to resources, lack of diversification options for subsistence livelihoods, and lack of health and education (Smit et al., 1999; Boon and Ahenkan, 2012). Adger et al. (2009) contends that limits to adaptation are endogenous to society and hence contingent on ethics, knowledge, attitudes to risk and culture. The assessment of vulnerability, exposure, sensitivity, barriers of adaptation measures and adaptive capacity are necessary to identify and implement subsequent actions. To develop alternatives for adaptation, a better understanding of the capacities of communities to adapt and the limits to adaptation are needed (Adger et al., 2009). However, communities and the resources on which their

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livelihoods depend are linked to larger intricate networks of ecosystems and the changing climate, including its uncertainty, makes adaptation at the local level challenging and difficult (Adger et al., 2009; Dessai and Hulme, 2004). The adaptation approach is being adapted for identifying crucial information regarding socio-economic vulnerabilities and opportunities, resource degradation, food scarcity and the provisions of basic services related to climate change at each local site (Gentle et al., 2014). The adaptation process is needed to understand the vulnerability of the system, the drivers of this vulnerability, and local adaptive capacities to address risk and resilience to the impacts of climate variability and change (Bollin and Hidajat, 2006; Füssel, 2007; Pelling, 2011). The term 'adaptation' in the context of climate change impact is now mostly considered to be synonymous with the 'capacity to cope with changes, reduce vulnerability, and improve livelihoods' (Agrawal, 2009; Orlove, 2009).

Climate change is a global concern with the perceived need to address climate-induced vulnerability through the process of adaptation planning. The climate sensitive social-ecological systems of the Nepali Himalaya are exposed to a high level of climate change and variability, which negatively affects the livelihoods of the region (Bhatta and Agarwal, 2015; Pandey and Bardsley, 2015). With the rise of climate change adaptation as a complex, multi-sectoral challenge that often overstrains policy-makers (in particular local ones), the demand for and the supply of various climate services increased (Clar and Steurer, 2018).

Countries like Nepal, where more than 80% of the population depends on agriculture and whose livelihood depends on agriculture land, and an extremely diverse landscape poses different levels of location and context- specific CC impact (GoN, 2011a, 2011b). Tiwari et al. (2014) argue that the situation is worsened by poverty, population pressures, land degradation, food insecurity, and deforestation. Recognizing climate change impacts and mitigation measures, the Government of Nepal (GoN) developed the National Adaptation Programmes of Action (NAPA), with local planning by proposing the Local Adaptation Plans of Action (LAPA). However, the LAPA framework has put the focus on local governments in terms of planning and implementation of adaptation activities and is silent on the role of community-level institutions (Paudel et al., 2013).

1.1. Social Innovation for local climate change adaptation planning

Social innovations act as drivers of social change (Cajaiba-Santana, 2014), making societies more sustainable and cohesive through inclusive practices, co-production and pro-active grassroots initiatives (Grimm et al., 2013). Understanding the role of the social, economic and political institutions, and learning from examples of social innovations linking ecosystem provisions to improve their wellbeing and resilience is important (Kluvánková et al., 2018). Communities that engage in the climate change adaptation plan of action (CAPA) initiative in Nepal are called CAPA groups, which consist of local institutions for social innovation, that support community engagement and self-organization. The local stakeholders are involved in sharing values, identify new actions and solutions to integrate the needs of the community and ecosystem based adaptation. The CAPA groups establish collaborative approaches with its members to create a shared vision, and formulate specific adaptation plans and actions to reduce climate change impacts as well as societal problems. In other words, CAPA members act as the change agents of society, following a bottom-up planning process, which engage local institutions and communities to improve the local adaptation system, by introducing new processes, approaches and solutions. CAPA groups prepare and implement a local adaptation plan focusing on forest management, biodiversity, and ecosystem related elements, including a vulnerability assessment, and other important social, economic and ecosystem aspects. CAPA groups provide new responses to reduce the impacts of climate change and improve human social conditions and quality of life. For this study, CAPA groups and their functionality were considered as a social innovation to address the adverse impacts of climate change as well as for identifying the best local adaptation practices. CAPA groups, which can be considered as grassroots initiatives for the vulnerable communities or community forest user groups (CFUGs) in Nepal, promote social innovations to foster the resilience of forest ecosystems and engage local people to satisfy their daily needs. Several vulnerability assessment tools are used to prepare the community adaptation plan for action, to address the problems of social and ecosystem vulnerability. Therefore, this study analyses the best practices of such CAPA groups during the preparation of local climate adaptation strategies in response to actual or expected climate impacts to increase the resilience capacity and ensure sustainability of their livelihoods.

1.2. Tools and techniques in adaptation planning in Nepal

Climate change is a complex problem interacting with different processes and the use of a mixed-method approach permits a holistic understanding of the different dimensions of the problem (Adger et al., 2009). Climate adaptation tools have been developed and applied by bilateral, multilateral and.

non-governmental development organizations (UNFCCC, 2005, 2007; Nkoana et al., 2017).

