Resilience in the rural Andes: critical dynamics, constraints and emerging opportunities

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Received: 27 August 2016 / Accepted: 8 September 2016 / Published online: 11 November 2016
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Introduction

The Andes present an ideal learning space to draw lessons on existing and emerging resilience challenges and opportunities. Andean people and societies have co-evolved with the unique high-mountain contexts in which they live, sometimes in altitudes of more than 3800 m. The high-mountain topography, related altitudinal gradients and geomorphologic heterogeneity create highly diverse microclimatic zones, ecosystems and landscape niches which Andean farmers use in complementary ways to produce crops and raise livestock (Murra 1975; Troll 1968; Stadel 2008; Sietz et al. 2012). In particular, the Andes are the centre of origin of potatoes and a hotspot of agrobiodiversity where Andean farmers manage and maintain a multitude of potato, maize, root and tuber varieties (Zimmerer 1991; De Haan and Juarez 2010). Differing strongly in agro-ecological requirements and stress resistance, this diversity of crops allows farmers to distribute efficiently harvest failure risks caused by local weather extremes, pests and diseases. Complex knowledge systems, social coping mechanisms involving complementarity and reciprocity, such as *ayni* and *minka*, and highland–lowland interactions further highlight Andean people’s capacity to prepare for and survive perturbations (Mayer 2002).

Although historical achievements including irrigation systems, domestication of cameloids (llama and alpaca) and crop preservation techniques facilitated the development of ancient civilisations in the Andes (Troll 1943; Erickson 1992; Dillehay and Kolata 2004), modern Andean people face serious challenges in achieving food security and wellbeing (CIESIN 2005; Sietz et al. 2011, 2012; FAO 2013; Kok et al. 2016). Compared with the surrounding lowlands, the Andes are more strongly affected by climate variability, which is closely tied to the El Niño Southern Oscillation (Vuille et al. 2000; Garreaud and Aceituno 2001), and climate change as indicated by the widespread melting of glaciers and hydrological changes observed in recent decades (Magrin et al. 2014). In addition, rural Andean communities are often marginalised (Forero and Ezpeleta 2007; Feola et al. 2015) and, as such, excluded from decision-making processes that mainly take place in national capital cities, reflecting widespread rural–urban disparities. Physical remoteness, together with cultural, social, political and economic marginality, often promoted by urban elites, not only results in poor access to information or financial and technical resources; it also leads to limited accessibility to these communities during emergencies caused by natural disasters. Ongoing climate change and economic globalisation will further aggravate existing constraints and inequalities in the future (CAN et al. 2007; Sillmann et al. 2013; Kaenzig and Piguet 2014; Neukom et al. 2015), such that socio-ecological systems in the Andes are likely to face growing challenges at a possibly unprecedented pace (Perez et al. 2010).

In addition, the Andes have become ensnared between neoliberal development policies on the one hand and the experiments of autonomous development alternatives on the other. Since the 1970s neoliberal development policies, including trade liberalisation, have been implemented at

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their strongest intensity in Andean countries and throughout Latin America (Liverman and Vilas 2006; Cupples 2013), generally causing conflicts, displacement and dispossession among rural people, in particular smallholder farmers, indigenous communities and Afro-American populations (Borras et al. 2012; Feola et al. 2015). Neoliberal policies have often reinforced inequality and reproduced extractivist dynamics that have affected Andean ecosystems and people since colonial times (Cupples 2013). Moreover, some of the most significant alternative movements have either emerged or been furthered in the Andes such as Buen Vivir, Food Sovereignty and La Via Campesina, besides many other small-scale autonomous developments and struggles (Bebbington 2000; Escobar 2010; Barkin 2011). Some of these movements have been incorporated into national constitutions, such as those of Ecuador and Bolivia, resulting in the recognition of constitutional commitments to social rights, collective citizens and the rights of nature (Radcliffe 2012).

However, it remains unclear as to whether current technical and social adaptation strategies will be effective in the future in responding to the increasing challenges posed by climate change, neoliberal development policies and other environmental and socio-economic changes. Hence, science is urged to support decision makers in Andean countries in navigating critical dynamics to prepare for disturbances and seize emerging opportunities while maintaining functioning ecosystems in the harsh high-mountain contexts (Eakin and Lemos 2010; Feola 2013; Huggel et al. 2015). Resilience offers an insightful concept to frame the complex relationships between socio-ecological systems and disturbances impacting upon these systems. This Special Issue aims to improve our understanding of the key dynamics of socio-ecological systems in response to risks, uncertainty and ongoing change that constrain or foster resilience in the rural Andes.

