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Research article

An assessment of potential synergies and trade-offs between climate mitigation and adaptation policies of Nepal

Subina Shrestha, Shobhakar Dhakal*

Department of Energy, Environment and Climate Change, School of Environment, Resources and Development, Asian Institute of Technology, Klong Luang, Pathumthani, 12120 Thailand

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ABSTRACT

Climate actions are centered on either mitigation or adaptation or both. Mitigation and adaptation actions can interact with each other resulting in synergies or tradeoffs. An integrated approach that considers these interactions is important to harness the synergies to create win-win situations and to avoid trade-offs for no-regret decisions. In this context, this study presents a qualitative analysis of the existing national level climate policies of Nepal to identify the extent and mechanism of their mitigation-adaptation interactions based on expert survey. Four key sectors having inter-relationships between mitigation and adaptation were identified as Agriculture, Forestry and Land use (AFOLU), urban planning, energy and water. We used Analytical Hierarchical Process (AHP) to rank and prioritize the opportunities and barriers for harnessing synergies and avoiding trade-offs of mitigation-adaptation interlinkage with these sectors in view. Our results show that such interactions in the Nepalese policy context are present mostly in the form of synergies in the order of AFOLU > Urban Planning > Energy > Water. We identified that developing an institution dedicated to climate change at the national level is the most important opportunity while inadequate institutional co-ordination is the most important barrier for harnessing these synergies.

1. Introduction

Two distinct mechanisms for addressing climate change are mitigation of greenhouse gases (GHGs) and adaptation to the impacts of climate change. However, these are fundamentally different in terms of spatial, temporal, institutional and administrative scales. This has led to the two strategies to be developed in silos, and thus these are considered separately (CIRAD, 2015). Mitigation has been considered, historically, as the issue of developed countries, while adaptation is prioritized by the global South (Ayers and Huq, 2009). Adaptation has only recently gained priority in global climate negotiations since the Paris Agreement (Edenhofer and Kornek, 2016), which encourages balanced allocation of funds for adaptation and mitigation actions. One way of overcoming this divide between the two strategies is an integrated approach that considers their interactions (Kengoum and Tiani, 2013), which could result in significant co-benefits, synergies or tradeoffs (IPCC, 2014). This is especially important in the context of Paris Agreement where nations have mitigation commitments as well as adaptation priorities. Most studies on climate policy integration have focused on mainstreaming either adaptation or mitigation (Kok and de Coninck, 2007; Mickwitz et al., 2010). Recent studies, however, suggest that identifying mitigation-adaptation interlinkages could help to bridge the gap between adaptation-centric development and the need to achieve a global engagement in mitigation (Ayers and Huq, 2009).

Studies have argued that national level climate policies should recognize mitigation-adaptation interlinkages, and incorporate an optimal balance between the two to maximize benefits from synergies and to safeguard against potential risks from trade-offs (Berry et al., 2014; Leonard et al., 2016). However, there is no single 'optimal balance' as it is context-dependent and varies by country and over time (Klein et al., 2005).

Synergies between mitigation and adaptation options can occur within same sector (Stoorvogel et al., 2004; Jarvis et al., 2011; Berry et al., 2014) or across several sectors (Landauer et al., 2015). Previous studies on synergies and trade-offs have been focused widely on Agriculture, Forestry and Other Land Use (AFOLU) sector, including REDD + (Torre et al., 2009), ecosystem-based conservation (Gregorio et al., 2016; Locatelli et al., 2015), agro-forestry (Duguma et al., 2014), and agriculture (Aguilera et al., 2013; Bryan et al., 2010; Kassam et al., 2012; Palm et al., 2010). Few studies have identified the potential for synergies in energy, infrastructure planning and construction, transportation, insurance and waste treatment sectors (Kengoum and Tiani,

* Corresponding author.
E-mail addresses: shrsubina@gmail.com (S. Shrestha), shobhakar.dhakal@gmail.com, shobhakar@ait.ac.th (S. Dhakal).

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2013). Despite growing emphasis on synergies, cases arise where synergies cannot be developed among all the components of a policy. This could be due to inadequate conditions, biases, competition among means for implementation (Moser, 2012) or the fundamental distinctions between adaptation and mitigation. In such circumstances, the most rational compromise should be considered in the form of tradeoffs (Kengoum and Tiani, 2013).

The landlocked and mountainous geography of Nepal coupled with its socio-economic condition of widespread poverty places it at a high vulnerability to climate change (Shrestha and Aryal, 2011). Nepal is the seventh country ranked for climate change impact in the world, and climate change will further exert additional stresses to the socio-ecological systems and pose major climate change challenges (Dhital and Koirala, 2016). Nepal is already witnessing rapidly retreating glaciers (average retreat of more than 30 m/year), rapid rise in temperature ($> 0.06\,^{\circ}C$), erratic rainfalls and increase in frequency of extreme events such as floods and drought like situation over the last few years (Karki et al., 2010). These alarming trends place Nepal's major sectors of economy such as agriculture, tourism and energy at high vulnerability (Karki et al., 2010). The most critical impacts of climate change in Nepal can be expected on its water resources, particularly glacial lakes, and its hydropower generation (Pathak, 2010) which could be seriously affected by a combination of variable flows, flooding risks, as well as sedimentation brought down by intense rainfall or GLOF(Glacial Lake Outburst Flood) events (Agrawala et al., 2003). The agriculture sector of the country, which is mostly rain – fed, could also be severely affected, causing food security issues (Pathak, 2010).

Consequently, Nepal has mainstreamed climate change into its development policies, albeit emphasizing adaptation over mitigation. Nepal is gradually increasing its mitigation efforts as its reliance on unsustainable and costly fossil fuels costs Nepal a substantial percent of its revenue. However, mitigation and adaptation policies in Nepal have been developed in silos, with mitigation efforts being largely directed towards energy policies and REDD+, and other policies emphasizing on adaptation. As a result, possible interactions between them are overlooked. Looking for mitigation-adaptation interactions in Nepal could increase the significance of mitigation in Nepal (Ayers and Huq, 2009), particularly in the wake of Nepal's low carbon economic development strategy. Nepal could also be able to tap into mitigation climate funds, which accounted for about 93% of total climate funds from 2015 to 2016 (Buchner et al., 2017) and address its adaptation needs partially through mitigation priorities (Venema and Rehman, 2007). This could also ensure sustainable development and prevent maladaptation (Cote and Teixeira, 2012), and could create foundations of the institutional capacity and sectoral collaboration required in effective climate policies. This paper aims to explore the mitigation-adaptation interlinkages in national level policies and assess synergies and trade-offs between these policies. Specifically, this paper aims to answer two research questions: What is the extent of interaction between mitigation and adaptation policies in Nepal? What are the opportunities and barriers to harness the synergies and minimize the trade-offs between mitigation and adaptation policies?

