



## From present to future development pathways in fragile mountain landscapes

Timos Karpouzoglou<sup>a,\*</sup>, Art Dewulf<sup>b</sup>, Katya Perez<sup>c</sup>, Praju Gurung<sup>d</sup>, Santosh Regmi<sup>d</sup>, Aiganysh Isaeva<sup>e</sup>, Marc Foggin<sup>f</sup>, Johan Bastiaensen<sup>g</sup>, Gert Van Hecken<sup>g</sup>, Zed Zulkafli<sup>h</sup>, Feng Mao<sup>i</sup>, Julian Clark<sup>j</sup>, David M. Hannah<sup>j</sup>, Prem Sagar Chapagain<sup>k</sup>, Wouter Buytaert<sup>l</sup>, Katarzyna Cieslik<sup>b,m,n</sup>

<sup>a</sup> Division of History of Science, Technology and Environment, KTH Royal Institute of Technology, Stockholm, Sweden

<sup>b</sup> Public Administration and Policy Group, Wageningen University & Research, Wageningen, the Netherlands

<sup>c</sup> Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN), Lima, Peru

<sup>d</sup> Society of Hydrologists and Meteorologists (SOHAM Nepal), Kathmandu, Nepal

<sup>e</sup> Mountain Societies Research Institute, University of Central Asia, Bishkek, Kyrgyzstan

<sup>f</sup> School of Public Policy and Global Affairs, University of British Columbia, Vancouver, Canada

<sup>g</sup> Institute of Development Policy, University of Antwerp, Antwerp, Belgium

<sup>h</sup> Department of Civil Engineering, Universiti Putra Malaysia, Serdang, Malaysia

<sup>i</sup> School of Earth and Environmental Sciences, Cardiff University, Cardiff, CF10 3AT, United Kingdom

<sup>j</sup> School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK

<sup>k</sup> Central Department of Geography, Tribhuvan University, Kathmandu, Nepal

<sup>l</sup> Department of Civil and Environmental Engineering, Imperial College London, London, UK

<sup>m</sup> Department of Geography, University of Cambridge, Cambridge, UK

<sup>n</sup> Knowledge, Technology & Innovation Group, Wageningen University & Research, the Netherlands

### ARTICLE INFO

#### Keywords:

Mountains  
Landscapes  
Power  
Social-ecological systems  
Development pathway  
Nepal  
Peru  
Kyrgyzstan  
Water

### ABSTRACT

Mountains are dynamic landscapes that are home to rich natural and human heritage. However, climatic variability, globalisation and increasing economic integration are making these landscapes more fragile with implications for present and future development. Using a pathways lens, we examine development trajectories in mountains and relate these to environmental and social-economic change currently taking place. We analyse and compare pathways in three case studies in Peru (Andes); Nepal (Himalayas); and Kyrgyzstan (Tien Shan). The paper highlights that development pathways in fragile mountain regions may be shifting in new directions, but because they emerge out of complex socio-environmental and historical contexts, there are also social risks associated with the articulation of future pathways, particularly in terms of social equity and sustainability. Building on different pathway approaches with their various strengths and weaknesses, this study examines the role of human agency and power, the role of historical and present context and feedbacks between social and ecological features in shaping future development pathways of mountain landscapes.

### 1. Introduction

Mountain regions encompass an exceptionally diverse cultural and natural heritage. They form an essential element in the overall balance of the planet's ecosystems and are considered an invaluable global asset (Foggin, 2016), particularly as unique providers of crucial ecosystem services (Schild and Sharma, 2011; Gentle and Maraseni, 2012).

Especially following the publication of Chapter 13 of Agenda 21<sup>1</sup> on development in mountain regions over 25 years ago, policy and academic communities have begun to address mountain development as a domain deserving focused and concerted analysis and engagement (UNCED, 1992; Balsiger and Debarbieux, 2015; Wehrli, 2014; Manuelli et al., 2015; Grainger et al., 2019). In addition to inherent difficulties in transport and access, research in mountain regions brings attention to

\* Corresponding author.

E-mail address: [timothy.karpouzoglou@abe.kth.se](mailto:timothy.karpouzoglou@abe.kth.se) (T. Karpouzoglou).

<sup>1</sup> Agenda 21 was a product of the Earth Summit (UN Conference on Environment and Development) held in Rio de Janeiro, Brazil, in 1992.

<https://doi.org/10.1016/j.envsci.2020.09.016>

Received 9 October 2018; Received in revised form 17 April 2020; Accepted 14 September 2020

Available online 21 October 2020

1462-9011/© 2020 The Author(s).

Published by Elsevier Ltd.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

more acute poverty and climate related challenges as compared to lowlands, foothills and urban areas (McDowell et al., 2014), due in part to acute and often unpredictable weather conditions and dynamic changes in land-cover (e.g. deep erosion of pastoral lands following intensification of agriculture and deforestation). Mountains are also more prone to environmental degradation associated with increasing weather extremes that generate problems, disrupting hillslope stability and increasing risk of landslides with potentially severe consequences for soil fertility, water quality, and sediment deposition as well as destruction of human habitation and loss of life (Gruber and Haeberli, 2007; Bhusal et al., 2016; Regmi et al., 2019; Uprety et al., 2019). Mountains further present a particular challenge for development theorists, as development outcomes strongly relate to complex social-ecological dynamics that can impact future development scenarios through non-linear causal mechanisms and influences (Folke et al., 2016; Sietz and Feola, 2016).

While there is a broad consensus about the fragility of mountain landscapes, people in mountain environments are often inappropriately framed primarily as victims of change (such as climate change), with such victimisation often seen as being further exacerbated by apparent political, geographical, social and economic isolation. In this study we develop a counter-argument to this narrative by providing a deeper understanding of how mountain residents are responding and adapting to change. We mobilise a development pathways approach in which inter-related socio-environmental systems of change are analysed over time (Leach et al., 2010). This approach recognises the need to engage with the narratives, actors and framings that help construct a particular system, and it sheds light on the various ways in which diverse actors prioritise goals for system change. Our study is therefore focused both on the present and on what the future may look like (Fazey et al., 2015). Understanding the broad directions of system change, and how these are informed by local realities, is crucial for re-creating the narrative about mountain regions, moving from ‘identities’ of isolation and victimisation toward greater appreciation of the complex dynamic systems in mountain regions and of political objects constructed in social relations (Fazey et al., 2015; Bastiaensen et al., 2015).

Another aspect that we wish to highlight is the value of expanding pathways approaches into mountain regions. There have been a number of studies focusing on development pathways in recent years, however there is still limited attention and application of pathways approaches in mountain environments and in agro-pastoral contexts characterised by social and climate vulnerability (Burnham and Ma, 2018; Gajjar et al., 2018; Van et al., 2019). As such, this article contributes substantially to filling this scientific knowledge gap. Specifically, we are guided in our analysis and review of the literature by the following main questions: (1) How have different forms of development pathway configurations evolved in recent years in fragile mountain regions, and how are they likely to evolve in the future in light of interacting social, economic and environmental change? (2) How does a development pathways approach help to better understand change in fragile mountain regions? (3) To what extent do development pathways converge or differ in different parts of the world?

