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Climate Change Adaptation (CCA) Interventions and Indicators in Nepal: Implications for Sustainable Adaptation

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Abstract: We reviewed 76 climate change adaptation projects that were operational between 2010 and 2020. The review was followed by office and field visits for verification. The office visit helped crosscheck the findings, and the field observations carried out between December 2020 and April 2021 asked 24 key informants and collected supplementary information appraisal and indicator development. Of the CCA projects studied, the most (n = 48, 32%) were community-based initiatives, while the least (n = 12, 8%) were ecosystem-based interventions. The main environment-centered projects were Ecosystem-based Adaptations and Ecosystems Protecting Infrastructure and Communities (EPIC) while Enhanced Action of Inclusive CSOs for Participation in Climate Resilient Economic Growth (UTHAN), Initiative for CCA (ICCA), Support to Rural Livelihoods and Climate Change Adaptation in the Himalayas (HIMALICA), etc., adaptation projects were community-based. Capacity building and awareness-raising were the major thrust of the CbA projects, while the abatement of climate vulnerabilities and risks through nature-based solutions were priorities of EbA. Payment for Ecosystem services is a nature-based solution that can play a role in enhancing adaptation to climate change at a local scale by adopting community-based and culturally appropriate methods and enhancing and incentivizing adaptation measures and capacities. A set of 11 criteria and 40 indicators comprised the institutional and behavioral responses and the use of technologies, and the design of climate-resilient plans and climate-smart practices were proposed as appraisal measures to evaluate the success of CCA interventions. The importance of criteria and indicators lies in the fact that such a comprehensive assessment would lead to effective and efficient adaptation projects, which could help benefit beyond the borders. It also furthers ongoing adaptation interventions and is set to be an integral part of associated studies and monitoring and review of new adaptation interventions.

Keywords: disaster risk; resilience; adaptation; project; indicators; Himalaya

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1. Introduction

1.1. Background

Nepal's population has surpassed 29 million [1], of which 79.4% people live in rural areas and depend on subsistence farming for their livelihoods [2,3]. About 80% of them were exposed to the risk of natural hazards such as earthquakes, droughts, floods, landslides, extreme temperatures, and glacier lake outburst floods [4]. With the varied physiographic and altitudinal setting, the relatively small country of Nepal exhibits the remarkably diverse bio-climatic conditions that cultivate its heterogeneity in culture, biodiversity, and ecosystems ranging from the tropical lowlands of Tarai to the temperate mid-hills to the alpine Mountains and the Himalayas [5–9]. The country experiences several climate hazards in its physiographic heterogeneity, and these are expected to be increased in the future [10]. Because of the erratic occurrences of different natural hazards and the

vulnerability of the population, Nepal is a disaster hotspot [4]. In a global comparison, Nepal ranks fourth in terms of climate risk according to the Global Climate Risk Index [11]. The country is in the top 20 of all the multi-hazard countries in the world [12].

The vagaries of climate change increase the vulnerability of the population who inhabit hills and mountains [13], and their livelihood stems from the agro-pastoral activities [14]. Rural hills and mountainous communities are expected to be affected more due to their extensive dependence on climate-sensitive livelihood options and limited adaptive capacity to adapt to the adverse climatic changes [15]. An increase in the daily variability of temperature can result in lower crop yields [16–18], and an increase in the daily average temperature can enhance pests and weed attacks [19–21]. Many places in the country (such as Manang, Mustang, Ramechhap, and Nuwakot districts) have already observed and experienced climate-led out-migration, leaving behind empty ghost villages [22–24]. However, conflict-led and climate-led migrations are not distinct, but the former was common in lowlands and midhills such as Chitwan and Gorkha districts [25,26], and the latter is common in mountains [27].

Chronic poverty, subsistence agriculture and dependency on natural resources make the rural communities more vulnerable to the impacts of climate change [28]. Socio-ecological systems in the Himalayas have been in the hardest hit in the recent days [29]. In the light of these constraints, Nepal is trying to offset the climate-associated risks, vulnerabilities and impacts through efficient and effective adaptation practices, planning, programs, and projects.

1.2. Nepal Initiatives in CCA

In 2002, Nepal started the National Capacity and Self-Assessment (NCSA) Project aimed at developing a national action plan to implement the commitments made in the international conventions, to be precise, the CBD and UNFCCC. The First National Communication (NATCOM-1) report to the UNFCCC (2004) provided an overview of national circumstances that reflect Nepal's capacity to respond to the problem and describes the causes and consequences with regard to vulnerability/impact and adaptation issues [30]. The NCSA report (2008) revealed the challenges, technologies and strategies of the country for adaptation activities [31]. In order to assess climate vulnerability and systematically respond to climate change issues through the development of appropriate adaptation measures, the Government of Nepal prepared a National Adaptation Program of Action (NAPA) in 2010 [32]. NAPA has created and enhanced awareness of climate change adaptation (CCA) issues at different scales and built long-term capacity through cross-sectorial and multi-stakeholder coordination. The National Adaptation Plan (NAP) approach was established under the Cancun Adaptation Framework (2010) and re-emphasized in the Paris Agreement (2015). The NAP process (2015) enables countries to assess climate risks and vulnerabilities and plan CCA at mid-term and long-term scales, however, it is imperative to facilitate the integration of CCA in new and existing policies, different programs and practices, and development processes and plans, as appropriate [33].