2. Nepal's climate policies

Numerous policy efforts have been made to address climate change in Nepal at both national and sub-national scales. In 2005 the government of Nepal ratified the Kyoto protocol. Since then several renewable energy projects have been able to access the Clean Development Mechanism (CDM). During 2009, there was a shift in Nepal's policy priorities towards climate change adaptation which resulted in policy documents such as National Adaptation Programme of Action (NAPA, 2010); Climate Change Policy (2011) and Local Adaptation Plans for Action (LAPA) framework (2011). Nepal also prepared its Nationally Determined Contributions (NDCs) in 2017 with targets for both mitigation and adaptation. Nepal's federal system of governance emphasizes the role of local government for environment conservation, while the federal government is responsible for climate change adaptation and mitigation. The government is now in the process of finalizing its national adaptation plan (NAP) and Low Carbon Economic Development Strategy.

NAPA (GoN, 2010) offers a comprehensive vision for adaptation in Nepal, with priorities in agriculture, community-based disaster risk management, forest and ecosystem, and a strong governance structure to support it. It is a comprehensive policy framework that has been developed through extensive stakeholder consultation. Nepal's NAPA places an emphasis on the need for and importance of local level decision making as well as control over the use of adaptation funds.

The Climate Change Policy (GoN, 2011) of Nepal was formulated with the goal of “enhancing the livelihoods of peoples by mitigating as well as adapting to the adverse impacts of climate change, while adopting a low carbon development pathway that supports the country's commitments to climate related agreements, both national and international”.

The NDCs (GoN, 2016) of Nepal comprises of 14 targets, wherein it emphasizes adaptation as well as mitigation. It envisions the use of National Adaptation Plans (NAPs) for post 2020 adaptation needs. Mitigation activities are focused on the energy sector, with targets to increase renewables and simultaneously decrease dependency on fossil fuels, diversify its energy mix and promote energy efficient and electric vehicles. It also sets a target of sequestering 14 million tons of CO_2 eq. by 2020 through a REDD + sub national pilot project.

Mitigation efforts in Nepal have been evident in the form of Clean Development Mechanism (CDM) projects for biogas and Improved Cook Stoves (ICS) projects. 8 carbon projects have been registered under UNFCCC so far. The government is also working on using REDD + mechanism for carbon sequestration. Mitigation potential from other sectors, however, are yet to be explored.

Apart from these, there are several sectoral policies in Nepal that directly or indirectly contribute to mitigation and adaptation. Policy 6 under the Forest Policy (2014) of Nepal comprises of strategies and working policies exclusively targeted at climate change mitigation and adaptation, under the heading “Examining solutions to adapt and mitigate against negative impacts of climate change”. It focuses on controlling carbon emissions, discouraging deforestation and addressing the community-level concerns through indigenous methods. Likewise, Rural Energy Policy (2006) has provisions for accessing carbon markets for carbon offset projects.

3. Methodology and data

In this study, we considered national and sectoral policies related to climate change, including NDCs, NAPA, National Communications to UNFCCC, Climate Change Policy of Nepal. Based on this review, we recognized that climate change policies in Nepal is primarily focused on four clusters: AFOLU, Energy, Water and Urban planning. We classified these policies as either mitigation or adaptation based on its content. We also identified potential opportunities and barriers to harness the synergies and avoid the trade-offs between adaptation-mitigation policies, as well as the criteria to assess these opportunities and barriers. The overall methodological framework is given in Fig. 1.

We used a qualitative research approach for this study. The target of the research and the use of the Analytical Hierarchy Process (AHP) dictated the need the respondents to be experts on climate change and the four sectors (AFOLU, energy, urban planning and water resources). We used a non-probability method for expert selection, and applied purposive expert sampling (FHI, 2005; Apostolopoulos and Liargovas, 2016) and snowball sampling (FHI, 2005; Abotah, 2015). Purposive sampling involves identification and selection of individuals or groups of individuals that are proficient and well-informed with a phenomenon of interest. Snowball sampling is defined as “a sampling method in which one interviewee gives the researcher the name of at least one

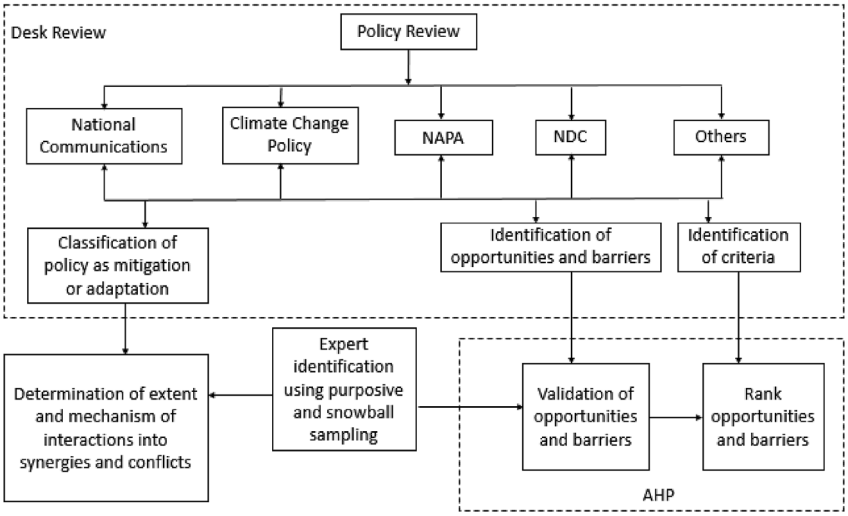

Fig. 1. Overall Methodological Framework of the study.

Table 1
Scoring system to determine the interaction between policies.
Source: (Nilsson et al., 2016)

Interaction Score	Name	Explanation
3	Indivisible	Inextricably linked to the achievement of another policy
2	Reinforcing	Aids the achievement of another policy
1	Enabling	Creates conditions that further another policy
0	Consistent	No significant positive or negative interactions
−1	Constraining	Limits options on another policy
−2	Counteracting	Clashes with another policy
−3	Cancelling	Makes it impossible to reach another policy

more potential interviewee. That interviewee, in turn, provides the name of at least one more potential interviewee, and so on, with the sample growing like a rolling snowball if more than one referral per interviewee is provided" (Kirchherr and Charles, 2018). In addition to knowledge and experience, the availability and willingness to participate, and the ability of the experts to communicate experiences and opinions in an articulate, expressive, and reflective manner is also important (Etikan, 2016).

We identified twenty-five experts from the four sectors mentioned earlier using the following criteria: worked in the field of policies relevant to climate change for three or more years; in decision making positions, and; availability to participate in at least one stage of interview.