In the following discussion, development pathways will be considered in relation to three case studies located in Mustang, Nepal; Naryn, Kyrgyzstan; and Huamantanga, Peru. Even though the cases are located in very different parts of the world, they share important social and environmental characteristics. They share a fundamental dependence on water, each comprised of watersheds of global significance (Messerli et al., 2004). Across the cases we also find a strong dependence of remote mountain communities on natural resources and functioning ecosystems for securing their livelihoods. Finally, all of the cases focus on communities with ties to local and regional institutions which are critical for stability in times of rapid change and for the preservation and use of indigenous knowledge (Tiwari and Joshi, 2014; Clark et al., 2017; Garnett et al., 2018). The cases are comparable since all these social-ecological systems are undergoing environmental change, both

slow and fast; each forms an essential part of trans-local livelihoods; and each comprises complex patterns of social inclusion, marginality, and adaptation (as well as maladaptation) to climate change. Despite the challenges posed by their seemingly isolated nature, the three case studies are further characterised by diverse livelihood strategies and local sources of knowledge that may be directly relevant for future climate adaptation (Wise et al., 2014; Xenarios et al., 2018).

The paper proceeds as follows: In the first section, we describe the main concepts that have informed our analysis of pathways. Following this, we describe the methodological approach and social-ecological characteristics of the three case studies. Next, we describe and analyse the pathways observed in the three cases. The discussion then explores the cases comparatively, along with reflections on the most pertinent characteristics of the pathways noted in fragile mountain regions. Finally, we provide a summary of key conceptual and empirical observations and emergent reflections deemed most pertinent for development in fragile mountain landscapes.

## 2. Theoretical perspectives for understanding development pathways

In recent years, a growing body of work has applied a pathways approach to specific development and environmental challenges. The various applications have been grounded in different epistemologies and have espoused variable aims and ambitions. For example, there has been work on pathways as an approach for understanding different future scenarios for climate adaptation (e.g. Haasnoot et al., 2013; Wise et al., 2014). Research on sustainability transitions that examines the co-evolving nature of technological and societal change has also used the pathways approach to analyse future technological scenarios (e.g. Geels and Schot, 2007). In this paper, however, the theoretical ideas are anchored in the environment and development literature, whereby pathways have been used to “reflect patterns of livelihood activities which arise from a coordination process among actors” (de Haan and Zoomers, 2005: 43) (Roden et al., 2016; Wilson, 2008).

One prominent approach to development pathways that informs this study was proposed by Leach et al. (2010) and is widely known as ‘pathways to sustainability’ (or sometimes as the STEPS Pathways approach). Leach et al. (2007: 18) describe development pathways as “the particular directions in which interacting social, technological and environmental systems co-evolve over time”. The strength of this approach is that it emphasises an understanding not only of the direction of development, but also the various ways in which diverse actors prioritise different goals for development; in other words, the role of human agency in shaping both perceptions and actions linked to different development possibilities. Drawing on Leach et al. (2007), a metaphor of ‘opening up’ the development process can help development theorists and practitioners alike to address a wider array of development scenarios. Furthermore, we align with Leach et al. (2007) in recognizing that development pathways are rooted or anchored in local realities and embedded in an understanding of historical path-dependencies and the role of power relations.

Finally, we are also interested in the particular geographies in which change occurs and we seek especially to understand how individual strategic behaviours (i.e., the ‘human agency’ related dimension of pathways, which is strongly featured in the STEPS approach) are embedded within a historical repertoire as well as in social differentiations, including power relations and institutional processes, both of which may equally pre-structure or constrain subsequent decision-making. Building upon Bastiaensen et al. (2015) we equally aim to understand human agency in relation to geographic space (the physical territory) as well as the “set of meanings and social relations that link together groups of human actors in a historical period and in given space” (i.e. the human relationships) (Bastiaensen et al., 2015: 31). Combined, the STEPS approach and the territorial development approach enable this study to highlight the role of human agency

(particularly of marginalised actors), the role of historical and present contexts, as well as the influence of territory including feedbacks between social and ecological features, in shaping present and future pathways and affecting future development outcomes.

### 3. Methodology

The qualitative data analysed in this paper were collected as part of a multi-site mixed methods study conducted over a period of three years (2014–16) in three locations with the support of local partner research organisations (ROs).<sup>2</sup> In order to cover the broad spectrum of heterogeneous actors, we collected information at individual (key-informant interviews), household (household surveys) and community levels (village workshops, focus groups, participant observation), all pertaining especially to use of natural resources (resource mapping, development of seasonal crop calendars) (see Table 1). Given the multi-site nature of the research, the timing and frequency of methods used in the research varied between the three cases.

In order to build a better picture of development pathways, we focused on eliciting a broad understanding of village life, examining its history as well as more recent changes. During the interviews and surveys we focused particularly on understanding the main farming and pastoral practices, including daily and seasonal tasks such as harvesting, irrigating and the use of pasture lands. We further related our understanding of agricultural practices with small-holder perceptions of change (economic and environmental) and risks or opportunities which they associate with different forms of change. The focus of the investigations was mostly at the village level, but we also sought to understand through the perceptions of small-holders and other local actors how perceived changes are related to the province or national levels.

### 4. Results: development pathways in three case studies: Peru, Nepal, Kyrgyzstan

All of the studies have important shared characteristics, as they all focus on agro-pastoral communities whose livelihoods heavily depend on well-functioning mountain ecosystems. We also observe comparable development and environmental changes, particularly in the forms of emerging constraints or enabling contexts for future development pathways.

The main characteristics of the case studies are summarized in Table 2.

#### 4.1. Huamantanga, Peru

Huamantanga is comprised of Huamantanga town as well as a larger area of 98.5 km<sup>2</sup> that consists largely of natural pastures and cultivated land. These pastures are in principle part of the communal land<sup>3</sup> of 700 inhabitants spread across two main neighbourhoods in the town itself, Shigual and Anduy. This land has a large altitudinal range (i.e. 1600–4600 m). In the lower altitudes (1600 m), land is used to grow crops such as corn as well as fruit trees such as apple, avocado and lemon. In the mid and higher altitudes (3000–3400 m) staple food crops such as potato, wheat and barley as well as the fodder crop, alfalfa, are grown. In the higher altitudes (above 3600 m), the land consists mostly of non-cultivated land used for animal grazing, except for a certain period of pasture conservation during the rainy season when access is restricted to allow the grass to recover.