In 2020, UNEP–GCF and NAP-Nepal put a thrust to consolidate the CCA interventions (government programs, funded projects, community practices) in Nepal and assessed their impacts in reducing climate vulnerability and enhancing ecosystem resilience. Over a period of about two decades (2002–2020), there has been a series of progress in integrating CCA in policy and planning and implementing the CCA projects and programs to reduce the climate vulnerability. The reduction of impacts and the enhancement of the benefit from climate change effects are sought while implementing CCA interventions. There are a handful of studies on CCA interventions in Nepal, and they are discrete, scattered and inefficient to pave the way forward for integrating adaptation into development planning. Low adaptive capacity is associated with limited information, poor access to service and inequitable access to assets [34]. In this connection, we aimed at cataloguing and analyzing the CCA projects and synthesizing their successes for sustainable adaptation and resilient ecosystems and society. We also developed criteria and indicators for the assessment of

CCA interventions. It is hypothesized that as the large percentage of communities still live in remote, rugged and rural mountains, community-based and nature-based adaptation interventions against climate change are common in Nepal. It is estimated that the outcome of this activity will strengthen the knowledge and guide the future investment and project requirements that aids enhancing the resilience of society and environment and supporting Nepal's NAP milestone as well. It is, therefore, a timely endeavor to consolidate the knowledge to pave the way forward to integrate CCA in development planning.

2. The Materials and Methods

A total of 76 CCA-related projects executed between 2010 and 2020 were reviewed, and their reports were analyzed. Over 60% of project reports were available in their webpages, whereas others were collected through emails and office visits. The review of the project website covered the project profile, programs, and progress that account the project success and support on climate change adaptation, as reflected in their title, goals statement, and/or objectives [35]. The webpage review was followed by consultative approaches where office and field visits were made. The former was meant for collecting project information and progress when the project has limited or no information in their webpages. The latter was made between December 2020 and April 2021. Field visits and consultations outside Kathmandu were made between March and April 2021. A total of eight field sites, Butwal, Dhangadi, Surkhet, Hetauda, Pokhara, Janakpur, Biratnagar and Damauli outside Kathmanudu, were visited and field-level project information collection and verification were performed. A total of 24 key informants were interviewed for cross-checking and further verification. Field-level verifications helped verify and validate the information. Some interviews were conducted with project personnel and experts for verifying the data.

A review of CCA interventions and portraying the strength and weakness of each CCA is requisite in order to streamline the NAP's advancement. In this pursuit, analysis of CCA types and their efficiency and effectiveness with due considerations of the country's physiography and bio-cultural diversity, climate risks and vulnerabilities, livelihood and poverty, and prevailing adaptive capacities and development plan is imperative. A Multi-Criteria Analysis (MCA) was used to evaluate the main focus of the adaptation, theme and area covered, and the resultant implications of the adaptation. The analysis also followed a qualitative method with quantitative steps since the qualitative information were quantified and measured for Qualitative Content Analysis (QCA) [36].

3. Results and Discussion

Nepal began accommodating CCA initiatives in national policy protocols in 2001. The Millennium Development Goals (2001), the 10th periodic development plan (2002–2006), the Sustainable Development Agenda (2003) and the Poverty Reduction Strategy Paper (2003) are the entry-level policy protocols for mainstreaming climate change into development planning in Nepal. Since 2002, the Government of Nepal recognized climate change as an emerging issue when the 10th Plan (2002–2007) acknowledged the influence of weather on overall economic performance [37]. The plan accompanied by Medium-Term Expenditure Framework (MTEF) paper for the agriculture sector pays attention to the climate-related risks. There are now two climate change dedicated policies (National Climate Change Policy 2011 and Climate Change Policy 2019) supporting the implementation of different types of CCA. In a report, the World Bank (2014) notes that in order to end global poverty, attention should be paid not just to growth but to the type of growth that increases returns to assets held by the rural and marginalized poor. The implications are that climate change policies should be embedded in development policies, not just to ensure economic growth but also to ensure poverty reduction, sustainable resource management, and to abate future climate change effects [38,39]. The interventions covering both development and climate issues are nowadays frequent.

3.1. CCA Interventions in Nepal

With adherences to NAPA programs (2010) and prioritized sectors of the NAP process (2015) and the NCCP (2019), the CCA Interventions in Nepal ranged from supporting community-based adaptation (CbA) to enabling climate-resilient development planning (CRDP). Other interventions include augmenting adaptive capacities made possible through climate-smart agriculture (CSA) and nature/ecosystem-based adaptation (EbA). There were altogether 76 projects spread over 77 districts, however, the distribution of these projects was disparate (Supplementary File 1). A total of six districts, Parsa, Taplejung, Gulmi, Palpa, Panchthar, and Rautahat, received no CCA investment despite their pronounced climatic vulnerabilities. Bardiya has the highest investment (number of projects = 14), however, it has low climatic vulnerability (Figure 1). Despite the disparities, the overall correlation between districts' vulnerability and CCA projects were positively associated (r = 0.12). Pearson's product–moment correlation coefficient (t = 1.0721, df = 75, p = 0.2871) showed that vulnerability and project interventions were insignificantly correlated. This redundancy could stem from the donor-driven approach in which the projects stay in the easily accessible areas. However, precipitation will be more erratic in the future, and the temperature is likely to go up in the region beyond borders irrespective to the accessibility, implying further jeopardy in the remote and rural highlands. The essence of the development of the backward areas and communities, provincial balance, equitable distribution, etc., was put forward by the Nepal planning Commission ([40,41]).