Resilience as defined in this Special Issue describes the degree of disturbance a socio-ecological system can withstand while remaining within critical thresholds, thus maintaining its core structure and functioning (Folke 2006). This conceptualisation presents a counterpart to vulnerability framings, which refer to damage potential due to stress exposure (Gallopin 2006). Resilience theory helps us better understand a system's state or development trajectory, supporting the discussion of how shifts between states can be facilitated or prevented and how a system can be transformed when it is in an irreversibly undesired state. This requires a differentiation of who or which part of a socio-ecological system is resilient to which disturbance (e.g. weather extremes) and which property (e.g. food security) is affected by the disturbance. In some cases, it may be necessary to break the feedbacks that stabilise a system in a resilient but undesired state, while feedbacks

that maintain desired states may need to be strengthened in other cases. It is vital to acknowledge the contested nature of resilience since the definition of 'desired' and 'undesired' states that shape development models, including dominant and alternative approaches, depends strongly on stakeholders' necessities, expectations and prospects. In normative framings of sustainable development, resilience is explicitly associated with the need to improve the livelihood prospects of disadvantaged groups in society. Also inherently linked to resilience thinking is a capacity for learning and adapting, as well as passing critical thresholds and entering new development trajectories, that is to say transforming into a new state (Folke et al. 2010). While critical refinement of resilience theory to better capture social dynamics is clearly needed (Brown 2014; Cretney 2014; Tanner et al. 2015), the theory's focus on learning, adaptability and transformability allows us to explore alternatives and emerging windows of opportunities for rural communities (Wilson 2012; Scott 2013).

The Resilience 2014 Conference in Montpellier, France provided an inspiring arena for discussing and further developing concepts of resilience, adaptation and transformation, building upon the preceding Resilience Conferences in 2008 and 2011. Reflecting the broad interest in and active demand for better understanding system dynamics and management options in the Andes, abundant research was presented addressing resilience and transformations in rural Andean systems, among others in two sessions on 'Andean communities in the face of global change: Risks, uncertainties and opportunities for transformation'. This Special Issue was compiled after the Resilience 2014 Conference to present important examples of innovative resilience research in the Andes.

Key factors of resilience in the rural Andes covered in this Special Issue

This Special Issue comprises six papers that investigate core features of resilience in a variety of socio-ecological systems in rural areas of the central and southern Andes (Fig. 1). These papers analyse underlying dynamics and discuss constraints to and opportunities for improving resilience in rural systems exposed to environmental, social and economic variability and change. In particular, the papers in this Special Issue assess three major factors of resilience in the rural Andes: diversity, connectivity and development models. While the diversity and connectivity factors refer to specific conceptual facets of resilience theory, the discussion of development models presents a more applied focus on how development priorities, agency and power relate to resilience, re-emphasising the role of diversity and connectivity. The papers' contributions to

Fig. 1 Andean regions and countries covered in this Special Issue [A = Vallejo-Rojas et al. (2016), B = Doughty (2016), C = Zimmerer and Rojas Vaca (2016), D = Montaña et al. (2016), E = Chelleri et al. (2016), F = Easdale et al. (2016); ordering according to location. Map based on Natural Earth]

understanding these resilience features are outlined in the following subsections.

Diversity

All papers in this Special Issue explore the role of diversity as a foundation of resilience. Diversity refers to the variety and heterogeneity of components and functional relations that shape socio-ecological systems, allowing ecosystems and people flexibility to cope with and manage the effects of disturbance and ongoing change. The papers presented here demonstrate that the integration of multiple crop varieties, environmental conditions, livelihood opportunities, social relations and actors' perspectives enables Andean people to respond in various ways to disturbance and adapt to uncertainty. This response diversity creates a

mosaic of resilient and vulnerable system parts, ensuring that some components persist, recover or transform when disturbed, while others may experience damage or disappear.

Easdale et al. (2016), Zimmerer and Rojas Vaca (2016) and Chelleri et al. (2016) assess ecosystem diversity and landscape, as well as crop and livelihood heterogeneity. Easdale et al. (2016) discuss ways in which transhumant pastoralists benefit from altitudinal heterogeneity, along with its related climate differences and ecosystem diversity, through mobilising their livestock herds. This discussion forms a basis for exploring policy options for reducing vulnerability to environmental disturbances through the maintenance of common property institutions that can support ecological diversity. Zimmerer and Rojas Vaca (2016) identify the spatial clustering of fields as a

viable strategy to conserve the high agro-biodiversity of traditional Andean maize. Cultivating phenologically diverse maize varieties allows farmers to adapt to unpredictable and highly variable climate conditions and water scarcity. Chelleri et al. (2016) show that the focus on mono-cultural quinoa cash-cropping has diminished natural and agricultural biodiversity and has caused soil degradation. Moreover, this paper argues that managing the trade-offs between exposure and communities' capacity to adapt to multiple disturbances requires a non-linear understanding of the interaction between resilience and vulnerability that goes beyond the linear notion that places these concepts at the extreme ends of a continuum.