Several tools and methods are used for gathering information about current and future community vulnerability exposed to hazards and risks of climate change, as well as the adaptive capacity in developing CAPAs in Nepal. Hazards mapping, seasonal calendar, historical timeline, vulnerability matrix, and stakeholder analysis are mostly used in building people's understanding about climate risks and adaptation strategies. They support in developing the CAPAs by identifying contextual information related the identified hazards and their impacts on livelihood assets and adaptive capacity. Such tools also empower local communities and enhance dialogue within the communities as a solid foundation for the identification of practical strategies to facilitate community based adaptation to climate change (Bishwakarma, 2010). The assessment and evaluation of adaptation strategies have become more inclusive over time and need to link future climate change with current climate risks and other policy concerns (Füssel, 2007). Different tools are proposed for supporting the selection of appropriate adaptation actions to reduce the adverse effect of climate on human health, livelihood and well-being, and to make the community capable of practicing the climate change adaptation measures (e.g. Care Int. and IISD, 2010; LFP, 2010; Care, 2012). Füssel (2007) drew lessons about adaptation planning and highlighted the unprecedented methodological challenges because of the uncertainty and complexity of the hazard. However, while there is no single tool or approach for assessing, planning and implementing adaptation to climate change, some robust adaptation principles have nevertheless emerged (Füssel, 2007). The tools/methods for any situation largely depend on how local stakeholders and facilitators understand the socio-ecological system, their ability to win trust and build a good rapport with local stakeholders (Khadka and Vacik, 2012a, 2012b; Vacik et al., 2013) and their understanding of system dynamics (Hujala et al., 2013). In the development field, evaluating the effectiveness of adaptation strategies is highly demanded from donors, who are eager to know the success of their investments (Schipper et al., 2010). Climate adaptation tools should incorporate a component of sustainability assessment as a final stage prior to the implementation of adaptation action plans (Nkoana et al., 2018). They should help to address socially relevant problems, through joint knowledge integration and mutual learning (Nkoana et al., 2018), produce robust knowledge including both scientifically valuable and relevant information for the societal progress (Schmidt and Pröpper, 2017; Schuck-Zöller et al., 2017; Schneider and Buser, 2018).

Most of the approaches, methods and tools are used to assess vulnerability and adaptive capacity, which rely on socio-economic and bio-

physical contexts, but it is still unexplored which tools are the most promising and to what extend they can contribute to the assessment. However, a nexus of historical, socio-political, cultural and economic factors may hinder the effective use of climate adaptation tools by rural communities in developing countries (McIntosh et al., 2011), like in Nepal. This study examined the contribution of tools in the assessment of social and ecosystem services in the preparation and development of the CAPAs of Nepal, highlighting the areas to improve and enhance the resilience of vulnerable communities of Nepal. The assessment of participatory tools and techniques illustrate their potential to identify adaptation measures and their priorities to increase the resilience and adaptive capacity of rural communities. The study recommends changes in the current tools employed for reformulating CAPA documents and its implementation modalities. Further, the study also prescribed a suitable combination of tools as optimal solution for developing and prioritizing community-based adaptation options or plans.

2. Methods

Nine CAPA groups of Nepal were selected from three districts: Kailali, representing the Terai -Terai Arc Landscape (TAL), Kaski representing the Mid-hills and the Gorkha High hills - the Chitwan Annapurna Landscape (CHAL) of Nepal (Fig. 1). These groups were chosen based on their categorization of being located in some of the most vulnerable regions, districts and communities in terms of the possible impacts on the livelihood of climate-induced hazards. About 10% of the CAPA groups were sampled out of the 94 CAPA groups from the three districts. A wide variety of indicators was used for evaluating the contribution of the tools in preparing CAPA documents. The evaluation was mainly focused on the tool for assessing the vulnerability of communities to climate change and selection of climate adaption strategies to reduce their impacts.

Evaluation of the CAPA documents included a short characterization of the documents was developed and the tools were selected from various manuals of climate vulnerability and adaptation capacity analyses (e.g. CARE International (CI), International Institute for Sustainable Development (IISD), 2010, Livelihood Forestry Programme (LFP), 2010, Ministry of Science, Technology and Environment (MoSTE, 2012, 2014). The tools include climate hazard mapping, trend analysis, ranking, and impact assessment, seasonal calendar, participatory well-being ranking, vulnerability matrix, best practices, stakeholder analysis, ecosystem vulnerability mapping, livelihood resource mapping, vulnerability assessment and participatory monitoring, evaluation, reflection and learning (PMERL) were coded using Redundancy analysis (RDA) in Canoco 5. Short descriptions of the selected methods and tools used for the identification of climate change variability, hazards and risks, impacts, livelihood options and possible adaptation measures during the CAPA documentation process in Nepal are displayed in Table 1.

Performance criteria were identified in terms of how they could be evaluated for the CAPA documents (Table 2). This required identifying the adaptation plan preparation process/steps, elements of the CAPA and the adaptation plans. The contribution of tools and techniques in developing the CAPA documents was evaluated using the performance criteria as benchmarks for assessing nine CAPAs in which the progress and achievement could be measured. The indicators, e.g. identifying the vulnerability context, ecosystem service provision, adaptation needs and priorities, stakeholder engagement, economic diversification and enabling innovation adaptation practices are related to the evaluation of tools.

In each dimension of vulnerability, the tools to be used and the number of indicators and activities were identified in each group involved in the preparation of the CAPAs. In the study, we applied a differential impact analysis to 73 households within the nine CAPA groups of the three districts in Nepal, focusing on local perceptions of the vulnerability contexts, vulnerability factors and potential adaptation measures to cope with the predicted changes and increase the resilience and adaptive capacities of the CAPAs. For this article, a review was followed by field observations in July and August 2013 which consisted of 13 key informant interviews included (1) community forest user groups, (2) soil and water conservation sub-committee members, (3) local leaders of political parties who were engaged in environmental issues, (4) women groups, (5) CAPA group committee members, and (6) social workers including teachers and local authority representatives. The survey identified the indicators of exposure, sensitivity and adaptive capacity that were recognized and given priority at the CAPA levels for adaptation planning in relation to climate change vulnerabilties.