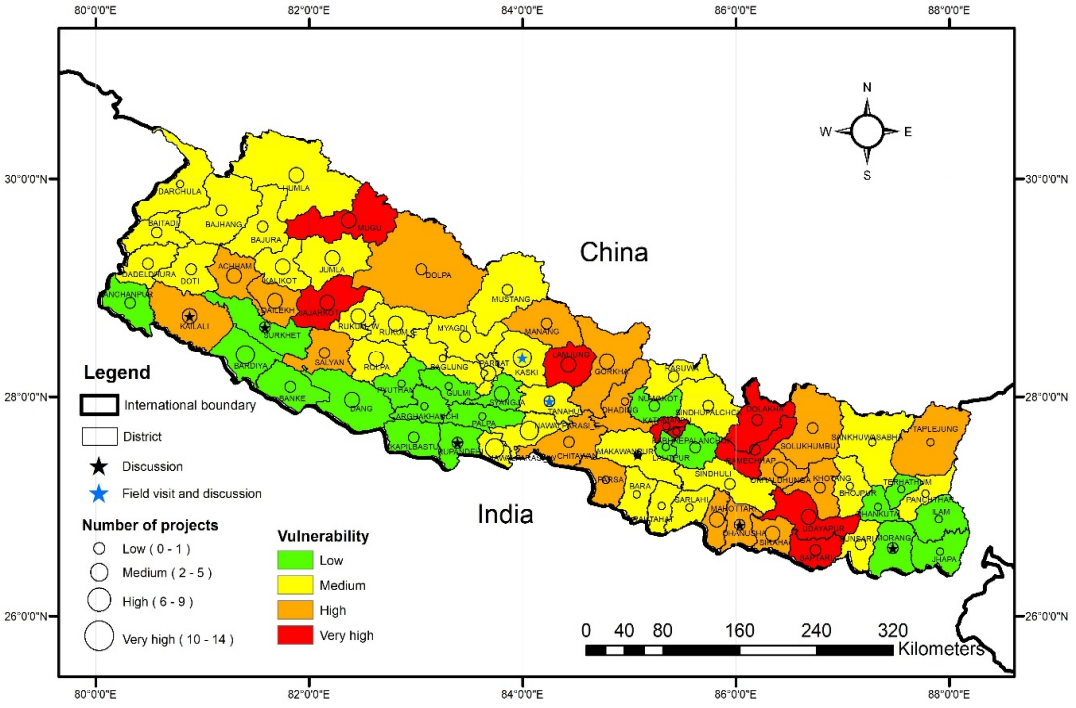

Figure 1. A district map showing climate vulnerability, number of CCA projects implemented, and study sites for field verification.

The distribution of CCA projects in Nepal at a temporal scale showed a hump-shaped curve (Figure 2), hinting that projects were outnumbered between 2013 and 2016, attributed by the plea of the NAPA (2010) and the CAF (2010). The Cancun Adaptation Framework enhanced action on adaptation with the same level of priority as mitigation. The drive was not derailed as the Paris Agreement (2015) called each country to prepare, communicate, and maintain successive nationally determined contributions that it intends to control emissions and promote CCA. As the NAP launched and the SDGs (2015–2030) called actions to combat climate change and its impacts through strengthening resilience and adaptive capacity, the CCA projects aligned with the call and appeared the most in 2015.

However, the investment was found to have a declining pattern after 2015, and it could be a reason for small-scale projects. The average duration of a CCA project in Nepal is 3.2 ± 1.7 years.