Two rounds of interviews were conducted, one for each objective. For the first round, experts were identified from government, International Non- Government Organizations (INGOs), Non-Government Organizations (NGOs) and academics relevant to climate change policy-making and implementation. Questionnaire-based in-depth interviews (Questionnaire in Supplementary Material) were conducted with the experts to score the interactions among policies, and to understand the mechanism of interactions.

We also asked the experts to validate the lists of opportunities and barriers identified from our desk review, and make any further additions as deemed necessary, relevant to the case of Nepal. Once all the opportunities and barriers were validated, a consolidated list was prepared by placing similar ideas under a broader terminology. The final consolidated list comprised of six opportunities and five barriers.

For the second round, we conducted Analytical Hierarchy Process (AHP) to prioritize the opportunities and barriers. When applying AHP, a hierarchical decision schema is constructed by decomposing the decision problem into its decision element. The importance or preferences of the decision elements are compared in a pairwise manner with regard to the element preceding them in the hierarchy (Kurttila et al., 2000). We used SuperDecisions software to form the hierarchy and interviewed twenty stakeholders, which comprised of some of the previously contacted experts and some new contacts. We also added new stakeholders from donor agencies to include donor perspective while investing in climate change projects, and freelance consultants to avoid biases, while those experts belonging to redundant sectors were avoided to minimize biases. We conducted questionnaire survey with the experts to conduct pairwise comparisons (Questionnaire in Supplementary Material) of the identified opportunities and barriers and computed the results. We then calculated consistency ratios to ensure that there were no inconsistent entries in the questionnaires. In case of inconsistent rankings, we sent back the questionnaires to the respective experts to revise their judgements.

3.1. Extent and mechanism of interactions

We used a seven-point scoring system (Table 1) for expert respondents to gauge the interactions into synergies and trade-offs (Nilsson et al., 2016). The scores determine the 'extent' of interaction (the qualitative definition of scores are explained in Table 1 too), and the 'mechanism' of interactions was determined by qualitative in-depth interviews with the experts.

3.2. Prioritizing opportunities and barriers using AHP

AHP is a multiple-criteria decision analysis tool that combines practical and theoretical considerations to make pairwise compromises (Ahmad and Tahar, 2014). In AHP, a pairwise comparison of criteria converts them qualitative data into a numerical format (Darshini et al., 2013) using weights. In this study, the weights ranged from 1 to 9 and were displayed as ordinal scale of importance in questionnaires (1 = Equal importance; 3 = Moderate importance; 5 = Demonstrated importance; 7 = Essential importance; 9 = Extreme importance).

The resulting ranking can be shown in the form of a matrix of weights, where the designated relative weight is keyed into the matrix as an element a_{ij} (element of row i column j) and its reciprocal value ($1/a_{ij}$) is then designated to element a_{ji} (Ahmad and Tahar, 2014; Catron et al., 2013; Darshini et al., 2013). All values for a_{ij} where i = j is 1, as shown in equation (1):

$$A = (a_{ij}) = \begin{bmatrix} 1 & w1/w2 & \cdots & w1/wn \\ w2/w1 & 1 & \cdots & w2/wn \\ \vdots & \vdots & & \vdots \\ wn/w1 & wn/w2 & \cdots & 1 \end{bmatrix} \quad (1)$$

Here, rows specify weight ratios of individual factors, and all the values of $a_{ij} > 0$. Multiplying matrix A by the transpose of the vector of weights (say matrix W) leads to Equation (2):

$$AW = N.\ W = \lambda_{max} W, \quad (2)$$

Where, N is the number of rows and columns, W = (W1, W2, …, WN), and λ_{max} is the largest Eigen factor. Consistency test is then conducted, whereby if the matrix is consistent, then $\lambda_{max} = N$. However, if the responses are inconsistent, then $\lambda_{max} \neq N$. Thus, matrix A must be examined for consistency using equations (3) and (4):

$$CI = (\lambda_{max} - N)/(N - 1), \quad (3)$$

$$CR = CI/RI, \quad (4)$$

Where, CI is the Consistency Index, RI is the Random Index produced for a random matrix of order N, and CR is the Consistency Ratio. A rule of thumb is that the CR ≤ 0.1 (Darshini et al., 2013).

4. Results and discussions

The results show that adaptation-mitigation interlinkages exist in Nepalese climate change policies in the form of both synergies and trade-offs. The details and degree of these interactions are discussed below. Since there are many policies as described in earlier sections, we went into detail of each policies during literature review and we clustered these specific policies into four categories, namely, AFOLU, Urban Planning, Energy and Water, that we call them sectors.

4.1. Extent and mechanism of interactions among policies

The extent of interaction scores ranges from −3 to 3 (refer to Table 1). In this study, the range of −2 to 3 was observed (see Tables 2–5). Below, we present insights for each category in detail. In Tables 3–6, we have presented the extent of interaction for the specific policies in broader climate policy documents falling into each sector and described their mechanisms of mitigation-adaptation interactions. In Figs. 1–4, we have presented the extent of interaction for same specific polices described in Tables 2–5

4.1.1. Agriculture, Forestry and Other Land Uses (AFOLU) sector

AFOLU sector scores range from −2 to 3 (Fig. 2), revealing that these policies have large spectrum of potential for trade-offs as well as synergies amongst all sectors. Four (A7, A11, A12 and A14; see Table 2) of the fourteen policies have the potential for trade-offs between mitigation and adaptation goals. As seen in Fig. 2, all the fourteen policies have a higher potential for synergies than trade-offs. The synergy scores range from enabling (score = 1) to indivisible (score = 3), and majority of interactions is present as enabling, i.e. these policies create enabling conditions for both mitigation and adaptation. In case of trade-offs, the majority of interactions are constraining (score = −1), i.e. they could limit the adaptation or mitigation potential of the policies.

4.1.2. Energy sector

The energy sector in Nepal is dominated by the traditional biomass energy for domestic usage accounting for about 78% of the national energy consumption (WECS, 2017). Energy sector policies are primarily directed towards basic access to energy and expanding the energy mix in Nepal. The mitigation-adaptation interaction scores range from 0 to 3 (Fig. 3). Not having negative score here, reveals that there are no trade-offs between mitigation and adaptation in energy sector (Table 3). The maximum interactions score in this sector were identified as 2, meaning that most policies in energy sector are reinforcing mitigation and adaptation.

4.1.3. Urban planning sector

Policies in urban planning categories are focused at both adaptation and mitigation. The scores range from 0 to 3 (Fig. 4), with the maximum interactions identified as enabling (score = 1) followed by reinforcing (score = 2). Most of the policies create enabling conditions for mitigation-adaptation while a few of the policies in urban planning sector reinforce mitigation-adaptation. No negative scoring in this sector means that there is no potential trade-offs in Nepal's urban planning policies (Table 4).