<sup>2</sup> ROs: In Peru, Consortium for Sustainable Development of the Andean Ecoregion (CONDESAN). In Nepal, Society of Hydrologists and Meteorologists (SOHAM). In Kyrgyzstan, Mountain Societies Research Institute, University of Central Asia.

<sup>3</sup> There are some pockets of private land that can be sold and is mostly inherited.

Central to the governance of these multi-sited land areas as well as the critical water resources for irrigation are the *comuneros*, i.e. the recognized male community members that are vested with the stewardship of the community's natural resources. Each neighborhood has its own *comuneros*,<sup>4</sup> organised in irrigation (informal water authority) and land committees (informal land authority). Communal assemblies take important decisions about land and water after negotiation between *comuneros*; usually seeking to achieve consensus but if necessary following a voting system. Historically, the communal land governance system has been a central part of the cultural identity of these Andean communities, in particular expressing and promoting a logic of common property with regard to natural resources as well as a strict equality among the *comunero*'s families in access and use rights of land and water (including restrictions on private land transactions and encroachment of water rights through market sales) (Bastiaensen et al., 2017).

Central to the historically situated pathway of combined subsistence agriculture with cattle raising has been the pre-Inca practice of water infiltration in Huamantanga, known as *mamanteo* (Collins, 2015). The *mamanteo* is based on the construction of small channels that divert water from streams in order to allow it to infiltrate in areas with natural underground storage capacity. In this way, water is captured and retained during the rainy season and remains available longer into the dry season at the natural springs near the village where it can be used for irrigation (Bastiaensen et al., 2017; Hommes, 2015). As part of the Awards Schemes for Ecosystem Services law introduced in 2014 by the Ministry of the Environment, the *mamanteo* figures prominently amongst measures to increase investments in hydrological ecosystem services of water catchments, and Andean upland water conservation more broadly (MINAM, 2014; Grainger et al., 2019).

Communal land governance is tied to a historically situated development pathway of subsistence agriculture (in different agro-ecological niches, each communally governed through annual distribution of the available land and water, conditioned by family consumption needs) and cattle raising in the upland mountains. Cattle raising has a central role in the production of meat and dairy products such as milk and cheese, both of which provide additional stable year-round monetary sources of family revenue. Local farmers traditionally raise a local breed of cattle, known as *chuscos*. This breed is well adapted to the high altitude and can feed on natural grass; in the dry season it can survive with only dry pasture and does not need additional fodder crops. However, although well suited to local conditions, it produces only small amounts of milk (2–5L/day) (Bastiaensen et al., 2017).

Under the influence of the overall changes towards a market-based economy in Peru, whose impact was particularly boosted by the construction of Canta highway linking Huamantanga with the capital city Lima, this historical pathway is gradually changing, as also are the related principles of communal land and water governance. Private appropriation of land is increasing, even if *de jure* still prohibited (Bastiaensen et al., 2017). Water for irrigation is increasingly allocated by the *comuneros* towards crops for animal feed. In terms of production, there is also a notable shift towards a new system of cattle raising and dairy production, substituting the cheaper, robust, but low yield *chusco* cattle with improved, more expensive and higher yield cattle breeds, particularly Holstein or Brown Suisse (mixed to different degrees with *chuscos*). Presently, about half of the cattle-owners work with this type of cattle. This improved cattle out-competes *chusco* cattle with two to five times more milk yield, provided that it is properly fed, leading to a growing dependence of farmers on fodder crops (alfalfa) and decreasing reliance on grazing in the upland mountains (since the most productive introduced cows cannot endure the mountain conditions). The need for alfalfa also implies competition with other (mainly subsistence) crops for land and water, contributing to pressures towards privatisation of land as well as changes in the communal governance of land.

<sup>4</sup> Shigual has 52 *comuneros* and Anduy has 76 *comuneros*.

**Table 1**  
Methodologies used to analyse the case studies.

Method used	Key-informant interview	Focus group	Household Surveys	Workshops	Participant Observation	Resource mapping	Seasonal crop calendar
Peru	57	2	–	9	8	2	2
Nepal	12	5	1 (103 households)	–	–	3	3
Kyrgyzstan	91	5	1 (68 households)	3	–	1	–

Shifting ideas, opportunities and interests, mediated by internal power relationships within the communities are producing a change in the assemblage of the enabling components of the historical subsistence pathway and are paving the way for a new pathway, one more specialised in cattle production. One *comunero* reflects “in our neighbourhood, Anduy, the majority of *comuneros* have realized that by improving the cattle breed the incomes also improve, and those who have not are observing and slowly coming to understand this is the case”. At the same time, increased access to food markets in Lima renders subsistence production less necessary, while market-oriented food production and greater specialisation in commercial products become more desirable (such as cheese production, as Huamantanga has a comparative advantage over neighbouring regions).

A clear sign of the collective pathway shift is that in Anduy, where farmers own a higher percentage of ‘improved’ animals compared to Shigual, community members have decided to no longer make communal land available for subsistence agriculture and instead to gear land and water use towards fodder crop production. The recent Awards Schemes for Ecosystem Services Law led to support for a local proposal for improved water management that includes a closure of parts of the grazing areas in upland mountains. This proposal strengthens the evolution towards the new, specialized cattle pathway, since it reduces feeding opportunities for *chusco* and mixed cattle and contributes to the de-legitimation of upland grazing as detrimental for water production. Finally, the rapid evolution away from traditional subsistence agriculture and lower-productivity cattle raising is also made possible by significant out-migration of the younger generation, generally less interested in a future as a farmer or unable to gather sufficient capital to establish viable cattle farms. A high school student said, “our option is to go to the city to study or to find a job, if we don’t want to stay only taking care of the cattle”. The gradual closure of the opportunities for subsistence agriculture and less capital-intensive *chusco* cattle production has hit harder the poorer older farmers and cattle raisers from both neighbourhoods because they still rely on communal land and resources both for subsistence agriculture and for grazing traditional cattle breeds. In contrast, wealthier *comuneros* are able to gain significant benefits from improved breeds despite their greater feed requirements, though at cost of limiting access to land for other people.

#### 4.2. Mustang, Nepal

Mustang, also known as the ‘Lost Kingdom’ of Tibet, predates by three millennia the formation of the Nepalese state (Bista, 1971). Mustang forms one of the 75 districts of Nepal, extends over a large territory of 3573 km<sup>2</sup> and has a population of more than 13,000 inhabitants (GoN, 2012).

The main income generation activities involve a combination of agriculture (i.e. cultivation of staple crops such as barley, wheat, buckwheat and potato) and livestock raising (i.e. goat, sheep and yak).<sup>5</sup> The distribution of resources and labour across the different activities is negotiated at the village level. Importantly, we find the existence of local institutions with a long historical lineage as critical for ensuring a stable governance of local resources. In particular, the *mukhiya* village leader (often a more senior person of the village) primarily decides on the

distribution of irrigation water and land or the resolution of intra- and inter-village conflicts over resources (Clark et al., 2017; Bhusal et al., 2016). In the current context *mukhiyas* also participate as representatives in meetings and programs organized by local government institutions such as the Village Development Committee (Regmi et al., 2019).