Additionally, we evaluated the importance of each tool against the performance criteria in all 9 CAPAs in August 2016 and September 2017. Based on the feedback, obtained in the interaction meetings in the nine CAPA case studies, the contribution of the tools was expressed on a scale ranging from no contribution/not relevant (0), small contribution/relevance (1), fair contribution/relevant (2) to high contribution/relevance (3). The ratings provided for the tools were verified

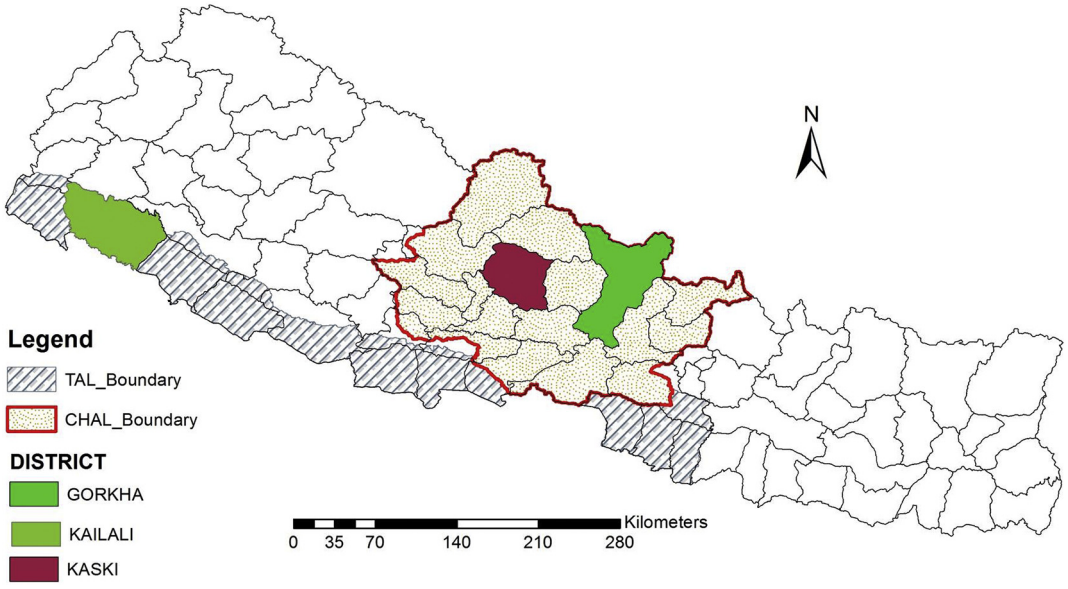

Fig. 1. The location of the study areas in the three districts and landscape boundaries of Nepal.

Table 1
Short description of community based vulnerability assessment tools and methods.

Tools/methods	RDA Code	Characterization of tools/methods
Climate hazard mapping	ClHaz_Mp	Map local climatic hazards and assess their risk including political, socio-economic or environmental features and identify hazard types and their impacts
Climatic hazard trend analysis	ClHaz_Ta	Gaining insight into past climatic hazards and identify trends in their nature, intensity and impacts and understand historical community reactions to and coping strategies for climatic hazards
Seasonal Calendar	Sea_Cal	Identifying individual climate variables over the time period, variability of rainfall or precipitation, other climate variable e.g. wind, temperature, and plant/animal behaviour
Climate hazard ranking	ClHaz_Ra	Compare and prioritize the most critical local climatic hazards and differentiate and evaluate between climate change induced and other natural hazards
Climate hazard impact assessment	ClHaz_IA	Identify the most likely impacts of local climatic hazards and increase and compare and contrast the impacts of major climatic hazards on livelihoods assets of the community
Participatory wellbeing ranking	ParWel_Ra	Identify socio-economic stratification on the relative well-being position and identify local climate hazard and assess their climate change vulnerability and risk
Vulnerability matrix	Vul_Mat	Gain an overview and quantify climatic hazard risk and resilience of local communities and identify the roles of different types of resources in increasing vulnerability and enhancing resilience
Best practices	Best_Pr	Identify the effectiveness of the current coping mechanisms and best adaptation options and actions to secure and improve the livelihood and conserve ecosystem services
Stakeholder analysis	SA	Analyse stakeholders for identifying the current services they have been providing, their roles and responsibility for effective implementation of the climate change adaptation plans and resource leverage.
Ecosystem vulnerability mapping	Eco_MP	Map of ecosystem vulnerability and most climate vulnerable communities, households and individual in wards and villages
Livelihood resource mapping/assessment	Liv_RP	Identify and categorise local livelihood assets and resources including ecosystem sustainability and bio-diversity
Livelihood resource vulnerability assessment	Liv_RVA	Assess and compare the intensity of impact of climatic hazards on livelihood resources including ecosystem sustainability and bio-diversity
Participatory monitoring, evaluation, reflection and learning	PMERL	Develop an Monitoring and Evaluation (M&E) framework, reflection and learning for the purposes of effectiveness of adaptation interventions for livelihood enhancement and building resilience to the effect of climate change

Table 2
Performance criteria descriptions for evaluating community based vulnerability assessment tools and methods.