4.1.4. Water sector

Although majority of water sector related policies are adaptation driven in Nepal, as shown in Table 5, our results show that these have potential for both synergies and trade-offs with mitigation (Fig. 5). The interaction scores range from −2 to 3. The most frequent interaction score was 0, revealing that the policies are mostly adaptation centric. Two policies in this sector identified trade-offs as constraining (score = −1), i.e. the adaptation-centric nature of these policies could limit mitigation potential. The extent of synergies scores ranges from 1 to 3 (Fig. 5), meaning the policies can enable, reinforce or be indivisibly linked to attaining mitigation potential.

4.1.5. Summary of results

It is thus evident that Nepal's climate change policies have potentials for both synergies and trade-offs, with the maximum mitigation-adaptation interactions being in AFOLU and Urban planning sectors. The maximum number of synergies were in the order of AFOLU > Urban Planning > Energy > Water. The extent of synergies ranged from creating enabling conditions for mitigation-adaptation interlinkages (score = 1) to being indivisible for attaining mitigation-adaptation goals (score = 3). Trade-offs were mostly identified in AFOLU and water sectors, and a higher number of trade-offs were present in AFOLU sector. Trade-offs in AFOLU sector arise from food carbon trade-offs policies for increasing forest cover are not consistent with policies for enhancing food security or current grazing practices. Previous studies have also identified both synergies (Mbow et al., 2014; Kongsager et al., 2016) and tradeoffs (Paterson and Bryan, 2012; Crossman et al., 2011) in other regions. In many countries, REDD + strategies currently do not make a link with agriculture, while in some countries clear conflicts have been identified between REDD + and agricultural policies (Visseren-Hamakers et al., 2012). An integrated consideration of cross sectoral interactions between agriculture and forestry is important to avoid the trade-offs to the extent possible and institutional mechanisms for the food-energy nexus needs to be in place (Campbell, 2008). Urban greening policies in cities across USA, Austria, Germany, Canada and Switzerland have also shown adaptation-mitigation synergies (Thornbush et al., 2013). In Nepal, energy sector policies are mostly mitigation-centric while water sector policies are adaptation-centric. Nevertheless, these also have potential for interactions with adaptation. Rural energy policies in developing countries are targeted at enhancing adaptive capacities of rural communities without increasing GHG emissions (Venema and Cisse, 2004). These contribute to livelihood diversification opportunities and other welfare benefits that strengthen communities' resilience, thereby creating synergies. Hydropower development related energy policies have been criticized (Pinho et al., 2007) as they could result in maladaptation by negatively affecting aquatic as well as terrestrial ecosystems, and possibly in community relocation. Such relocations are common in the case of storage type hydropower plants. West Seti Hydropower project has faced much controversy due to the huge resettlement costs resulting from dam construction (ADB, 2018). Majority of the hydropower development so far in Nepal is run-of river type, and has not resulted in such relocations. Nepal's total hydropower potential on run-of river basis has been estimated to be approximately

Table 2
Table showing the mechanism of interactions in AFOLU policies.

Policy ID	Policy Description	Mechanism of interaction
A1	Maintain at least 40% forest area (Forest policy page 5, 2015)	Primarily formulated as mitigation policies, A1-A4 bear adaptation co-benefits, thereby presenting the potential for synergies. Maintaining forest cover, enhancing forest carbon stock and expanding the scope of carbon sequestration are inter-related policies that not only aid to mitigate the impacts of climate change, but also provide opportunities for alternative livelihoods as well as livelihood diversification for forest users. This in turn increases the adaptive capacity of the users, making them more resilient to the impacts of climate change. The formulation and implementation of land use plans that integrate Sustainable forest management can also contribute to adaptation by supplying forest products and increasing benefits of livelihoods, thereby enhancing the local economic activity. Forestation can lead to restoration of land that has been degraded been degraded by over-extensive agriculture, manage water runoff, retain soil carbon and benefit rural economies by providing employment and income. Planting forests and sustainable forest management can aide in the protection of soil and land against detrimental impacts of flooding.
A2	Enhance forest carbon stock by at least 10% by 2025 compared to 2015 level (Forestry Sector Strategy 2015–2025)	
A3	Expanding the scope of carbon sequestration through sustainable management of forests, formulating and implementing land use plans and controlling deforestation (Climate Change Policy 8.2.3, 2011)	
A4	Encouraging carbon sequestration and investing some of the benefits from the use of forest products for controlling forest fires and conserving forests (Climate Change Policy 8.7.6, 2011; Forest policy, 2015)	
A5	Forest and Ecosystem management for supporting climate led adaptation innovation (Forest Policy page 12, 2014)	Both these policies imply integrated approaches to natural resource management. Forest based adaptation can directly contribute to synergies by increasing the forest cover (mitigation potential), and providing habitat for biodiversity, aiding in water conservation, rehabilitate degraded land and maintain water quality by trapping sediments, taking up nutrients, and immobilizing toxic substances providing opportunities for agro- forestry as well as use of forest products (adaptation potential).
A6	Community based management through integrated management of agriculture, water, forest and biodiversity sector (NAPA page 29, 2010)	
A7	Prioritizing and implementing programs on sustainable management of forests, agro- forestry, pasture, rangeland and soil conservation (Climate Change Policy 8.7.3, 2011)	86% of the experts responded that this policy is synergistic as sustainable management of resources can contribute to mitigation by reducing emissions from haphazard management of the resources. However, 14% experts identified trade-offs in this policy on the grounds that current pasture and rangeland management practices are not conducive for controlling deforestation and land degradation. Moreover, they also have the potential to compete with land for food production and may be negative for biodiversity, giving rise to trade-offs.
A8	Utilization, promotion, conservation of forest resources as a means of alternative livelihoods (Climate Change Policy 8.7.2, 2011)	Despite being formulated as an adaptation policy, A8 has potential for mitigation. Experts responded that promoting the use of forest resources as alternative livelihoods encourages forest conservation, including community forestry among user groups, and can aid in mitigation by enhancing forest carbon stocks.
A9	Afforestation in urban areas, including residential areas, and road- side plantations for environment friendly infrastructure development (Forest Policy page 6, 2014)	Urban greening can contribute to mitigation by fostering carbon sequestration. They can also affect the micro- climate and help in regulating temperatures in urban areas. Additionally, this policy builds linkages between urban planning and forestry, thereby making way for inter- sectoral interactions.
A10	Use integrated river basin approach for land and water conservation and increased land productivity (Forest Policy page 8, 2014)	Integrated river basin approach is a strong adaptation based program that can contribute to increased productivity. Although this policy is more focused on adaptation, it can contribute to mitigation by increased land productivity and consequently increased soil carbon stock. However, 28% of the experts argue that there are no interactions because in the context of Nepal, forest management, water conservation and land productivity policies are not in line with one another.
A11	Developing mechanism for optimal utilization of international regional and local funding sources, including REDD (Climate Change Policy 8.7.7, 2011)	28% of the experts stated that there are possible trade- offs in these policies because no appropriate mechanisms have been developed yet under the current legal and policy measures. Likewise, because carbon trading is a relatively new concept in Nepal, social and other policy supports for this are yet to be harnessed. 49% of the experts are in favor of possible synergies as REDD +, despite being a mitigation centric concept, can contribute to increasing livelihood and adaptive capacity.
A12	Use REDD + as a means for generating finance through carbon trading (Forest Policy page 13, 2014)	
A13	Provide financial and technical support for alternative energy, biogas, bio-briquette, improved cooking stoves and biofuel (Forest policy page 13, 2014)	Synergies in this policy are derived from increased access to energy and diversified livelihood options while simultaneously reducing dependence on fossil fuels and promoting renewable energy and energy efficiency. Experts did not identify tradeoffs with food security as biomass energy policies in Nepal are largely targeted at agricultural and forest residues rather than bioenergy crops related liquid biofuels.
A14	Enhancing the adaptive capacity of food grains and species from the possible impacts of climate change (Climate Change policy 8.4.4, 2011)	28% of the experts stated that there is possible trade- offs, primarily because climate policies and measures have not been fully implemented in agriculture sector in Nepal. At the same time, this policy does not support REDD + as enhancing food security is believed to conflict with increasing forest cover and reducing land degradation.