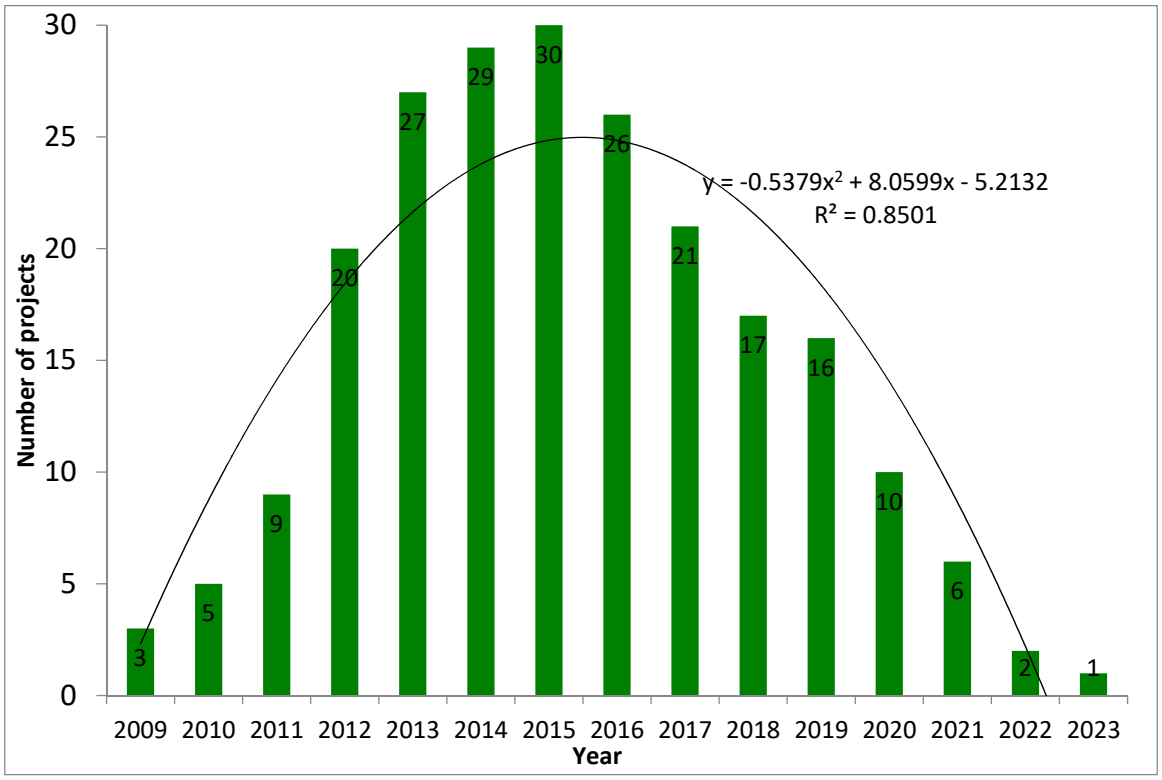

Figure 2. Distribution of CCA projects and their numbers between 2009 and 2023.

Of the CCA projects sampled, the most 40% (n = 48) were associated with community-based initiatives or investments working at the community level in order to manage climate change impacts. The projects enabling the integration of CCA in policy and planning and those promoting smart climate adaptations were 21% (n = 32) and 17% (n = 25), respectively. The least number of projects (n = 12, 8%) were subjected to increased CCA through EbA. In addition to these four types, there were some projects (n = 33) that sought the promotion of research, data, and baselines. For this analysis, we focused only on the former four since these were directly associated with field, biodiversity, and community interventions.

Most of the CbAs are themed for Socio-economy, DRR, and GESI (livelihood, governance), whereas the CSA are meant for agriculture and food security and the adoption of new technologies. EbA in particular acknowledges local knowledge, appreciates multi-stakeholders, incorporates hard infrastructure-based approaches, and works for the betterment of ecosystems, social culture, and DRR (please see in Figure 3). The projects meant for mainstreaming climate risks and vulnerability actions into development plans are grouped under climate-resilient development planning (CRDP). Thus, CCA interventions could not be exclusively of one particular type or focused on one particular theme/sector. They are inter-connected and multifaceted.

The IPCC's fourth assessment report [42] defines anticipatory, reactive, public, and planned CCA that focuses on both technical and institutional adaptation measures. While some stakeholders relate CCA with the community-based adaptation practices and technology, and the others use a broader definition and emphasize the institutional/policy side of adaptation, we classified CCA interventions into community-based practices to government-led programs to development-partner-funded projects. In this study, we discussed more on the latter and found that CCA projects ranged from CbA to EbA to CSA

to CRDP. All four types of CCA approaches are applied in CCA projects in Nepal, however, their intensity is varied, and their scope is intermixed.

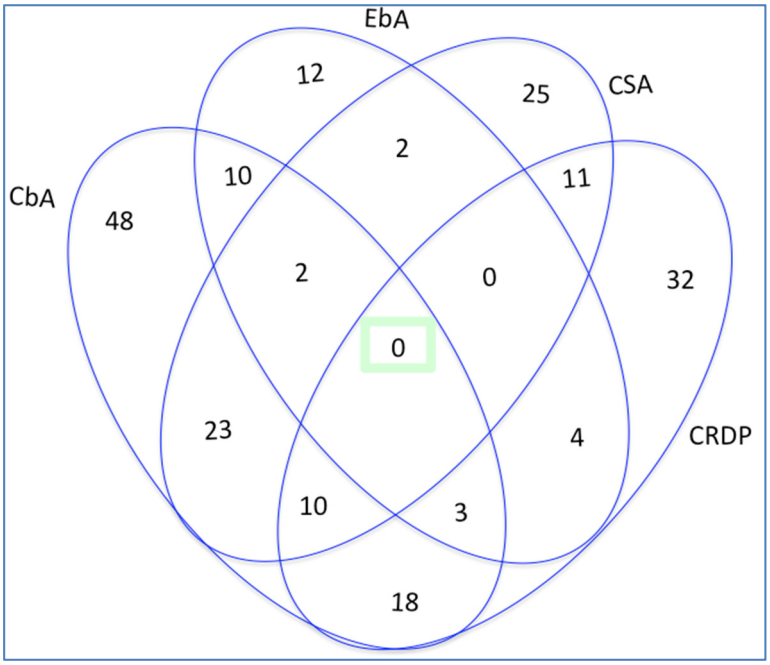

Figure 3. Interconnectedness of four types of CCA projects and their numbers.

3.2. Community-based Adaptation (CbA)

CbA is a management of climate change impacts and pressures by local people. It is a community-led form of proactive adaptation based on the communities' priorities, needs, knowledge, and capacities, which empowers people to plan for and cope with the impacts of climate change [43]. The primary objective of CbA is to improve the capacity of local institutions and communities to adapt to climate change, applying an integrated approach that often combines traditional knowledge with innovative strategies [44]. It is more frequent in Nepal as higher investment is in place in communities and their socio-economic systems. Of the 76 CCA projects sampled, the most 40% (n = 48) were associated with community-based initiatives or investments working at community level in order to manage climate change impacts. The CbA is more frequent as higher investment is in placed in communities and their socio-economic system of CCA. Considering that the vulnerability of poor communities tend to be located in rural and remote flood-prone, drought-prone, alpine-hazard-prone, and landslide-prone steep slope areas, CbA seems to be more pertinent in Nepal since the poor communities are likely to be worst affected [45].