RDA code	Performance criteria	Descriptions
PC_1	Addressing vulnerable population demand	The tools/methods identify/address the demand and preference of vulnerable groups that are particularly vulnerable to climate change
PC_2	Exploiting new local opportunities	The tools/method supports the new adaptation strategies and deploy new technology and practices through the process of negotiation among stakeholders
PC_3	Creating supportive social structure and experiences	The tools/methods have the potential to support existing and creating institutions structure, support for best practices related to climate change and seek to appropriate policies, plan and strategies
PC_4	Gathering and sharing information	The tools/methods have the potential to gather and sharing the perceptions and interests of all relevant stakeholders on the climate change variability
PC_5	Reducing poverty and vulnerability	The tools/methods support poverty and vulnerability mapping along livelihood options and adaptation strategies
PC_6	Engaging local communities and defining the problems	The tools/methods foster local engagement in defining the problems of socio-economic, ecological and environmental features to identify opening and barriers for adaptations
PC_7	Developing problems solutions	The tools/methods have the potential to develop the problems, preference and compromise solutions of all relevant stakeholders on the climate contexts
PC_8	Encouraging disadvantages and poor groups participation	The tools/methods foster to engage the most vulnerable communities in adaptation planning, monitoring and evaluating climate change adaptation
PC_9	Allowing number of stakeholders	The tools/method have the potential to engage a certain number of stakeholders to work on the assessment, prioritize plans for livelihood and resilience capacity of climate change impacts
PC_10	Analysing alternative adaptation measures	The tools/methods foster to define potential adaptation options to address priority adaptation issues for different target groups and at different level
PC_11	Encouraging integrated plan preparation	The tools/methods foster to integrate strategies to address the underlying causes of vulnerability, including gender and marginalisation
PC_12	Allowing quantitative data analysis	The tools/method/allows considering quantitative information (e.g. data on vulnerability) involved in analysing exposure, sensitivity and adaptive capacity for adaptive plans and interventions
PC_13	Delivering mainstreaming CAPA	The tools/methods allows mainstreaming of climate change adaptation plan with the local and Village Development Committee (VDC) level planning processes
PC_14	Assessing ecosystem and communities scenarios	The tools/methods support to understand the ecosystem functions and services and analysing of past change and future climate projections based on preference of communities
PC_15	Identifying ecosystem services	The tools/methods have a potential to identify ecosystem services and livelihoods-vulnerability and adaptation to a changing climate

and refined by experts from Nepal until a consensus was reached in an iterative process. The level of importance of each tool varied between the CAPAs; therefore the attributes and identified indicators were documented. The overall performance of the 13 tools/methods for each CAPA was calculated based on the rating gained for each performance criterion. This would allow for a maximum rating of ± 45 supporting all 15 criteria with a maximum score of "3" or a minimum score of "0". However, the maximum scale for the evaluation of all methods in all CAPA case studies was between 0 and 27 in reality. An analysis was made in order to identify groups of methods that share similar characteristics. Another analysis compared the evaluation of tools against each criterion (Table 2), independently of the importance of the respective criterion for all nine CAPAs. The evaluated data were used to classify a number of methods into groups, so that the methods of one group showed as much similarity as possible, whereas the methods of different groups were as diverse as possible. The multivariate data were analyzed using Redundancy analysis (RDA) in Canoco 5 (ter Braak and Šmilauer, 2012). Tools and CAPAs were used as the explanatory variables in two separate partial analyses using the other variable as a covariate while the performance criteria were response variables. The

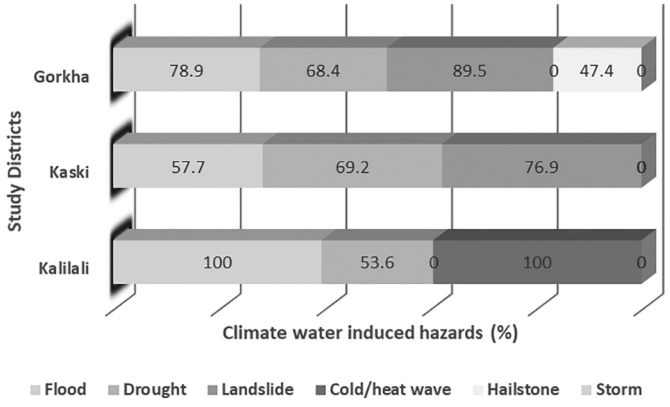

Fig. 2. Climate induced hazards expressed by respondents.

significance of their effect was tested by Monte Carlo permutation test.

3. Results

3.1. Major climate induced hazards to livelihood resources

The respondents of the household interviews ($n = 73$) were asked to describe their experiences with climate induced hazards which directly or indirectly are considered to impact their daily life, crop production, livelihood and health. CAPA members identified six major climate induced hazards in the three study districts, affecting their livelihood conditions (Fig. 2). Flood severity, cold/heat wave and drought are major climatic risk factors in Kailali district while landslide, drought and flood were identified as the major threats in the Kaski and Gorkha districts. The obtained results showed that the most vulnerable households in the communities of the Kaski and Gorkha districts are, living in sloppy and close to landslide prone areas, whereas the most vulnerable households in the communities in the Kailali districts are settled on riverbanks and flood prone areas. Most respondents are vulnerable because they fail to secure their resources due to their settlements being situated in areas prone to natural disasters. People may perceive their goals and values of risk (e.g. exposure), potential benefits, services and livelihood opportunities (e.g. sensitivity and adaptive capacity) differently, which would influence their capacity to anticipate and cope with the impacts of hazards.

Most respondents and their households are located in locations with high exposure to hazards within the CAPA prepared areas. Flood and drought were major problems in the Chetana, Dhanuwaphat and Bangaon CAPA units in Kailai district when assessing the climatic signal based on the perception of respondents, whereas landslide, cold/heat waves and hailstones were climate change signals experienced by community members from Shanti Salghari and Bhumepujne in Kaski district and ThuloBan and Bhubanisthan in Gorkha district (Table 3).