53,000 MW (Jha, 2011), which can ensure energy security without causing community displacements. It is, however, still important to consider benefit sharing mechanisms as well as equitable distribution of revenue generated by these projects while pursuing hydropower projects of any scale (Ridel and Jeuland, 2017).

The results show ample of interactions between mitigation and adaptation, however, the scope of analysis of synergies and trade-offs should also encompass system complexities in the perspective of interlinked energy, water, and land-use systems (Nordic Council of Ministers, 2017).

4.2. Identification and prioritization of opportunities for harnessing synergies and addressing trade-offs

After getting insights on the extent and mechanism of interactions between mitigation and adaptation in existing climate and climate related policies in Nepal, we tried to look into opportunities for harnessing synergies and addressing trade-offs. We identified six such opportunities through our desk study based on past literature, review of Nepalese policies and practices, and our expert judgment of Nepalese context. As mentioned earlier in the methodology section, they were

Table 3
Table showing the mechanism of interactions in Energy policies.

Policy ID	Policy description	Mechanism of interaction
E1	Expand and decentralize energy mix, and promote renewable energy including solar/hydro/bioenergy (National Communications, 2014)	These policies are chiefly mitigation policies that aim to reduce the dependence on fossil fuels by encouraging renewable sources of energy. Synergies in these policies arise from the fact that these not only ensure mitigation, but also help to build the adaptive capacity of communities. Decentralized renewable energy can provide energy for irrigation pumping and post-harvest processing, which in turn provides new water resource management options and livelihood opportunities, thereby increasing communities' adaptive capacities (Venema and Rehman, 2007).
E2	Encouraging investments in clean energy sources with priority on hydropower from national, regional and international sources (Climate change policy: 8.7.4, 2011)	Experts identified hydropower development policies having synergies between mitigation and adaptation, stating that these increase communities' resilience by ensuring reliable power supplies. Investments in the country's hydropower would also mean decreasing reliance on diesel power generators in industries to deal with power cuts, which contributes to mitigation. Nepal consists of mostly run- of-the- river hydropower plants. Experts did not identify any trade- offs of such hydropower schemes. In any case, the settlement in mountains are sparse and large-dam based storage hydro project are not in sight except for potentially exporting power to India. Although experts did not identify any trade- offs, other studies highlight the potential physical, ecological and social impacts of storage- type hydropower development on aquatic biodiversity, riverine habitat, land acquisition and involuntary displacement (Anderson et al., 2006). Storage hydropower plants are known to cause community resettlement (Garada, 2015) and affect their livelihoods. West Seti Hydropower development in Nepal has been a controversial project due to huge resettlement costs (ADB, 2008).
E3	Increases in fuel taxes, incentives for mass transport systems, and fiscal incentives and subsidies for alternative fuels and vehicles. (National communications page 66, 2014)	Fuel tax as a policy aims to reduce the dependence on fossil fuels, thereby helping in mitigation. 66% of the experts also believe that fuel taxes policies do not have any interactions as these are mostly mitigation policies, with no adaptation co- benefits. However, the revenue generated from this can be used to subsidize renewable energy technologies and energy efficient technologies thereby aiding in energy security and enhancing rural communities' access to such technologies. The experts also asserted that revenue generated from these taxes have not been efficiently utilized yet, which has caused an increased economic burden on consumers, as the consumers have to pay additional taxes.
E4	Development of solar energy technologies will be encouraged by integrating it with technologies for drying and cooking of food, purifying water, lighting and communication systems (Rural Energy Policy 4.4.3, 2006)	These policies have been formulated primarily to ensure rural energy access as well as security. However, an emphasis on renewable rural energy reduces the dependence on traditional fuel sources (primarily biomass) for domestic purposes, thereby helping to reduce emissions. Moreover, these policies also make renewable energy affordable to rural households, thereby promoting the use of clean and renewable sources of energy.
E5	Subsidies, credit and soft loan for Renewable energy sources (Renewable Energy Subsidy Policy, 2016)	

Table 4
Table showing the mechanism of interactions in Urban Planning policies.

Policy ID	Policy description	Mechanism of interaction
U1	Formulating and implementing design standards for climate resilient construction of bridges, dams, river flood control and other infrastructure (Climate Change policy 8.2.8, 2011)	This policy is primarily targeted to adapt to the negative impacts of climate change. However, these can also have some effects on mitigation. Design standards for dams as well as transmission lines, in particular, can have repercussions for mitigation. Moreover, climate resilient infrastructure designs can also help in mitigation from a life- cycle assessment point of view. Construction of climate resilient infrastructures will provide lower emissions in the long run than development of the same infrastructure multiple times.
U2	Building codes with provision for rainwater harvesting and solar lighting (Climate Change Policy, 2011)	Although formulated chiefly as a mitigation policy, this policy also has potential for synergies with adaptation, especially in addressing water and energy security. Rainwater harvesting can help to address the pressing issue of water scarcity, thereby increasing the adaptive capacity. The mitigation potential comes from lesser use of diesel generators used for groundwater extraction. Provision of solar lighting can help to shift from the dependence on fossil fuel backed power sources in the urban areas.
U3	Promoting climate smart urban settlement (NAPA page 31, 2010)	Climate smart urban settlement is a rather broad terminology, with an emphasis on adaptation. 100% of the experts believed that enforcing building codes have synergies ranging from 1 to 3. These synergies can be achieved with a proper model for smart settlements that has provisions of proper water drainage, designs for waste-to- energy, rainwater harvesting, renewable sources of energy, urban greening and other considerations, which can all contribute to mitigation.
U4	Enforcing building codes in municipal areas with climate change dimensions (NAPA page 31, 2010)	
U5	Developing and promoting transport industries that use electricity (Climate Change policy 8.2.7, 2011)	Urban transport policies are chiefly mitigation- driven. When applied with other transportation policies including traffic management as well as modal shifts and development of transportation infrastructure can contribute to climate resilience.
U6	Increase electric vehicle up to 20% by 2020 (Environment-Friendly Vehicle and Transport Policy as mentioned in INDC page. 4, 2016)	

Table 5
Table showing the mechanism of interactions in Water policies.