Unpredictable rainfall and erratic precipitation made the communities highly vulnerable. Heat stress, insects, pests, and diseases are serious problems that climate change appears to be exacerbating. Rural hills and mountainous communities are expected to be affected more due to their extensive dependence on climate-sensitive livelihood options and limited adaptive capacity [46].

They have long been using their knowledge to adapt to both climatic and non-climatic changes for centuries [47,48]. Erratic climate variability has brought sudden and unprecedented changes and unfamiliar impacts and consequences that are difficult to manage through indigenous knowledge and practices alone. CbA may start by identifying communities that are most vulnerable to climate change and cataloguing and capacitating local and indigenous knowledge of climate change adaptation [49–51].

Reaching out to the millions of people living in rural remote areas and supporting their genuine participation in any decision making about resource allocation for CbA is an immense challenge for any program focusing on adaptation [45]. Moreover, partici-

patory and CbA approaches need time to develop, and they need flexible and long-term funding [52]. There are some challenges in upscaling the CbA projects because CbA is intrigued with local and community values, and it is skeptical about how useful localized perceptions of risk of future climate change are in upscaling in the areas that have not yet been experienced by vulnerable people. Another skepticism is that CbA adopts the development approach to adaptation, and it unfolds how the development approach can protect people against their immediate and primary needs. However, the latter challenge is diminished as the earlier succeeds in differentiating and prioritizing the needs under way in Nepal (http://community.eldis.org/.59d669a8/research.html (accessed on 16 June 2020)). Since CbA is grounded in community values, coping strategies, priorities, and decision-making structures, it needs to start more work with local communities' expressed needs and perceptions and have poverty reduction and livelihood benefits, as well as reduce the vulnerability to climate change and disasters. As community forestry in Nepal is a participatory forest management system hailed for its success in forest biodiversity conservation and local livelihood enhancement [53], it is estimated that the CbAs follow the success of the CCA services that are sustainably generated and shared selectively to the climate vulnerable communities first and the society and system become adaptive and resilient. It is assumed that the delivery of adaptation services to the climate-vulnerable groups and poor communities is eased through CbA approaches while fostering community-based and locally based mechanisms such as, e.g., community forest-user groups (CFUGs) [54]. While instituting CbA through the integration of CFUGs, we should also redress the weaknesses of CFUGs such as elite-dominated committees, disregard for the distant users, and utilitarian perspectives.

CbAs' future success depends on how participatory and deliberative risk assessment and interventions can reveal the importance of social vulnerability in climate risk, and they are addressed in adaptation options. Incorporation of Disaster Risk management measures in local adaptation strategies are other options directly related to poor communities. The approach of working with CBOs, CSOs, and NGOs could be viable in reaching out to the poor communities because these organizations have the trust of local communities. CbA strategies should take a 'vulnerability first' approach to adaptation. Now, CbA has been increasingly adopted to operationalize local adaptation [55]. Local Adaptation Plans for Action (LAPA) is an instrument greatly aligned with the goals of communities and being complementarity of CbA. Building on the LAPA and lessons learned, guidelines are developed for integrating CCA in sub-national-level planning [7]. Thus, CbA draws on a number of different fields, including local planning, disaster relief work, local community development work, indigenous knowledge, and climate science.

3.3. Ecosystem-based Adaptation (EbA)

Ecosystem-based adaptation has people at its center, and it uses participatory, culturally appropriate ways to address challenges, but there is a stronger emphasis on ecological and nature-based solutions. In Nepal, where household and national economies largely depend on natural resources and their biophysical services, EbA could be a strategic entry point in reducing climatic risks and vulnerabilities and improving economies [10]. Thus, EbA is an approach of planning and implementing CCA considering community-based resource management practices for the betterment of ecosystem health and human well-being. EbA is thus developed in enhancing existing indigenous and traditional practices such as the sustainable management of rangelands and pastures, sustainable water management, sustainable forest management through indigenous knowledge, etc. [56–58].

EbA approaches for planning and implementing CCA consider ecosystem and biodiversity services and their usefulness to human well-being ([59,60]. In a country such as Nepal, where about two-thirds of the population are dependent on agriculture, natural resources, and the provision of ecosystem services [61] for their subsistence, EbA could be a useful approach to reduce risks of climate change impacts and ensure that development proceeds on a pathway that is resilient to climate change [62,63]. There

were 12 EbA-related projects implemented in Nepal between 2010 and 2020 of them, six are exclusively based on EbA (https://www.iucn.org/asia/countries/nepal/ecosystem-based-adaptation-mountain-ecosystems (assessed on 16 June 2020)) while the rest are meant to support capacity development, rural livelihood, policy support, and knowledge management through ecosystem and CbA approaches.

The full suite of benefits from EbA usually manifests over a decade. This is particularly the case in a system where tree seedlings take several decades to fully mature. As a result, there is seldom sufficient information generated from EbA projects to enable policymakers to abstract take-home messages [64]. The current EbA practices are skewed towards biodiversity- and conservation-related interventions along with increasing expansion to the DRR area [65]. EbA tools are yet to be mainstreamed as one of the key adaptation interventions for managing missing sectors such as gender mainstreaming, livelihood, governance, and community participation [66]. EbA could not be easily replicated since the lessons of the EbA are mountain-focused [67]. Thus, EbA is still a developing concept, and it should be considered alongside adaptation actions.