Table 3
Climate induced hazards expressed by CAPA groups in percentages.

CAPA Groups	Climate induced hazards					
	Flood	Cold/heat wave	Drought	Hailstone	Storm	Landslide
Chetana	100	100	42.9	14.3	0	0
Simreni	100	100	100	33.3	0	0
Dhamitole	100	100	33,3	50	0	0
Bangaon	100	100	80	20	0	0
Dhanuwaphat	100	100	0	25	0	0
Shanti Salghari	81.3	18.8	68.8	31.3	0	81.3
Bhumepujne	20	0	70	30	20	81.3
Thuloban	100	0	71.4	28.6	0	71.4
Bhubanisthan	66.7	16.7	66.7	58.3	8.3	100

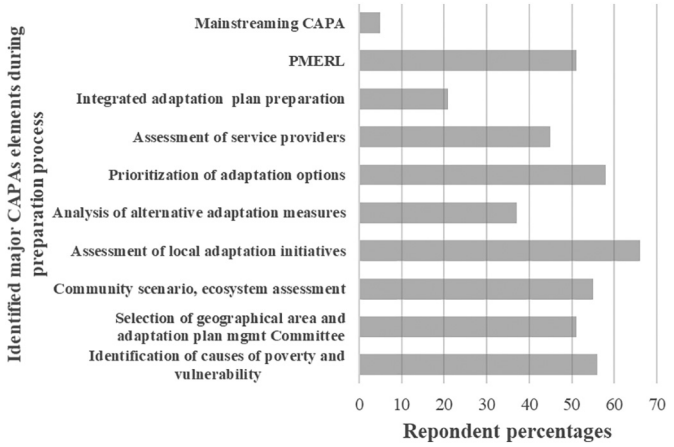

Fig. 3. Percentage of respondents being familiar with the major CAPA elements during preparation process.

The specific hazard or set of hazards have an impact on the adaptation response in improving community understanding of climate change and developing adaptation strategies at the local level.

3.2. Identified Major CAPA elements during preparation process

Respondents were asked about the CAPA preparation process and adopted tools in order to identify the major CAPA elements. The major elements of the CAPA planning process identified by the respondents included (i) mainstreaming CAPA, (ii) integration of the prepared adaptation plan with the forest operational plan and (iii) analysis of alternative adaptation measures. Other elements were the identification of causes of poverty and vulnerability, assessment of local adaptation initiatives, selection of geographical area and unit, formation of the adaptation management committee and prioritization of adaptation options (Fig. 3). The results showed that only 51% of the respondents knew that PMERL was a part of their adaptation strategy and an important element of the CAPA preparation process.

3.3. CAPA preparation process and integration of forest ecosystem services into adaptation plans

The Local Adaptation Plan for Action (LAPA) framework consists of a seven step process for developing an adaptation plan and integrating it into local-to-national planning processes (Fig. 4). The steps, followed

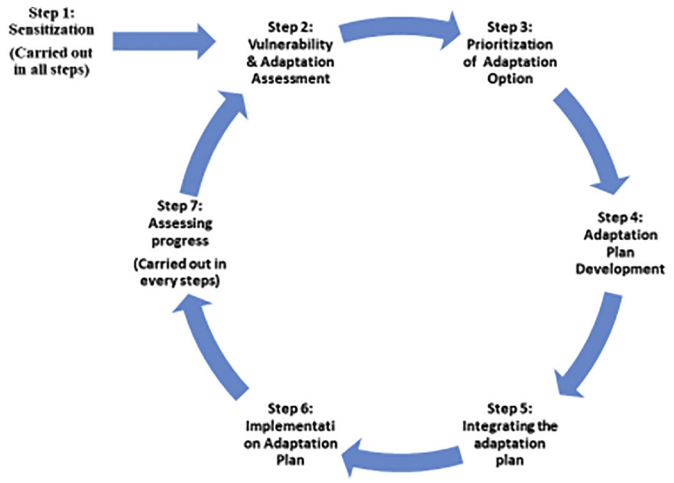

Fig. 4. LAPA steps in cyclic order.
Sources: GoN (2011a, 2011b).

by the CAPA groups in preparing and implementing local adaptation plans for action, include: (1) Climate Change Sensitization (analysis of poverty and underlying causes of vulnerability, topographic coverage of the CAPA, sensitization and capacity building on climate change, risk, vulnerability and livelihood resource mapping, historical trend analysis of the hazard, seasonal calendar analysis, participatory well- being ranking, target group and household identification). (2) Climate Vulnerability and Adaptation Assessment, including the analysis of community vulnerability, analysis of ecosystem vulnerability (e.g. forest, agriculture land and wetlands), stakeholder analysis, analysis of climate data (rainfall and temperature) and estimation of future scenarios. (3) Prioritization of adaptation options including community scenario planning, assessment of a local adaptation option, alternative analysis of an adaptation option, and prioritization of adaptation options. (4) Developing local adaptation plans for action, CAPA implementation committee formation, PMERL plan preparation, stakeholder information need analysis, logical frame work, measuring behavioural change and monitoring and evaluation plan preparation. (5) Integrating local adaptation plans for action into planning processes, in which CAPA groups endorsed the adaptation plans from the CFUG general assembly and presented at an integrated planning workshop of the village development committee/municipality. (6) Implementing local adaptation plans for action with periodic review and learning incorporation on the process. (7) Assessment of the progress of the local adaptation plan for action, which consists of monitoring and evaluation of the entire process of planning and implementing of the CAPA groups. The major climate change impacts, ecosystem services, key indicators, forest products and adaptation were categorized by the CAPA groups (Table 4). The CAPA process supports the identification of different forest ecosystem services including timber, fuelwood, grass, fodder, water, medicinal plants, food provision, biodiversity, and water regulation. The adaptation measures were identified in order to support community infrastructure, settlements, agriculture productivity, and soil conservation and irrigation systems.