Due to high climatic variability and strong seasonality of rainfall and temperature (e.g. severe cold in winter), agro-pastoralists are usually only able to produce one crop per year and therefore also involve themselves in off-farm activities such as winter trade (Manandhar et al., 2011; Regmi et al., 2019). Particular changes in the patterns of precipitation (largely attributed to regional changes in climate) have resulted in decreasing water yields for irrigation (Regmi et al., 2019; Bhusal et al., 2016). Winter trade occurs with adjoining districts such as Dolpa, as well as seasonal migration to the lowlands in Nepal and across the border to India. The main products for trade are livestock and local mountain herbs such as is *Jimbu* along with the fungus known as *Yarsagumba* (*Cordyceps Sinesis* used in traditional Tibetan and Chinese medicines). Winter trade is especially pronounced during religious festivals such as *Dashain* (in late September, early October) when demand for mountain goat is high in larger cities such as Pokhara and Kathmandu. Despite strong reliance on agro-pastoral activities, large areas of land also remain largely unused, either barren or abandoned. Government data show that only 13 % of the population in Mustang are food secure all year round on basis of their subsistence farming.

Removal of travel restrictions to Mustang since 1992 has led to steadily increasing tourism. A tourism master plan recently developed by the Mustang District Development Committee, the Nepal Tourism Board and the Annapurna Conservation Area Project (ACAP) placed an even more prominent emphasis on growth in the tourism sector (NTNC, 2008). Furthermore, many agro-pastoralists in Mustang see a significant opportunity in expansion and commercialisation of apples. This is in part due to changes in temperature, which have increased the suitability of the mountainous social-ecological system for apple cultivation<sup>6</sup> (Manandhar et al., 2013), and it has also coincided with a new form of regional entrepreneurship based around apple farming, which has created a catalysing context linked to collective processes of self-organisation. ‘Green Tangbe’ is one recently established apple farm in Mustang that started in 2010. The Tangbe village apple farm is principally a community driven enterprise financed through involvement of several village members. Agro-pastoralists engaged in this activity see new opportunities for income generation as a result of rising demand for the ‘Mustang’ apple variety, locally as well as in more distant markets. We have found that apple farming at this moment represents more the co-ordination of actors in some villages, rather than a fully articulated pathway across the entire district, but this could change if water availability, access to markets and access to expertise and experience in apple growing becomes more widely available. The increase in tourism could in principle operate in tandem with apple farming, though it could potentially equally create labour shortages for agriculture if too many community members (particularly younger members) were to turn primarily towards tourism.

<sup>6</sup> Agriculture statistics received from district authorities show that the number of distributed apple seedlings in Mustang is increasing. According to the statistics, the number of distributed plants exceeded 240,000 in 2012, compared to an estimate of only 46,000 plants in 1997.

<sup>5</sup> According to our household survey data, approximately 80 % of people in Mustang follow this pathway.

**Table 2**  
Important features of the three case study locations.

Country	Peru	Nepal	Kyrgyzstan
Location of study sites	Huamantanga, Upper Chillon watershed, Andean mountains	Mustang, Upper Kaligandaki watershed, Himalayan mountains	Naryn, Naryn watershed, Tian Shan mountains
Average elevation <sup>†</sup>	~1600 m - 4600m	~1400 m - 5400m	~1500 m - 5100m
Average annual precipitation <sup>‡</sup>	~800 mm	~300 mm	~300 mm
Socio-ethnic groups <sup>§</sup>	Highland communities of Anduy and Shigual.	Gurungs and Thakalis with cultural, historical and religious links with Tibet.	Kyrgyz herders and livestock owners (with knowledge of traditional clan affiliations).
Local institutions critical for stability under change	Land is communally organised through communal assemblies. Assemblies are comprised by <i>comuneros</i> (male household heads) that together govern most important decisions about land and water distribution.	Traditional village institutions <i>mukhiya</i> overseen by the village senior leader play a vital role in determining land and water entitlements of households and village irrigation routines.	Key decisions about the use of communal resources (pastures and water) are made by user associations, operationalised through village committees that are comprised of resource users along with representatives of local communities as well as government administrations.
Recent development characteristics	The construction of the Canta highway in 1952 linked Huamantanga with the national capital, Lima. This changed social dynamics (influenced strongly by out-migration) and increased urban-rural linkages (such as through agricultural trade with Lima).	Until 1992, Mustang was a restricted access due to its involvement in the Tibetan China conflict. The removal of travel restrictions to Mustang has created more favourable conditions for agriculture and tourism (trekking tours, lodges and campsites) with various links to trade and small enterprises.	Historically, development in Naryn was shaped for many decades by the central control of the Soviet Union. Since Kyrgyz independence in 1991, new natural resource management and land regulations have been introduced aiming to strengthen local and traditional livelihoods and creating or strengthening incentives to increase pasture health – largely through a devolution of powers to more local institutions.
Environmental change <sup>#</sup>	Increasing water scarcity in the dry season combined with increased occurrence of frost and droughts.	Changes in rainfall patterns associated with temperature increases, creating higher risks of water scarcity, flooding and landslide events.	Soil erosion and loss of agrobiodiversity combined with higher frequency of drought, floods and mudflows.

<sup>§, #</sup> Data on socio-ethnic groups, development characteristics and environmental change is primarily based on information received in the form of field reports,

scientific and grey literature collected by the three Research Organisations (see also Buytaert, et al. 2014).

<sup>†</sup> Elevation data has been collected from government data sources in the three study countries.

<sup>‡</sup> Average annual precipitation for the regions retrieved from government hydro-meteorological records.

### 4.3. Naryn, Kyrgyzstan

Naryn is a province of Kyrgyzstan that spans an area of 45,200 km<sup>2</sup> and has a population of 264,450 people. The most prominent social-ecological features include rangeland, agricultural fields, shrubland and forest. Historically, people relied on seasonal movements with their livestock between summer, spring-fall and winter pastures, forming a development pathway of mobile pastoralism (transhumance). Alongside raising livestock, agro-pastoralists are realising the economic potential of grasslands as a source of other marketable goods. Typical livelihood practices associated with this pathway include herders moving livestock from pastures close to permanent settlements to more distant, higher altitude pastures during the warmer season, and other community members (non-herders, but still owning livestock) engaging in farming, small business and a variety of other activities (Shigaeva et al., 2016).

Kyrgyzstan has experienced major political and social transformations over the last two decades as a result of the collapse of the Soviet Union in 1991. During the Soviet rule, the introduction of collectivised farming (*kolkhoz*) weakened the traditional essence of transhumance and eventually replaced the historically and culturally embedded system of communal governance and management of pastures (such as in the Huamantanga case) with a centrally planned, politically collectivised governance system in which pastoralists were treated only as remunerated workers (Van Veen and Tjaart, 2010). More recently, legal reforms such as the 2009 Law on Pastures have sought to re-introduce and encourage more local decision-making and greater movement between seasonal pastures.