As part of a larger adaptation strategy, EbA accommodates at one or more levels (i.e., local, national, regional, landscape, and sectoral levels) for multiple benefits towards sustainable development, agriculture, land use, poverty reduction, natural resource management, climate change adaptation, and DRR. It is a policy mix that has the potential to utilize ecosystem services while adapting to climate change, thus driving sustainability transitions ([65,68]). EbA focuses on reducing vulnerability and building resilience to the impacts of climate change through the use of biodiversity and ecosystem services [69]. Adopting EbA in NAP generates multiple co-benefits in addition to protection from climate change impacts, including improved biodiversity protection, enhanced water and food security, alternative livelihood opportunities, community health, and disaster risk reduction. In this regard, EbA should be embedded into existing policy frameworks so that interventions could be sustainable and scalable, rather than short-term and standalone. The authors of [70] argued to encompass EbA in a national adaptation plan so that EbA can bridge the gap of adaptation, development, environmental restoration, and DRR interventions.

3.4. Climate Smart Agriculture (CSA)

CSA regards the food security issues of adaptation and helps communities adapt to climate change by adopting climate smart practices [71]. CSA aims to improve food security, helps communities adapt to climate change, and offsets climate change by adopting smart practices and developing enabling policies and institutions [71]. We found that 22% (n = 26) of CCA projects are related to climate smart measures aiming at developing resilience and adaptive capacity (ability of systems, institutions, and humans to adjust or respond to potential climate change impacts or take advantage of opportunities) through adopting appropriate climate smart practices and enabling development planning. Of them, there are six projects funded by the FAO and five projects supported by the CCAFS, all of which work to integrate pro-poor adaptation through working to support agriculture by increasing food security, diversifying livelihoods, and applying climate smart technologies and practices.

As Nepal is diverse in terms of climatic zones, land use types, food production systems, and socioeconomic conditions [72], the CSA needs to consider these multiple dimensions along with the agricultural production and its traits including gender, youth, and socioeconomically marginalized farmers. Promoting climate-friendly practices in agriculture is one of the strategies set out in Nepal's Nationally Determined Contribution (NDC). Thus, CSA options through multipronged and multidisciplinary approaches are required in Nepal, with consideration of the local context (socio-economy and physiography), climatic vulnerability, the nature of technologies, and synergies and wider partnerships (public–private).

3.5. Climate-Resilient Development Planning (CRDP)

CRDP is a way to advance climate-resilient development through the integration of CCA interventions in plans, policies, and programs to achieve sustainable development [73,74]. It provides the opportunity to explore ways to build partnerships among development actors and to devise innovations, which make development works sustainable and cost-effective [75] and plans resilient. The emerging climate scenario also demands that development plans and programs be made resilient enough that they can adapt to the changing situation and context.

From a review, there are 33 projects (28%) that have been working on supporting the integration and mainstreaming of CCA in development planning. Mainstreaming was a priority program in the strategic program for climate resilience (SPCR) of Nepal 2011 [76]. SPCR bolstered the Pilot Program for Climate Resilience (PPCR). Component 3 of the PPCR, Mainstreaming Climate Change Risk Management in Development (MCCRMD), developed knowledge management tools suitable for CCA and contributed significantly to mainstreaming climate risks and vulnerabilities in development planning. Mainstreaming involves the integration of climate change considerations in planning, budgeting, implementation, and monitoring processes [77].

The authors of [78] argued that building resilience into both human and ecological systems is an effective way to cope with environmental changes, and this can be achieved and sustainable once the climate risks and vulnerabilities actions are adequately mainstreamed in development plans. GoN endorsed a Climate Change Financing Framework (CCFF) in 2017 and prepared a roadmap to mainstream climate actions into development plans and budgets and improved accountability and reporting on the effectiveness of climate investments [79]. Climate-resilient planning (2011) and the budget code on climate change (2012) largely eased the process of the introduction and integration of climate issues in development planning. As CCFF (2017) and NCCP (2019) urged the integration of CCA interventions in development planning, the CCA-enabling institutions and policy instruments and sustained climate financing are way forward.

3.6. CCA Project Assessment Criteria and Indicators

A successful adaptation is any adjustment that reduces the risks associated with climate change to a reference level, without compromising economic, social, and environmental sustainability. Therefore, the successful adaptation should embrace the twin objectives of addressing climate risk and vulnerabilities and enhancing the livelihood of poor and vulnerable households [80], as well as ecosystem resilience. The broad range of adaptation attributes defies the use of a single common indicator to measure adaptation outcomes [81]. This comprises a complex interlinkage of institutional, socio-economic, governance, social, and infrastructural conditions and capacities. The identification of a set of candidate evaluation indicators for adaptation is complicated. This is because what constitutes success following an adaptation intervention changes over space and time, as climate change impacts differ across sites, time, and sectors [81,82]. The measurement of CCA's effectiveness thus involves a mix of institutional and behavioral responses, the use of technologies, and the design of climate-resilient plans and climate smart practices, which balances economic, social, and environmental sustainability and enables to appraise efficiency, effectiveness, sustainability, and equity. Thus, we developed a set of criteria to gauge CCA outcomes following [83–86] (Table 1).