3.4. Performance of participatory tools regarding the performance criteria

Based on a cross-evaluation of all 13 tools, employing the set of 15 performance criteria (code PC_1 to PC_15), an RDA analysis was made to classify the methods according to their potential to support the given performance criteria. It also produced cluster groups to identify between the individual tools and problems to satisfy the performance criteria (Fig. 5). The cluster analysis showed that four community-based vulnerability assessment tools, climate hazard trend analysis (CliHazTA), climate hazard mapping (ClHaz_Mp), vulnerability matrix (Vul_Mat) and climate hazard impact (ClHaz_IA) assessment, were able to satisfy 9 performance criteria. Most of the used tools were unable to address exploiting new local opportunities (PC 2) except the best practice methods. The tools were also less applicable for developing mainstreaming CAPA (PC 13) and creating supportive social structure and experiences (PC 3) except the PMERL tools and stakeholder analysis (SA). The same situation was true for encouraging disadvantaged and poor groups participation (PC_8), except for the tools participatory wellbeing ranking (Par_WBR) and climate hazard ranking (ClHaz_Ra). The ecosystem vulnerability mapping (Eco_VM), livelihood resource and vulnerability assessment (Liv_RVA), livelihood resource mapping (Liv_RP), Seasonal calendar (Sea_cal), stakeholder analysis (SA) and PMERL have not been conducted well enough to satisfy most of the performance criteria during the process of developing CAPA documents. Additionally, almost all methods were limited in addressing vulnerable population demand (PC_1) and allowing the number of stakeholders (PC_9).

3.5. Contribution of tool satisfying performance criteria regarding the CAPAs

We were able to identify CAPA groups with similar preferences regarding the performance criteria based on the contribution of the tools for satisfying them. The results showed that all four CAPAs from the Kailai district and one CAPA from Kaski were very similar in relation to the performance criteria and most of the criteria were successfully applied in the CAPA process. However, two CAPAs from Gorkha and one from Kaski formed another cluster group where most of the performace criteria were only weakly fullfilled, showing only a closer relation to PC12. Shanti Salghari CAPA from Kaski (Ssal_Kaski) is isolated and the performance criteria are not well met compared to the other CAPAs (see Fig. 6).

4. Discussions

Individuals, households and groups that are located in frequently inundated parts of Kailali district or in the hilly area with sloppy land, prone to landslide in the Gorkha and Kaski districts, are at greater risk. The systematic assessment of forest ecosystem functions and services is highly demanded in order to identify the performance of investments in adaptive measures. The economically and socially marginalized groups of society, such as women, and caste/ethnic groups, are differentially impacted by climate variability in terms of their vulnerability to livelihood options and access to capacity and resources (Dhungana et al., 2017). Floods, landslides, drought and other climate induced hazards cause the greatest risk especially in fragile systems when disturbances cause damages to road construction, communication system, drinking water supply as well as agriculture production, land use and soil conservation. Key informants and local communities in the focus group discussions revealed that the impact of climate change negatively affected the provision of various agro-forest ecosystem services which ultimately hamper the livelihood of local communities in the study areas. Part of the CAPA preparation process was to assess how climate and water induced hazards have affected the agro-forest ecosystem (e.g. forest and agro-ecosystem biodiversity, drinking water, irrigation, land use) in the areas and how to figure out the response to climate and other stresses in order to reduce their vulnerability.

Focusing CAPAs to interlink socio-ecological processes and ecosystem services should minimize total vulnerability. For these reasons, a systematic vulnerability assessment is required especially to address the socio-economic problems of the most vulnerable households and promote their adaptation to climate change. Various conceptual frameworks were proposed which assess vulnerability differently and provide mixed results (Dixit et al., 2015). Vulnerability assessment should not attempt to achieve high-level precision as no method can capture vulnerability in its entirety (Patt et al., 2011). Since the CAPAs have identified the most vulnerable communities in a given location, they can thereby prepare their adaptation strategies. The adaptation plan and actions are developed to minimize the impact of climate change. However, the highly vulnerable members have limited access to capacity and resources to implement their identified adaptation activities for addressing climate change risk. In reality, CAPA members have less bargaining power to diversify their livelihood options, to access information, technology and participate in decision-making, which limits the economic opportunities for poor women, ethnic and marginalized groups.

This study synthesized the performance of specific tools which are used for assessing the capability to reduce vulnerability and increase adaptive capacity for developing the climate change adaptation plan. Such studies are highly demanded by donors, planners and decision makers who are eager to know the success of their investment (ADB, 2006). The United Nations Framework Convention on Climate Change (UNFCCC) provides observations on the use of methods and tools and the key areas that need to be improved for adaptation planning,

Table 4
Assessment of key climate change impacts, forest ecosystem services and adaptation measures of CAPAs documents.