Naryn exemplifies some of the tensions associated with the socio-political legacy of the Soviet *kolkhoz* system and the subsequent struggle to restore the traditional historical pathway associated with transhumance movement in the Tian Shan mountains. During the Soviet period there was a clear division of labour between herders, responsible for livestock fattening and reproduction, and state-appointed agrarian scientists, charged with monitoring pasture conditions. At the same time, the priority was to maximize livestock numbers, rather than ensure long-term pasture health (Liechti, 2012). Recent field research also has ascertained that despite a partial return toward community-based resources management, some aspects of Soviet-era mindsets and development goals are still prevalent among many sectors of society (Isaeva and Shigaeva, 2017; Levine et al., 2017). Another consequence of the Soviet legacy is that many herders have become accustomed to managing livestock with little rotation between pastures, and instead concentrating livestock grazing in ‘easy-to-access’ pastures. As one Kyrgyz herder from Tash Bashat village explained, “We always go to the same pastures. All herders have their own [traditional or preferred] sites.” This implies that many herders remain resistant to aligning their actual practices with the requirements or recommendations of the Law on Pastures, which seeks to localize (decentralize) decision-making and through this to match livestock numbers and grazing patterns with annually variable pasture conditions.

Some herders also try to render livestock husbandry more profitable through purchase and breeding of high-producing animals. However, only relatively well-off farmers (livestock owners) can afford investing in introduced livestock breeds. There are path-dependencies at play as well, since people more closely aligned with the former Soviet *kolkhoz* farming system and their associated power structures often have a stronger claim over land, even up to the present. For instance, wealthier villagers who used to occupy or were associated with key positions in the management of the collective farms are now generally in better

positions, largely because they benefited from low land prices of collective *kolkhoz* farm properties shortly following independence. By contrast, poorer herders increasingly are seeking to move to livelihood options beyond traditional livestock raising. As one herder from Tash Bashat village explained, "I had taken a loan to buy livestock, but they all were eaten by wolves. So we had to sell some livestock in order to pay back the loan – and we ended with the same number of livestock as before." Such scenarios could easily give rise to search for future pathway alternatives – based largely on a combination of social legacies and territorial constraints. Heretofore untapped development opportunities also exist. For example, some of the more proactive villagers communicated that they had applied to international organizations, requesting support to build greenhouses and kindergartens. Similar to the Mustang case, tourism-related enterprise also is on the rise, indicative of an increasing integration of Naryn in a globalised economy. A network of community-based tourism operators in Naryn now is widely used by foreigners, enhancing development benefits for many villagers.

### 5. Discussion: comparing pathways in three mountain regions

In each of the three cases, a dominant present pathway can be identified, with inherent tendencies to continue into the future – suggesting certain path dependencies, yet still allowing scope for new development possibilities. Comparing the three cases, we observe that each exemplifies several processes of an ‘opening up’ of development possibilities facilitated by closer connections emerging between local communities and regional, national and global development players (c.f. Leach et al., 2007). Across the cases, it is noticeable that higher levels of connectivity may create new modalities of access to markets and new kinds of value chains that reconfigure what is possible or desirable. This is very much in line with the STEPS pathways thinking and is underscored by important developmental shifts occurring locally as well as regionally and even globally. In the articulation of a future pathway for Huamantanga, for example, an aspiration for materialising new livelihood options such as cheese production and improved cattle breeding became realistic only in the context of rural-urban linkages between Lima and Huamantanga (Grainger et al., 2019). (See also Table 3 for a comparison of the different pathways identified).

We can further distinguish important ways in which development

pathways have been shaped in part by individual and in part by collective livelihood trajectories and hence even though the pathways share commonalities, they are each distinct. We have observed that while ‘farmers always have good reasons to do what they do’, they also are continually interpreting changes in their immediate environment, testing and developing new ideas (Cochet et al., 2007). In some cases, this gives rise to new momentum for ‘doing things differently’ – and hence creating a seed for a new development pathway. In Mustang, the formation of ‘Green Tangbe’ (with its shift from staple crop cultivation to apple farming) exemplifies an effort to translate a change in individual livelihood trajectories into a collective strategy. Such a model could subsequently be considered as part of a large process of ‘opening-up’ a future pathway around apple farming, and it aligns well with the interests and resources of vulnerable mountain groups. However, what Bastiaensen et al. (2017) shows, building on Leach et al. (2007), is that these possibilities for future alternatives emerge not from a single niche of change (e.g. market-orientated production of cheese in Huamantanga) but rather through intricate relationships formed across a range of niche changes occurring across the multifunctional mountain landscapes by multiple actors (cf. Wilson, 2008).

In all cases, we see consistently strong linkages between changes in the local-regional environment with implications for development pathways, for example through effects on water availability, which in turn can intensify soil loss in places where land degradation is already high. As observed in other pathways studies in mountain regions and elsewhere, these environmental changes have an impact on social-ecological systems – and on the (non)realization of people’s desired livelihood trajectories, such as opting for commercialised modern agricultural practices and introduction of livestock breeds (as in the case of Huamantanga) (McDowell and Hess, 2012; Sietz and Feola, 2016). Furthermore, some of the sources of social-ecological dynamism can equally be found in the way that future pathways interact with historical path-dependencies and social legacies.

Finally, the existence of unjust social rules and regulations implies not only unequal negotiation abilities and entrenched power relations that compromise the equitable realisation of different pathways, it also can lead to a limiting dynamic that deprives the poor of having or articulating their own vision of the future, even the ‘capacity to aspire’ to different futures. Power analyses should therefore be central when