Table 1. Criteria Indicators for measurement of CCA outcomes.

Criteria	Indicators	References
Increased resilience of health and well-being and food and water security	• Percentage of total beneficiaries relative to the total population. • Number of persons (male/female) benefiting from introduced health measures to respond to climate-sensitive diseases. • Number of food-secure households (in areas/periods at risk of climate change impacts). • Number of males and females with year-round access to reliable and safe drinking water supply despite climate shocks. • Uptake of measures to improve water and air quality. • Percentage of land with improved irrigation facility.	[84,85]
Increased resilience and enhanced livelihoods of the most vulnerable people, communities, and regions	• Estimated change in losses of lives of males and females due to the impact of climate-related disasters. • Estimated change in losses of economic assets. • Percentage of population adopting climate-resilient livelihood options (agriculture, tourism, fisheries, etc.) • Average income from sustainable crop and/or livestock production. • Increase access to insurance and financial services.	[83–86]
Increased resilience of infrastructure and the built environment to climate change threats	• Estimated change in losses of infrastructure damages (by satellite images). • Number of physical assets constructed and/or made more resilient to climate variability and change. • Value of physical assets constructed and/or made more resilient to climate variability and change.	[83,85,86]
Improved resilience of ecosystems and ecosystem services	• Extent of ecosystems strengthened, restored, and protected from climate variability and change (by number, area, quality). • Increase in the number of climate resilient varieties. • Number of inventories of climate change impacts on biodiversity. • Conservation of genetic resources. • Area under landscape level conservation. • Soil conservation measures (bioengineering, mulching, organic farming, etc.)	[83–85]
Strengthened institutional and regulatory systems for climate-responsive planning and development	• Number of gender-friendly policies, institutions, coordination mechanisms, and regulatory frameworks created or amended that improve incentives for climate resilience and their effective implementation. • Number of policy/documents based on modeling scenarios and Vulnerability assessments. • Number of technical staff received training on adaptation.	[83–85]
Increased generation and use of climate information in decision making	• Number of climate responsive products/services in decision-making in climate-sensitive sectors developed, delivered, and used. • Number of early warning and health hazard information centers and dissemination outlets. • Number of public awareness campaigns on CCA.	[83–85]
Strengthened adaptive capacity and reduced exposure to climate risks	• Use by vulnerable households (including number of female beneficiaries), communities, businesses and public-sector services of fund-supported/developed tools, instruments, strategies, and activities to respond to climate change and variability. • Number of males and females reached by climate-related early warning systems and other risk reduction measures established/strengthened.	[85]
Strengthen awareness of climate threats and risk reduction	• Number of males and females made aware of climate threats and related appropriate responses.	[85]
Crosscutting	• Number of technologies (including gender-friendly technologies) and innovative solutions transferred or licensed to promote climate resilience.	[85]
Tourism, Culture, Industry, and Habitats	• Percentage of climate resilient roads in the country. • Number of new major projects in areas at climate risk. • Funding for climate-adaptation construction. • Percentage of treated wastewater. • Number of climate resilient LEED buildings.	[84]

Table 1. *Cont.*

Criteria	Indicators	References
Water and Energy	• Uptake of riparian tree planting • Priority areas for precautionary flood protection • Adoption of water efficient technologies (water reuse, rainwater harvesting, water trench for recharge, etc.) • Number of Hydroelectric projects that consider future climate risk. • Energy storage capacity.	[84]

3.7. Assessment of CCA Projects

Successful CCA is what balances effectiveness, efficiency, sustainability, and equity through decision-making structures that promote learning and are perceived to be legitimate as an ideal from which much adaptation inevitably evolves. Through the lens of CCA sustainability, equity, efficiency, and effectiveness, a few project instances of progress are worth describing. The projects' successes are championed by local authorities and are incorporated into local development plans. With referring to the indicators proposed in Table 1 and following the CCA types we categorized, we sorted out some projects with their best practices, successes, and effective performances.

A project that helped transform the systems of planning and delivery to cope with climate change and disaster risk is Climate Proofing Growth and Development (CPGD) (2012–2020), funded by DFID and implemented by OPML/ACT and UNDP (Table 2). This project helped out the First Citizens Climate Budget in Nepal and the Climate Change budget code. CPGD supported the study on understanding the demand for and supply of climate change knowledge management in collaboration with the Nepal Climate Change Knowledge Management Center (NCCKMC) at the NAST. Since then, there has been a significant increase in climate financing [87]. By mainstreaming climate change considerations, the project helped improve the efficiency and effectiveness of governments to address the climate vulnerability through policy mechanisms [88].

Table 2. Best practices and lesson learned of the CCA projects.