Policy ID	Policy description	Mechanism
W1	Conserve soil and water through measures such as source protection, rain water harvesting and environmental sanitation (Climate Change policy 8.7.5, 2011)	Addressing water scarcity can indirectly help mitigate emissions by reducing the dependency on diesel pumps for water extraction, or fossil fuel operated water tankers to meet with the water demands, thus resulting in synergies. The extent of interactions depends on the processes used for water conservation: for example, water conservation in ponds could lead to increased methane emissions (possible trade-offs) as opposed to groundwater harvesting. A basin approach for source protection could potentially limit hydropower development thereby impacting potential mitigation.
W2	Adopting a basin approach for water management through regular monitoring of water resource availability (Climate Change Policy 8.7.8, 2011)	
W3	Cost-Effective Hydropower Developed in a Sustainable Manner (National Water Plan page 12, 2002)	71% of the experts interviewed responded that there are possible synergies in this policy, while 29% stated that this was solely mitigation oriented. Possible synergies arise when the energy generated is affordable and accessible to all, especially in rural communities; and the infrastructures for the hydropower are built in a climate resilient manner, with components of Disaster Risk Reduction (DRR) as well as climate change into consideration.
W4	GLOF monitoring and Disaster Risk Reduction (NAPA page 30, 2010)	These two policies are primarily focused on adaptation. 50% of the experts stated these policies are solely adaptation policies. The remaining experts believe that these policies have synergies with mitigation as these can further the development of climate resilient infrastructures, including dams, reservoirs and transmission lines for hydropower, which can enhance mitigation potential. Plantations for reducing flood risk can also add to mitigation potential.
W5	Forecasting water-induced disasters and risks created from climate change and providing early warning information, developing necessary mechanism for the implementation of preventive measures and ensuring regular supervision, and enhancing capacity (Climate Change policy 8.1.4, 2011)	

validated by experts through interviews and then consolidated into six categories. These six opportunities are:

(i) Carbon Market and Finance
(ii) Climate Change Dedicated Institution
(iii) Low Carbon Economic Development Strategy
(iv) Payment of Ecosystem Services
(v) Private Sector and Civil Society
(vi) Transformative Adaptation

A detailed description of the opportunities is available in the Supplementary Materials. We conducted pairwise comparisons (using AHP method) of these opportunities based on four criteria. We reviewed current research papers (Heinrich Blechinger and Shah, 2011; Konidari and Mavrakis, 2007; Thanh Nguyen et al., 2010) to suggest the criteria for Nepal. The four criteria selected were: administrative feasibility, sustainability, anticipated effectiveness and political acceptability.

Experts ranked political acceptability as the highest ranked criteria followed by sustainability and administrative feasibility. Experts assert that without political acceptability, opportunities cannot materialize. The results of AHP pairwise comparison the opportunities, as obtained from expert survey, are shown in Fig. 6.

The priority of opportunities is in the order O2 > O3 > O6 > O5 > O1 > O4 (Fig. 6). A climate change dedicated institution is the most important opportunity for pursuing mitigation-adaptation synergies. In the context of Nepal, the chief institutions responsible for formulation and implementation of climate change policies are the Ministry of Forest and Environment (MoFE) and Ministry of Federal Affairs and General Administration (MoFAGA) respectively. Nepal also has a National Climate Change Support Group (NCCSP) under MoFE and an Alternative Energy Promotion Centre (AEPC) under the Ministry of Energy, Water Resources and Irrigation (MoEWRI) working towards renewable energy. Environment ministries are traditionally less powerful within national government, and may be less able to influence mainstream development planning that might offer some of the main win-wins – such as energy access, transport or agriculture (Fisher et al., 2014). Therefore, having a single institution that is dedicated to all climate change related decisions in the country is desirable so that other departments cannot override its decisions and inter-sectoral trade-offs can also be managed. One such institution can be the pre-existing Climate Change Council, and for this to be an effective opportunity, the council should be staffed with well-trained human resources from multiple sectors so as to avoid any biases

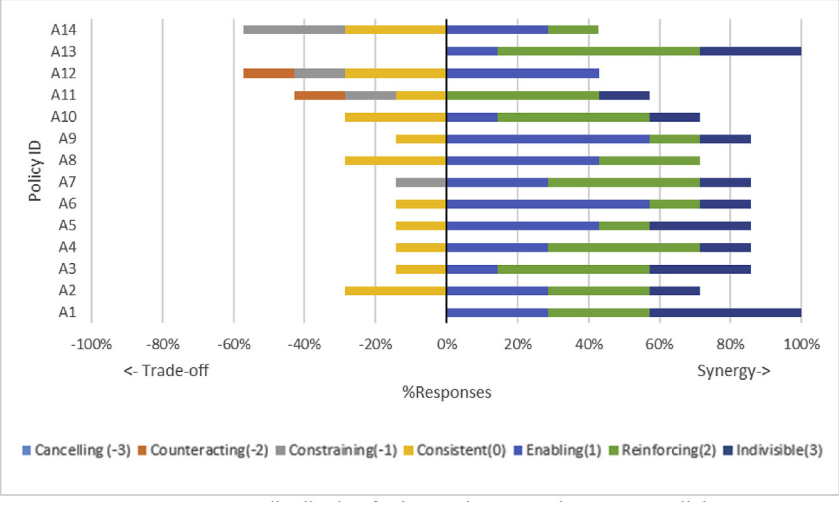

Fig. 2. Frequency distribution for interaction scores in AFOLU policies.