**Table 3**  
Comparison of development pathway characteristics in the three case studies.

Pathway examples	Pathway description	Enabling conditions	Risks and challenges
Huamantanga			
Pathway of commercialization of agricultural production to escape poverty	<ul style="list-style-type: none"> <li>• Agro-pastoralists use of improved cattle breeds supported by strengthened integration of Huamantanga with food markets in Lima</li> <li>• Commercialization particularly orientated towards cheese and meat production</li> </ul>	<ul style="list-style-type: none"> <li>• Water conservation reforms resulting from The Awards Schemes for Ecosystem Services Law (2014)</li> <li>• Limiting overgrazing in the highlands by increasing crop production in the midlands</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in land tenure arrangements (i.e. shift from communal to private land governance) can over time shift power balances in favour of rich landowners (<i>comuneros</i>)</li> <li>• Water conservation reforms could tip water autonomy away from upland agro-pastoralist water users in favor of richer lowland urban water users</li> </ul>
Mustang			
Pathway of income diversification as adaptation to environmental shocks	<ul style="list-style-type: none"> <li>• Agro-pastoralists diversify their incomes by practicing a combination of livestock farming, agriculture, winter trade and tourism based activities</li> <li>• Income diversification spreads some of the risks associated with environmental shocks across livestock herding, crop production, and supplemental wages from tourism</li> </ul>	<ul style="list-style-type: none"> <li>• Creation of more favourable conditions for tourism</li> <li>• Cultivation of new types of cash crops (particularly apples) became possible due to changes in the local climatic profile (i.e. increased temperatures)</li> </ul>	<ul style="list-style-type: none"> <li>• Power differences and division of labour may create a skewed distribution of benefits from tourism activities</li> <li>• Commercial switch to apple farming can reduce food security for agro-pastoralists with smaller landholdings</li> </ul>
Naryn			
Pathway of pasture revitalisation through land reform	<ul style="list-style-type: none"> <li>• Reforms in pasture land management strengthen pastoralist livelihoods and create incentives to increase pasture health together with a devolution of powers to more local institutions</li> </ul>	<ul style="list-style-type: none"> <li>• Traditional livelihoods fairly well integrated with commercial agricultural practices</li> <li>• Development of community based (eco)tourism can help reduce pressures on pastures and promote conservation</li> </ul>	<ul style="list-style-type: none"> <li>• The social legacy of Soviet rule means that entrenched power relationships have not entirely disappeared, thus creating risks for unequal distribution or access to important livelihood assets, namely land</li> </ul>

considering different pathways possibilities. In the case studies presented herein, unequal power dynamics manifest as internal (a product of unequal relations at the local governance scale), as external (e.g. due to wider political and economic pressures) or as a combination of internal and external factors (c.f. Bastiaensen et al., 2017). We have seen, for instance, that increasing market integration may increase access to new income opportunities, on the one hand, but may also shift power balances in favour of richer landowners (Naryn) or lowland water users (Huamantanga), on the other hand; while also disrupting well functioning systems of communal governance of pasture and agricultural land.

## 6. Conclusion

In this article, we have engaged with development pathways in a way that attempts to capture the roles of human agency, power, history and social relations, in fixed territorial contexts, in the shaping of responses to change and thus the enabling and enacting of different forms of pathways. By examining three different mountain regions, in a first instance as separate stories about mountain development and secondly through a synthesis of findings, we have highlighted both regionally and globally significant patterns influencing past, present and future pathway articulation.

Our analysis has been built on two main conceptions of development pathways – namely, the conceptualization proposed by Leach et al. (2010) that focuses on the future scope and direction of change, and the one proposed by Bastiaensen et al. (2015) that focuses on the present and historical agro-pastoral context. These two models complement each other and have allowed us to describe development pathways in relation to the intricate relations of past, present and future.

A pathways approach has enabled the questioning of a universalistic approach to development in mountain regions and offers a different way to conceptualise how development occurs in such systems. A universalistic approach simply extended to mountain regions is a symptom of a systemic failure to treat mountains as fundamentally embedded in regional and global economies. At the same time, while we do find certain commonalities between the development paradigms of the different mountain regions studied, human agency strongly influences the actual change process. In other words, even though the problems may at times be similar, there is a plethora of potential ways forward. This is where the ‘opening up’ metaphor has been useful to understand how development processes can extend and accommodate this wider array of development possibilities and to align these possibilities with livelihood trajectories and aspirations.

Interrelating human agency in development pathways with both constraining and enabling social-ecological conditions may be challenging, but often productive. In particular, we have been able to identify a crucial role for local institutions that have evolved over long timescales in efforts to navigate change and actually make new pathways possible (Wilson, 2012; Sietz and Feola, 2016; Clark et al., 2017). As we have shown, such local institutions are undergoing significant changes due to rural-urban intensification, land privatisation and out-migration, and therefore the wider development apparatus must become more consciously engaged with supporting these kinds of institutions. Recent work has also shown that new kinds of citizen engagement tools for enabling knowledge co-production in mountain regions can play an important role in developing new types of development models (Buytaert et al., 2016; Regmi et al., 2019; Clark et al., 2017).

Lastly, this study shows how development pathways are mediated by power relations that are continuously shifting over time. There is therefore a need to embed the analysis of change in mountains with a more concrete understanding of the workings of power and how the distribution of power may result in different outcomes for different community actors (Van et al., 2019; Bastiaensen et al., 2017; Leach et al., 2010). A more careful power analysis can help to understand

mountain communities not as primarily self-contained systems (which often leads to their assumed victimisation) but rather as part of regional, national and global flows of power and opportunities. More work is needed to link existing studies around adaptive responses to change with power analysis (Wise et al., 2014; Haasnoot et al., 2013; Sietz and Feola, 2016).

Perspectives on development possibilities informed by both power dynamics and human resilience can lead to a more accurate representation of not only the diversity of what is possible, but also to identify and highlight what is more socially ethical and just.

## CRedit authorship contribution statement

**Timos Karpouzoglou:** Conceptualization, Formal analysis, Writing - original draft. **Art Dewulf:** Conceptualization, Writing - review & editing, Funding acquisition. **Katya Perez:** Investigation, Writing - review & editing. **Praju Gurung:** Investigation, Writing - review & editing. **Sanjosh Regmi:** Investigation, Writing - review & editing. **Aiganysh Isaeva:** Investigation, Writing - review & editing. **Marc Foggin:** Conceptualization, Writing - review & editing, Supervision. **Johan Bastiaensen:** Conceptualization, Writing - review & editing, Formal analysis. **Gert Van Hecken:** Conceptualization, Writing - review & editing. **Zed Zulkafli:** Conceptualization, Writing - review & editing, Visualization. **Feng Mao:** Conceptualization, Writing - review & editing, Visualization. **Julian Clark:** Conceptualization, Writing - review & editing, Visualization. **David M. Hannah:** Writing - review & editing, Funding acquisition, Supervision. **Prem Sagar Chapagain:** Investigation, Writing - review & editing, Supervision. **Wouter Buytaert:** Conceptualization, Writing - review & editing, Funding acquisition. **Katarzyna Cieslik:** Conceptualization, Writing - review & editing, Visualization.

## Declaration of Competing Interest

The authors report no declarations of interest.

## Acknowledgements

The authors would like to acknowledge funding received from the UK Research Council NERC/ESRC/DFID ESPA programme (project NE-K010239-1, ‘Adaptive governance of mountain ecosystem services for poverty alleviation enabled by environmental virtual observatories’ Mountain-EVO).

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.envsci.2020.09.016>.