Lessons	CCA Type	Theme	Project
* Holistic and multi-stakeholder approaches, and multi-sectorial support can help effective community level adaptation.	CbA	Forest, Biodiversity, and Watershed Management	MSFP
* Technology can help to make resilient communities through effective and timely communications and early warning system.	CbA	DRR and Management	ANUKULAN
* Local institutions should be sensitized, empowered, and capacitated for identification, sustainable management, and protection of resources.	CbA	Water Resource and Energy	ASHA
* Ownership at local level is key for the program's success and, at the same time, institutionalization with the government systems can yield a positive impact. Localizing climate adaptation actions has been deeply rooted in planning and implementation.	CbA	Awareness Raising and Capacity Development, GESI	NCCSP 1
* Strengthening CSOs and the coordination mechanisms creates synergies among different adaptation actors/actions.	CbA	GESI	CLACC

Table 2. *Cont.*

Lessons	CCA Type	Theme	Project
* Income generation through high-value crops, NTFPs, is the key aspect to empower the women in the context of Climate Change. Lease-based farming could be a good adaptation option (e.g., Mushar community through SAMARTHYA).	CbA	GESI	HIMALICA, ICCA, SAMARTHYA
* Skill-based training and promotion of Indigenous local knowledge and crop and varieties that have higher potential to cope with challenges of climate change and food security help to build more resilience.	CbA	Agriculture and Food Security, Awareness Raising, and Capacity Development	CCCR, WFP
* Differential Impact Assessment and Response Planning (DIA-RP) framework should be adopted to identify the impacts, underlying causes and adaptation planning at a local level.	CRDP	Forest, Biodiversity, and Watershed Management	Hariyo Ban
* Employing a multimodel ensemble approach is helpful for the vulnerability mapping of watersheds in mountain regions.	CRDP	Research, Technology Development	BCRWME
* Climate finance policies (First Citizens Climate Budget in Nepal and Climate Change budget code, etc.) helped order the climate budgeting.	CRDP	CF	CPGD
* Underutilized resources (plants, areas) can be beneficial to increase food production. For instance, crops being grown in places they were not before can improve the diets of poor farmers. CSA practices such as off-season vegetable farming in order to offset the CC impacts could be a good solution.	CSA	Agriculture and Food Security	NCCSP 1, ASHA, Scaling up CSA
* Existing institution should involve for long-term research across multiple platforms and institutions such as Tribhuvan University and the Government of Nepal, which can account for the positive result. Watershed management (reforestation, infiltration recharge ponds, small storage tank, and bioengineering for gully protections) can successfully recharge the watershed area.	EbA	Forest, Biodiversity and Watershed Management	EbA 1
* An isotope study related to hydrological recharge zones of the natural springs could help to understand the water flow situation in climate impact areas.	EbA	Water Resource and Energy	BCRWME
* Develop knowledge-management center and tools suitable for CCA that contribute significantly in mainstreaming climate risks and vulnerabilities in development planning.	CRDP	Awareness Raising and Capacity Development	NCCKMC, MCCRMD

The MCCRMD project was carried out to database indigenous knowledge and local practices, integrate knowledge in policies and plans, and support development works in climate-sensitive sectors in Nepal [89]. Climate change requires lasting solutions with integrated interventions in the long run. The integration of indigenous and scientific knowledge to improve the adaptation and disaster risk reduction options in Nepal, especially in rural areas for marginalized and disadvantaged communities, is deemed necessary. It trained nearly 800 district planners and provided intensive support to eight line ministries in mainstreaming CCA measures [28]. The authors of [90] emphasized the importance of 'community-centric provisions' to empower local institutions and encourage inclusive

decision-making and benefit- sharing for such mainstreaming in Nepal. CLACC project, which is operated by IIED, helped strengthen the capacity of community service organizations (CSOs) to adapt to climate change and foster adaptive capacity among the most vulnerable people [91]. The USAID-ICCA project (2012–2017) provided support for local adaptation planning to develop sustainable livelihood opportunities for over 20,000 smallholder families through sustainable use and management of non-timber forest products (NTFPs), high-value crops, coffee, and essential oils [92].

Government program of SPCR, and agency-run projects such as the NCCSP and the Hariyo Ban Program are being implemented for effective and local-level CCA to the vulnerable people of Nepal [93]. Over 67,000 ha of land was conserved, and biodiversity conservation was achieved while undertaking local CCA, evidenced in the Hariyo Ban project [94]. Building on the LAPA and lessons learned from the NCCSP, guidelines are developed for integrating CCA in sub-national-level planning [7]. IIED and IUCN are using evidence from the Mountain EbA Project, to explore the effectiveness of EbA approaches to CCA and inform national adaptation planning processes [95]. A CSA up-scaling project (2015–2017) funded by CDKN/CCAFS and implemented by LiBIRD in Kaski, Lamjung and Nawalparasi districts identified a range of context-appropriate practices that have high potential for scaling up within Nepal's various agro-ecological systems [96].

4. Conclusions

Community-based investments that worked at the community level in order to manage climate change impacts were the dominant CCA type in Nepal. Capacity building and awareness raising were the major impetus of most of the projects while the projects addressing the vulnerabilities and risks associated with climate change through nature-based solutions were quite low. The low number of EbA projects, applying nature-based solutions for CCA, have reduced the vulnerability of people, natural systems, and economies to climate stressors. Most of the rural communities are dependent on local resources, indigenous knowledge and occupational practices to survive the harsh climate as well as chronic deprivation. Community-based adaptation intrigued with local socio-economy and development contexts that are therefore important in offsetting the climatic vulnerabilities. The initiatives acknowledging participatory, nature-based, and local culture/indigenous knowledge friendly measures are likely to be feasible. A set of 11 criteria and 40 indicators comprises the institutional and behavioral responses, use of technologies, and the design of climate resilient plans and climate smart practices were proposed to consider for evaluating the success of CCA. However, there is a need to test the feasibility of the indicators proposed and promote their uses so a robust understanding of the role of CCA and its particular type in providing adaptation benefits is ensured.

This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex.

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