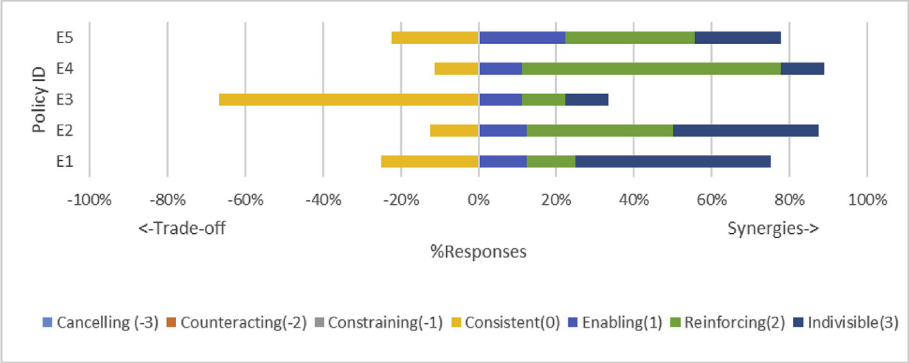

Fig. 3. Frequency distribution of interaction scores in Energy policies.

towards any particular sector.

Low Carbon Economic Development Strategy ranked as the second most important opportunity. Nepal's development agenda is focused on achieving sustainable economic development via low carbon pathways. A draft version of this strategy has already been prepared, which focuses on Energy, Forestry, Agriculture, Industry, Transport, Building & Waste, and cross cutting issues (Policy, Financing, Gender Equity and Social inclusion (GESI) & Institutions). This is therefore an important opportunity to explore sustainable low carbon economic growth while building climate resilience. Other developing countries such as Rwanda, Ethiopia, Bangladesh, Lao, Mozambique and Cambodia also have formulated their low carbon strategies to address both mitigation/low-carbon development and resilience/adaptation.

4.3. Identification and prioritization of barriers for harnessing synergies and addressing trade-offs

We identified five barriers in the same manner as opportunities, and assessed these barriers based on three criteria: impact of barrier on operationalizing the opportunity, level of political effort required to remove the barrier and lifespan of the barrier.

The barriers are:

(i) Inadequate institutional co- ordination
(ii) Donor-interest driven implementation
(iii) Knowledge gaps
(iv) Resource and capacity constraint
(v) Lack of willingness to pursue mitigation

The criteria for barrier evaluation were based on review of literature (Heinrich Blechinger and Shah, 2011; Konidari and Mavrakis, 2007; Thanh Nguyen et al., 2010). A detailed description of the barriers is available in the Supplementary Materials.

Experts AHP ranking revealed that the level of political effort is the most important criteria for evaluating barriers to address mitigation-adaptation interactions. Political and bureaucratic efforts play major roles in removing barriers. The efforts can include lobbying, introducing bureaucratic initiatives, and providing clear instructions to policy makers. Experts argue that a lot of political will and commitment is required to overcome the barriers for harnessing mitigation-adaptation synergies. The results of AHP ranking of barriers for harnessing synergies and addressing trade-offs are shown in Fig. 7.

The importance of barriers is in the order B2 > B1 > B5 > B3 > B4. The most prominent barrier for harnessing synergies in the context of Nepal is inadequate institutional co- ordination. Such lack of institutional co-ordination as a barrier while pursuing synergies has been highlighted in other studies as well, stating that there are diverse stakeholders involved (Klein et al., 2005) and reaching a consensus can therefore be difficult. At both the international and national levels, adaptation and mitigation are addressed through different processes, discussed in parallel policy debates that are rarely linked, led by distinct ministries or institutions, and involve different constituencies and funding sources (Verchot et al., 2007; Locatelli et al., 2011). Several ministries are key in implementing climate change relevant programs: Ministry of Forest and Environment (MoFE) is the UNFCCC focal ministry, Ministry of Energy, Water Resources and Irrigation is responsible for energy sector policies, Ministry of Agriculture and Livestock Development for agriculture sector policies. Although not directly involved with implementation of Nepal's climate change policies, the National Planning Commission (NPC) and the Ministry of Finance

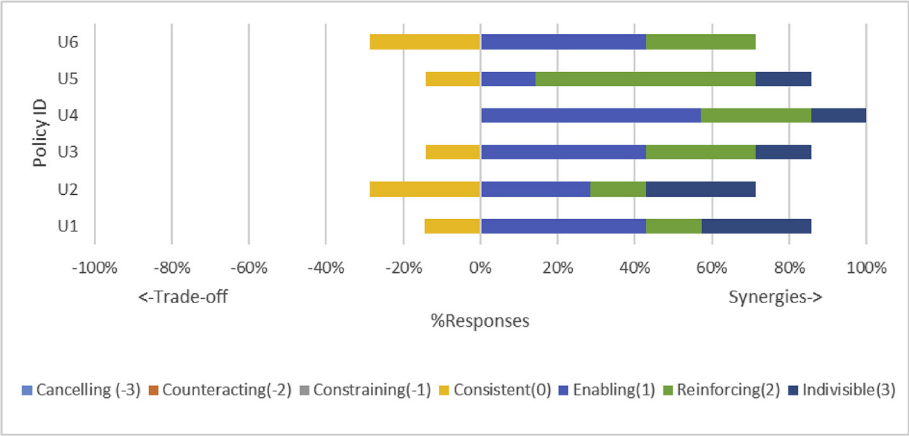

Fig. 4. Frequency distribution of interaction scores in Urban Planning policies.

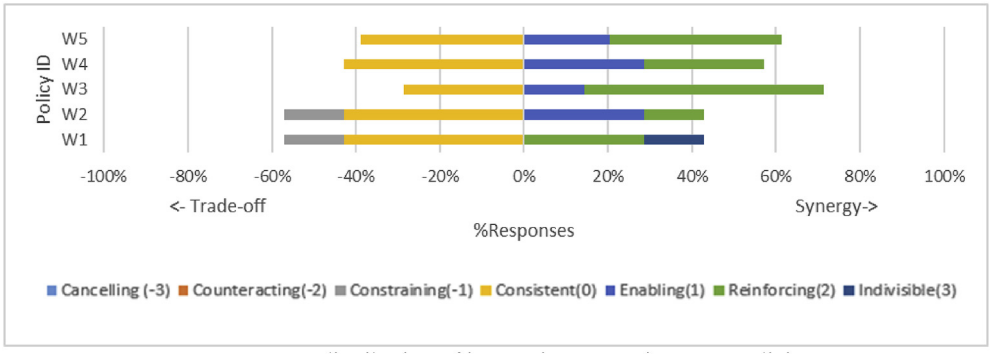

Fig. 5. Frequency distribution of interaction scores in Water policies.

(MoF) are two key national government institutions with an advisory and financial role. The NPC advises the GoN on all aspects associated with periodic national plans, programs, and projects. It also plays a central role in advising ministries and departments on foreign aid and is the key national institution for cross-sectoral coordination of programs under various international conventions. Despite the need of integration of these diverse arrays of institutions into climate change policy formulation, a siloed approach is prevalent in Nepal and each institution has biases to develop its respective sector over other sectors. This could create the possibility of competition, making inadequate co- ordination a very prominent barrier across all levels to pursue potential synergies (Nightingale, 2017).