RDA Code	CAPA groups	Districts	Climate change impacts on the provision of ecosystem services	Key indicators	Major forest products (Ecosystem goods)	Adaptation measures
Chet_Kai	Chetana	Kailali	Loss of NTFPs, drying of wetlands, decrease in aquatic populations, disruptions of low-lying riverine habitats and agro-ecosystems, loss of key productions	Spread of invasive species, outbreak of pest and diseases	Timber for furniture, fuelwood	Biological dam, gabion dam, concrete dam, training on hazards management
Sim_Kai	Simreni				Timber for furniture and other house constructions	Biological dam, establishment of disaster relief fund, construction of community building for safe shelter, high founded water tap, small and alternative irrigation plan
Dhami_Kai	Dhamitole				Timber for household purpose and fuelwood	Biological dam, gabion dam, concrete dam, plantation, training on disaster management
Ban_Kai	Bangaon				Timber for furniture, Rattan, fuelwood	Promotion of river bank farming (Bagar Kheti), biological dam, establishment of disaster relief fund, sensitization on flood preparedness, high founded house, high founded water tap, small and alternative irrigation channel
Dhan_Kas	Dhanuwaphat	Kaski	Drying of springs, rivers, wells and ponds, loss of NTFPs and medicinal plants, threat to agricultural productions, change of cropping patterns	Early flowering, spread of invasive species, pest outbreak	Timber for house constructions, fuelwood, grass collection	Biological dam, community shelter house, establishment of flood relief fund, flood preparedness plan
SSal_Ka	Shanti Salghari				Timber for house constructions, fuelwood, Ningalo (*Arundinaria species*)	Construction of dam, plantation (bamboo, canes, Amriso), control open grazing, improvement of irrigation channel, construction of pond
BPuj_Kas	Bhumepujne				Fuelwood, timber for house constructions, grass/fodder	Plantation of bamboo and Amriso at landslide area, plantation, gabion box filling at landslide site, sensitization on fire
Tban_Gor	Thuloban	Gorkha	Shift in vegetation line/succession, loss of NTFPs, drying of streams, waterholes and springs, disruption of agro-ecosystem by landslides, changes in high altitude ecosystem characteristics	Shift in vegetation line, Emergence of new species and crops, early flowering of species	Timber for house construction, pine needles, leaf litter for compost, medicinal and aromatic plants, fuelwood, grass	Construction of gabion dam, formation of disaster management committee, power water pump for irrigation from river, construction of plastic ponds, cultivation of drought tolerant species, bamboo plantation
Bhu_Gor	Bhubanisthan				Pine needles, leaf litter for compost, medicinal and aromatic plants, leaf litters, timber for house constructions	Plantation of Amriso, Tejpat and Amala, Drip irrigation, Construction of plastic ponds

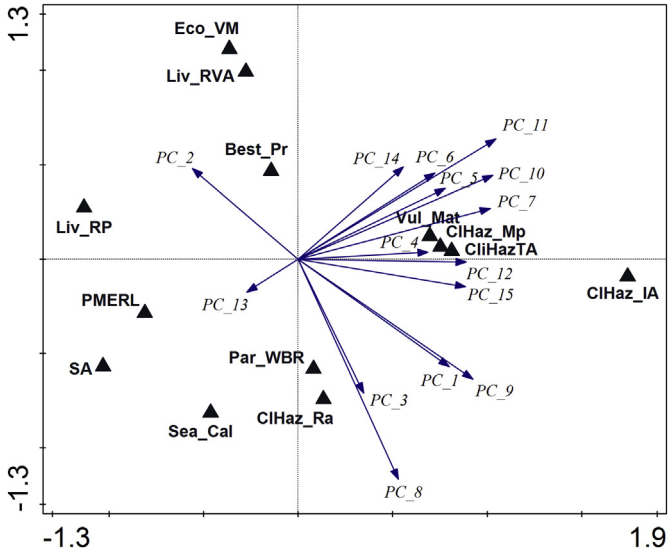

Fig. 5. RDA analysis of performance criteria with tools used as explanatory variables.

including the importance of understanding model limitations and increasing local level data collection (UNFCCC, 2005). Several reports provide interesting insights into experiences with adaptation planning, even focusing integrated adaptation planning across different scales and sectors (e.g., UNFCCC, 2009). However, they do not present any specific tools or methods for assessing and evaluating vulnerability contexts to climate change in local context. Therefore, the need to properly document the performance of the proposed tools and methods for multi-scale assessment and analysis of multiple perspectives is required, including local adaptation plans and ecosystem service provisioning. Local people and community representatives should be supported to conduct a sustainability assessment exercise to assess the resilience of climate adaptation action plans against maladaptive practices that might increase the vulnerability of the intended beneficiaries in the long-term (Nkoana et al., 2018). Decision makers are often baffled by the risk and adaptation priorities of local communities shaped by socio-economic, political and cultural contexts (Van Aalst et al., 2008; Nyong et al., 2007; Luseno et al., 2003; Roberts, 2008).

Selecting the most appropriate tools for identifying the appropriate information is challenging because each tool has some limitations. Key stakeholders rely on the knowledge of local facilitators or managers, which limits the application of a broad range of tools as well (Jalilova et al., 2012; Khadka and Vacik, 2012b). In most cases, an experienced facilitator was needed to select the viable tools to generate significant data and engage the local people for the planning and implementation process. However, there is not any blue-print for assessing and evaluating an adaptation plan. In Nepal, several participatory tools and methods are prescribed for adaptation planning, but information is needed about the rate of application and effectiveness of these tools. The identification of a set of performance criteria for evaluating adaptation planning is useful for the CAPA groups. The performance criteria must be context specific for evaluating the tools in gaining acceptance by vulnerable communities and adequately reflecting the complexity and inter-linkages between socio-economic and climate change. However, the performance criteria used in this study provided an opportunity to determine what further research is needed concerning multiple-scalar and scenario assessments to overcome the issues of adaptation measures in the delivery of services and enhancing the resilience of households.