## References

- Balsiger, J.örg, Debarbieux, Bernard, 2015. Should mountains (really) matter in science and policy? *Environ. Sci. Policy* 49, 1–7. <https://doi.org/10.1016/j.envsci.2015.03.015>.
- Bastiaensen, Johan, Merlet, Pierre, Craps, Marc, Tom De Herdt, Selmira Flores, Huybrechts, Frédéric, Mendoza, René, Steel, Griet, Van Hecken, Gert, 2015. Making Sense of Territorial Pathways to Rural Development: A Proposal for a Normative and Analytical Framework. IOB Discussion Paper/2015.04. University of Antwerp, Belgium.
- Bastiaensen, Patricia Velarde, Pérez, Katya, Van Hecken, Gert, Bièvre, Bert De, 2017. Water and local development in Huamantanga. A Pathway Interpretation of Opportunities and Risks of the Law of Compensation and Reward Mechanisms for Ecosystem Services in Peru. University of Antwerp, Belgium. IOB Discussion Paper/2017.01.
- Bhusal, J.K., Chapagain, P.S., Regmi, S., Gurung, P., Zulkafli, Z., Karpouzoglou, T., Pandeya, B., Buytaert, W., Clark, J., 2016. Mountains under pressure: evaluating ecosystem services and livelihoods in the Upper Himalayan region of Nepal. *Int. J. Ecol. Environ. Sci.* 42 (3), 217–226.
- Bista, Dor Bahadur, 1971. The political innovators of Upper Kali-Gandaki. *Man* 6 (1), 52. <https://doi.org/10.2307/2798427>.