Donor interest driven implementation is the second most prominent barrier for harnessing synergies. Donor funded projects are driven by the interest of the donors and their mandates (Khatri et al., 2015), which often pursue either mitigation or adaptation and overlook the potential synergies and trade-offs. This can therefore be a very important barrier for harnessing the synergies and avoiding the barriers.

The Ministry of Forest and Environment (MoFE) is the central body for climate change. However, co- ordination among other ministries is still lacking. As a result, overarching policies of resource use, development and climate change are formed in silos, and important interlinkages are often missed. There are plenty of opportunities to harness mitigation-adaptation synergies in Nepal. Pilot projects throughout Nepal are already making use of these opportunities (PES, transformative adaptation, carbon markets), albeit there is plenty of room for scaling up. The LCEDs, once finalized and approved, can create an enabling environment to use these opportunities and streamline projects to explore mitigation -adaptation interlinkages. Effective climate change policy planning calls for both horizontal and vertical

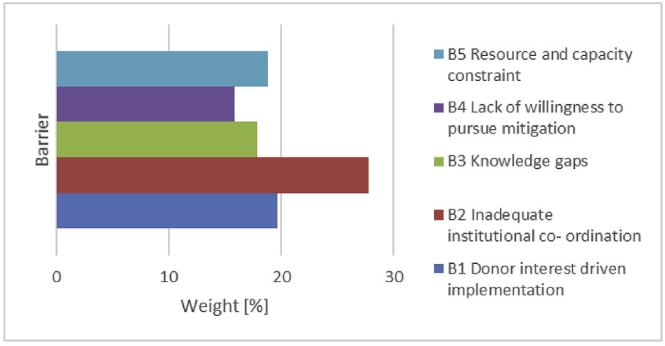

Fig. 7. Overall ranking of barriers for addressing mitigation-adaptation interactions.

collaborations across institutions (Kamal-Chaoui, 2008), and transformative changes in current policies and institutional arrangements (Harvey et al., 2014). The government can ensure that NAPA, NDC and other national level policies are complementary to reach the same target, and governments can also set up policy frameworks, institutional arrangements, and planning processes that support the integration of adaptation and mitigation goals (Harvey et al., 2014).

5. Conclusions and policy implications

The overall assessment of the state of mitigation-adaptation interlinkages in the national level policies in Nepal showed the presence of both synergies and trade-offs in existing national level policies. The scores range from −2, i.e. mitigation-adaptation goals clash, to 3, i.e.

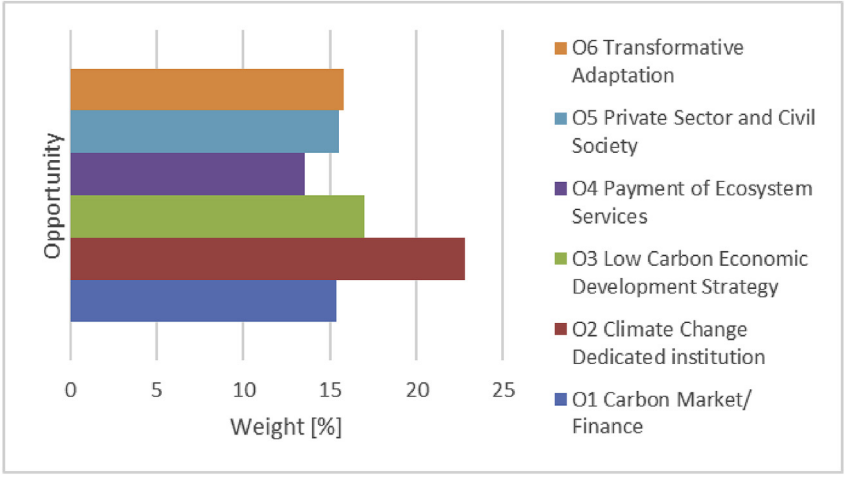

Fig. 6. Overall ranking of opportunities for addressing synergies and trade-offs.

mitigation-adaptation goals are indivisible. Synergies between mitigation and adaptation in national policies have been identified across AFOLU, Urban planning, energy and water sectors, while trade-offs are identified only in AFOLU and water sector policies. Cross sectoral interactions were also identified: water sector policies overarch with energy and AFOLU policies. These cross-sector interactions, when not considered in policy formulation, could result in trade-offs between sectors.

This paper also provides insights into the possible opportunities and barriers to enhance these synergies and minimize trade-offs. The most prominent opportunity is existence of dedicated climate change institution in the country. The Climate Change Council (CCC), which was formed as the highest advisory body dedicated to climate change could be a suitable avenue. The CCC can provide high-level policy and strategic oversight, to coordinate financial and technical support to climate change-related programs and projects, as well as to secure measures to benefit from climate change-related international negotiations and decisions (ADB, 2014). The most prominent barrier for harnessing synergies is inadequate institutional co-ordination among the various institutions that are responsible for formulating the sectoral policies related and relevant to climate change. This lack of co-ordination refers to the siloed-approach towards policy formulation for mainstreaming climate change components into the development agenda.

While this study clearly reveals that synergies exist, there are challenges in implementing these synergies. One way of overcoming these challenges could be initiating pilot projects that aim to harness synergies that showcase under which criteria and how synergies can be harnessed, and trade-offs avoided in the best possible way. This will help tackle concerns related to potentially higher transaction costs or challenges in project planning and monitoring when addressing mitigation and adaptation simultaneously (Laurikka, 2013). The concept of synergies can be linked with climate mainstreaming agenda, in that the efforts invested in demonstrating mitigation and adaptation synergies should be integrated into ongoing climate change risk management activities. Finally, attention should be paid to opportunities to catalyze private sector climate action also in harnessing synergies (Illman et al., 2013) and incentivizing synergies through funding criteria (Nordic Council of Ministers, 2017).

Based on the findings of this study, following policy implications are observed:

a) An institution dedicated to climate change is important to promote adequate and effective co-ordination among relevant institutions, and explore potential synergies and trade-offs in climate change policies. Role of such institution is critical.
b) Policy formulation should be a comprehensive and integrative process that adopts a cross-sectoral and interdisciplinary approach that encourages synergies across sectors to pursue climate resilient pathways. This calls for mainstreaming of climate change impacts into all development policies while simultaneously integrating and considering the possible interactions with other sectors as well. All sectors could have an overarching goal of addressing climate change and support in looking for well-crafted and coordinated opportunities to adapt to and limit the negative impacts of climate change.
c) Donor-driven policies and implementation in Nepal exist due to lack of need-analysis. Comprehensive need-analyses could find out the missing links in policies between mitigation and adaptation, and on the mitigation potential of the country, especially from AFOLU and urban planning sectors as these have the highest number of identified synergies.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2019.01.035.

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