Participatory tools must be applicable for different problem settings and for multiple scales (Khadka and Vacik, 2012a; Hujala et al., 2013; Vacik et al., 2014). It was found that most of the tools are good for assessing the vulnerability context and vulnerable population demands, exploiting new local opportunities and resources, creating supportive social structure and experiences, and gathering and sharing information. However, these tools are not focused on cross-sectorial interactions and neglect or undervalue the importance of the dependencies between the availability of resources, the provision of ecosystem services and a cost-benefit analysis. The identified adaptation measures and options are often short-sighted whereas participatory tools or computer-based tools would allow to incorporate scenarios and trade-offs in developing and selecting the best alternative adaptation plans (Khadka et al., 2013; Hujala et al., 2013). The used tools help to diversify the livelihood options of local communities and increase the support for developing climate change adaptation plans of action at the community level, but it is still a challenge to integrate climate change impacts into local level planning processes, e.g. rural municipality, municipality and district level. The CAPAs initiatives should implement with the Local Adaptation Plan of Action (LAPA) and multi-sectorial activities at the rural municipality level. The limitations of current ecological assessments are apparently visible and therefore a combination of tools related to qualitative and quantitative valuation methods are required to estimate the value of forest ecosystem functions and services.

5. Conclusions

A systematic assessment of the vulnerability of local communities,

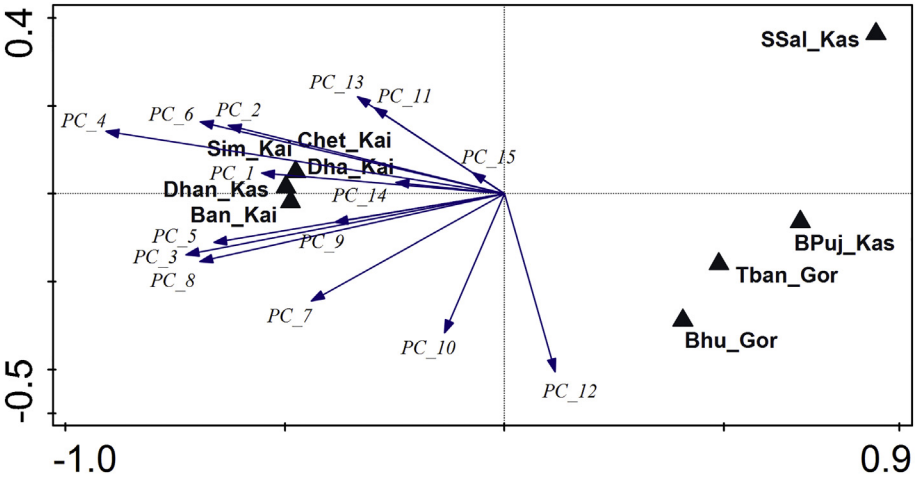

Fig. 6. RDA analysis with CAPAs and performance criteria with respect to contribution of tools.

the climate change impacts on ecosystems and their services and the links between them is needed to increase their resilience and integrate the adaption strategies in the CAPAs. CAPA groups are autonomous institutions, but a range of support to enhance their skills, capacities, and access to resources, including financial, institutional mechanisms and alternative livelihood options, is highly required to implement the adaptation plan and actions. For instance, the policies must ensure that the CAPA groups have access to new sources of finance, technical knowledge and other kinds of resources for innovation and effective implementation of the adaptation plan. In other words, the design of the CAPAs needs to be a part of the process for making the CFUG operation plan where a local resource based institution is required. The tools are designed and outlined to assess vulnerability, livelihood and adaptation processes, but there is a lack of documentation of the used tools making it hard to evaluate them and provide lessons learned to CAPA groups. Studies which assess the current status of CAPAs as the basis of integrated assessment of socio-ecological and ecosystem services are currently lacking in the Nepal.

The tools are suited for guiding and bringing stakeholders together in the planning processes. However, local stakeholders involved in preparing the CAPAs do heavily rely upon the expertise and skills of facilitators/field trainers. The tools are recognized as suitable for the assessment in the early-planning stages and engage the stakeholders in the adaptation process. However, analysis of the dimensions of climate change and its impacts in developing a CAPA are still relatively limited; most of the tools used to identify the socio-economic issues are influenced by individual power-relationships in decision-making. Therefore, there is a need for approaches that allow to incorporate science-based information and to integrate diverse scenarios for the potential impact of climate change on human well-being. The study provides some suggestions for selecting the best combination of tools to deal with the complex problems that arise when evaluating the adaptation plan.Their application depends upon a broader understanding of climate change variability and community resilience and a sound understanding of the pros and cons of each technique. A mixed methods approach include several assessments to identify and evaluate adaptation strategies and alternative plans. There is the need to increase the scientific understanding of the cause-effect relationships among the involved facilitators, thereby placing existing knowledge of climate change adaptation into a scientific approach to reduce the risks of failure and build resilience capacity. We recommend to critically review the tools applied in adaptation planning that can be used to deal with possible risks and uncertainties, consider climate change scenarios, allow to quantify impacts, trade-offs and synergies in management. Computer-based tools in conjunction with decision support systems are highly demanded for assessing the impacts of climate change variability and analysing alternative adaptation measures.

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