- Burnham, Morey, Ma, Zhao, 2018. Multi-scalar pathways to smallholder adaptation. *World Dev.* 108, 249–262. <https://doi.org/10.1016/j.worlddev.2017.08.005>. Elsevier Ltd.
- Buytaert, Wouter, Dewulf, Art, Bert De Bièvre, Julian Clark, Hannah, David M., 2016. Citizen science for water resources management: toward polycentric monitoring and governance? *J. Water Resour. Plann. Manage.* 142 (4), 01816002. [https://doi.org/10.1061/\(ASCE\)WR.1943-5452.0000641](https://doi.org/10.1061/(ASCE)WR.1943-5452.0000641). American Society of Civil Engineers.
- Clark, Julian, Gurung, Praju, Chapagain, Prem Sagar, Regmi, Santosh, Jagat, K., Karpouzoglou, Timothy, Mao, Feng, et al., 2017. Water as ‘time-substance’: the hydrosocialities of climate change in Nepal. *Ann. Assoc. Am. Geogr.* 4452 (July) <https://doi.org/10.1080/24694452.2017.1329005>.
- Cochet, Hubert, Devienne, Sophie, Dufumier, Marc, 2007. L’agriculture Comparée, Une Discipline de Synthèse? *Économie Rurale* (297–298 (May)), 99–112. <https://doi.org/10.4000/economierurale.2043>.
- Collins, D., 2015. Peru Harnesses Ancient Canal System to Tackle Lima Water Shortage | Dan Collins | Global Development | The Guardian. <https://www.theguardian.com/global-development/2015/jun/22/peru-harnesses-ancient-canal-system-to-tackle-lima-water-shortage>.
- Fazey, Ioan, Wise, Russell M., Lyon, Christopher, Câmpeanu, Claudia, Moug, Peter, Davies, Tammy E., 2015. Past and future adaptation pathways. *Clim. Dev.* (February), 1–19. <https://doi.org/10.1080/17565529.2014.989192>.
- Foggin, J.M., 2016. Conservation issues: Mountain ecosystems. Reference Module in Earth Systems and Environmental Sciences. <https://doi.org/10.1016/B978-0-12-409548-9.01919-5>.
- Folke, Carl, Biggs, Reinette, Norström, Albert V., Reyers, Belinda, Rockström, Johan, 2016. Social-ecological resilience and biosphere-based sustainability science. *Ecol. Soc.* 21 (3) <https://doi.org/10.5751/ES-08748-210341>.
- Gajjar, Sumetee Pahwa, Singh, Chandni, Deshpande, Tanvi, 2018. Tracing Back to move ahead: a review of development pathways that constrain adaptation futures. *Clim. Dev.* 1–15. <https://doi.org/10.1080/17565529.2018.1442793>. Taylor & Francis.
- Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, A., Molnár, Z., Robinson, C. J., Watson, J.E., Zander, K.K., Austin, B., Brondizio, E.S., Collier, N.F., 2018. A spatial overview of the global importance of Indigenous lands for conservation. *Nat. Sustain.* 1 (7), 369.
- Geels, Frank W., Schot, Johan, 2007. Typology of sociotechnical transition pathways. *Res. Policy* 36 (3), 399–417. <https://doi.org/10.1016/j.respol.2007.01.003>.
- Gentle, Popular, Maraseni, Tek Narayan, 2012. Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environ. Sci. Policy* 21 (August), 24–34. <https://doi.org/10.1016/j.envsci.2012.03.007>. Elsevier Ltd.
- GoN, 2012. National Population and Housing Census 2011 (National Report). <http://unstats.un.org/unsd/demographic/sources/census/wphc/Nepal/Nepal-Census-2011-Vol1.pdf>.
- Grainger, S., Hommes, L., Karpouzoglou, T., Perez, K., Buytaert, W., Dewulf, A., 2019. The development and intersection of highland-coastal scale frames: a case study of water governance in central Peru. *J. Environ. Policy Plan.* 1–18.
- Gruber, S., Haeblerli, W., 2007. Permafrost in steep bedrock slopes and its temperature-related destabilization following climate change. *J. Geophys. Res.* 112 (F2), F02S18 <https://doi.org/10.1029/2006JF000547>.
- de Haan, Leo, Zoomers, Annelies, 2005. Exploring the frontier of livelihoods research. *Dev. Change* 36 (1), 27–47. <https://doi.org/10.1111/j.0012-155X.2005.00401.x>.
- Haasnoot, Marjolijn, Kwakkel, Jan H., Walker, Warren E., Maat, Judithter, 2013. Dynamic adaptive policy pathways: a method for crafting robust decisions for a deeply uncertain world. *Global Environ. Change* 23 (2), 485–498. <https://doi.org/10.1016/j.gloenvcha.2012.12.006>. Elsevier Ltd.
- Hommes, Lenna, 2015. Back to the Roots? – Framing of Ancestral Water Infiltration Structures and Their Recuperation in the Chillón Watershed Lima, Peru. MSc Thesis. Wageningen University, Wageningen, The Netherlands.
- Isaeva, A., Shigaeva, J., 2017. Soviet legacy in the operation of pasture governance institutions in present-day Kyrgyzstan. *J. Alpine Res. Revue de géographie alpine* (105-1).
- Leach, M., Scoones, I., Stirling, A., 2007. *Pathways to Sustainability: An Overview of the STEPS Centre Approach*. Brighton, UK.
- Leach, M., Scoones, I., Stirling, A., 2010. *Dynamic Sustainabilities: Technology, Environment, Social Justice*. Earthscan, London.
- Levine, J., Isaeva, A., Eddy, I., Foggin, M., Gergel, S., Hagerman, S., Zerriffi, H., 2017. A cognitive approach to the post-Soviet Central Asian pasture puzzle: new data from Kyrgyzstan. *Reg. Environ. Change* 17 (3), 941–947.
- Liechti, Karina, 2012. The meanings of pasture in resource degradation negotiations: evidence from post-socialist rural Kyrgyzstan. *Mt. Res. Dev.* 32 (3).
- Manandhar, Sujata, Vogt, Dietrich Schmidt, Perret, Sylvain R., Kazama, Futaba, 2011. Adapting cropping systems to climate change in Nepal: a cross-regional study of farmers’ perception and practices. *Reg. Environ. Change* 11 (2), 335–348. <https://doi.org/10.1007/s10113-010-0137-1>. Springer-Verlag.
- Manandhar, Sujata, Pandey, Vishnu Prasad, Kazama, Futaba, 2013. Assessing suitability of apple cultivation under climate change in mountainous regions of Western Nepal. *Reg. Environ. Change* 14 (2), 743–756.
- Manuelli, S., Hofer, T., Wolter, P., 2015. FAO’s work on sustainable mountain development and watershed management - a 2015 update. *Mt. Res. Dev.* 35 (3), 299–304.
- McDowell, J.Z., Hess, J.J., 2012. Accessing adaptation: multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Glob. Environ. Change* 22 (2), 342–352.
- McDowell, Graham, Stephenson, Eleanor, Ford, James, 2014. Adaptation to climate change in glaciated mountain regions. *Clim. Change* 77–91. <https://doi.org/10.1007/s10584-014-1215-z>.
- Messerli, Bruno, Viviroli, Daniel, Weingartner, Rolf, 2004. Mountains of the World: Vulnerable Water Towers for the 21st Century. *Ambio Spec No 13* (November), pp. 29–34. <http://www.ncbi.nlm.nih.gov/pubmed/15575180>.
- MINAM, 2014. Law N° 30215- Ley de Mecanismos de Distribución Por Servicios Ecosistémicos. [http://www.minam.gob.pe/wp-content/uploads/2014/06/ley\\_302105\\_MRSE.pdf](http://www.minam.gob.pe/wp-content/uploads/2014/06/ley_302105_MRSE.pdf).
- NTNC, 2008. Sustainable Development Plan Mustang (2008–2013).
- Regmi, S., Bhusal, J.K., Gurung, P., Zulkafii, Z., Karpouzoglou, T., Tocachi, B.O., et al., 2019. Learning to cope with water variability through participatory monitoring: the case study of the mountainous region, Nepal. *Meteorol. Hydrol. Water Manage. – Res. Operat. Appl.* 7 (2).
- Roden, Paul, Bergmann, Christoph, Ulrich, Anne, Nüsser, Marcus, 2016. Tracing divergent livelihood pathways in the drylands: a perspective on two spatially proximate locations in Laikipia County, Kenya. *J. Arid. Environ.* 124, 239–248. <https://doi.org/10.1016/j.jaridenv.2015.08.004>. Elsevier Ltd.
- Schild, Andreas, Sharma, Eklabya, 2011. Sustainable mountain development revisited. *Mt. Res. Dev.* 31 (3), 237–241. <https://doi.org/10.1659/MRD-JOURNAL-D-11-00069.1>. The International Mountain Society Centre for Development and Environment (CDE), Institute of Geography, University of Bern Hallerstrasse 10, CH-3012 Bern, Switzerland.
- Shigaeva, Jyldyz, Hagerman, Shannon, Zerriffi, Hisham, Hergarten, Christian, Isaeva, Aiganysh, Mamadalieva, Zuura, Foggin, Marc, 2016. Decentralizing governance of agropastoral systems in Kyrgyzstan: an assessment of recent pasture reforms. *Mt. Res. Dev.* 36 (1), 91–101. <https://doi.org/10.1659/MRD-JOURNAL-D-15-00023.1>.
- Sietz, D., Feola, G., 2016. Resilience in the rural Andes: critical dynamics, constraints and emerging opportunities. *Reg. Environ. Change* 16 (8), 2163–2169.
- Tiwari, Prakash C., Joshi, Bhagwati, 2014. Local and regional Institutions and environmental governance in Hindu Kush Himalaya. *Environ. Sci. Policy* 49, 66–74. <https://doi.org/10.1016/j.envsci.2014.09.008>. Elsevier Ltd.
- UNCED, 1992. Agenda 21 - Managing Fragile Ecosystems: Sustainable Mountain Development - United Nations Environment Programme. United Nations, New York. <http://www.unep.org/Documents/Multilingual/Default.Print.asp?DocumentID=52&ArticleID=61&l=en>.
- Upreti, M., Ochoa-Tocachi, B.F., Paul, J.D., Regmi, S., Buytaert, W., 2019. Improving water resources management using participatory monitoring in a remote mountainous region of Nepal. *J. Hydrol.: Reg. Stud.* 23, 100604.
- Van, Hecken, Gert, Pierre Merlet, Lindtner, Mara, Bastiaensen, Johan, 2019. Can financial incentives change farmers’ motivations? An agrarian system approach to development pathways at the Nicaraguan agricultural frontier. *Ecol. Econ.* (January) <https://doi.org/10.1016/j.ecolecon.2016.12.030>. Elsevier B.V.
- Van Veen, Schillhorn, Tjaart, W., 2010. *The Kyrgyz Sheep Herders at a Crossroads. Pastoral Development Network, Network Papers*, London.
- Wehrli, A., 2014. Why mountains matter for sustainable development. *Mt. Res. Dev.* 34 (4), 405–409. <https://doi.org/10.1659/mrd-journal-d-14-00096.1>.
- Wilson, Geoff A., 2008. From ‘Weak’ to ‘Strong’ multifunctionality: conceptualising farm-level multifunctional transitional pathways. *J. Rural Stud.* 24 (3), 367–383. <https://doi.org/10.1016/j.jrurstud.2007.12.010>.
- Wilson, Geoff A., 2012. Community resilience, globalization, and transitional pathways of decision-making. *Geoforum* 43 (6), 1218–1231. <https://doi.org/10.1016/j.geoforum.2012.03.008>. Elsevier Ltd.
- Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E. R.M., Campbell, B., 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. *Glob. Environ. Change* 28, 325–336. <https://doi.org/10.1016/j.gloenvcha.2013.12.002>.
- Xenarios, Stefanos, Gafurov, Abror, Schmidt-Vogt, Dietrich, Sehring, Jenniver, Manandhar, Sujata, Hergarten, Chris, Shigaeva, Jyldyz, Foggin, Marc, 2018. Climate change and adaptation of mountain societies in Central Asia: uncertainties, knowledge gaps, and data constraints. *Reg. Environ. Change*. <https://doi.org/10.1007/s10113-018-1384-9>.