Doughty (2016), Montaña et al. (2016) and Vallejo-Rojas et al. (2016) stress the importance of recognising and pursuing diverse development pathways. They refer not to diversity within a socio-ecological system per se but to the need for differentiated rural development approaches to foster resilience. For example, rural Andean communities have built resilience by diversifying livelihood options including tourism and agricultural activities (Doughty 2016) as well as by intentionally deviating from modern and industrial trajectories, thus developing along alternative pathways that do not follow the principles of economic growth and efficiency maximisation (Montaña et al. 2016). In discussing how knowledge, resources and capacities are circulated—or trapped—through social structures and networks, Montaña et al. (2016) differentiate upstream and downstream land users' opportunities for responding to and preparing for environmental variability. Vallejo-Rojas et al. (2016) have developed a socio-ecological framework for analysing agri-food systems which explicitly covers not only diversity in agricultural practices and agro-ecological contexts but also actors and institutions as drivers of vulnerability. This framework serves as an elaborate analytical tool to explore alternative development trajectories and ways of achieving food sovereignty.

Together, these papers underline that environmental and socio-economic diversity greatly matters in building resilience. By seizing benefits and balancing trade-offs that emerge in space and time, rural communities in the Andes flexibly manage the heterogeneous resources they have available. While the variety of experiences and perceptions can facilitate a community's response to socio-ecological disturbance, it is also necessary to draw up a detailed analysis of specific social groups within a community and individual people's adaptive capacity to better understand who wins and who loses within a community.

Connectivity

Connectivity describes the nature and strength of socio-ecological connections and interactions. This Special Issue highlights the circumstance that connectivity in the rural

Andes is closely related to the complementary use of diverse ecosystems and landscape niches that are characteristic of the high-mountain topography and networks through which ecosystems and people interact. In particular, connections involve pronounced highland–lowland and rural–urban interactions resulting from, for example, migration and market relations. These connections demonstrate that agro-ecological complementarity and the exchange of products at broader scales, which has always been key for the wellbeing and resilience of Andean populations (Murra 1975; Troll 1968), retains its importance today, though requiring differentiated analysis.

Easdale et al. (2016) underline the importance of the structure and complexity of transhumance networks which connect highland pastoralists and a wide range of altitudes and ecosystems, creating diverse trade and socio-cultural relations. Highlighting the role of centrality, these authors suggest that more centralised networks can decrease resilience as adverse impacts of land degradation or communicable diseases can easily be transmitted or cascade towards the directly connected nodes. Chelleri et al. (2016) illustrate changes in social networks and collaboration between farmers caused by migration and the mechanisation of agriculture. For example, urban people who temporarily migrate to rural areas to cultivate their land may neglect traditional rules and communal duties such as cleaning water channels, largely undermining reciprocity relations and causing tension and conflict within local communities. Zimmerer and Rojas Vaca (2016) discuss connectivity with regard to labour and knowledge flows as well as the spatial clustering of crops in association with information sharing, trust building and reciprocity. They depict how formal and informal coordination among farmers closely relates to the spatial clustering of agricultural fields, enhancing resource use efficiency and resilience. Doughty (2016) shows that development projects can build resilience by creating or expanding socio-ecological networks. These networks link communities and the environment at a local level through reinforced conservation ethics as well as communal, governmental and non-governmental organisations at regional and international levels.

These contributions demonstrate the value of identifying both well-connected and more isolated ecosystems and actors in order to evaluate the resilient and the vulnerable parts of a system. Highlighting the fact that connectivity entails close interactions within and across spatial scales and institutional levels, these papers reflect the challenge of finding an institutional fit between cross-scale disturbances and local, regional and global actors and decision-making. Since key ecosystems, actors and connections between them can emerge and disappear due to both endogenous changes and external disturbances, understanding the

dynamics of connectivity is a cornerstone of resilience building.

Development models

Different models of development are proposed and contested by a range of actors such as international organisations, governments and farmer organisations operating at international, national and local levels. Relating to particular ways in which development objectives are framed and addressed, including opposing neoliberal and alternative views, development models directly influence a socio-ecological system's resilience. For example, integration into regional and global markets through trade liberalisation can cause disturbances that aggravate the effects of climate variability and change, possibly undermining adaptability and transformative potential. Taking a normative perspective, various authors in this Special Issue discuss the impacts of economic globalisation and trade liberalisation on rural communities' resilience to environmental disturbance. They provide new insights into exposure to multiple disturbances (O'Brien and Leichenko 2003; McDowell and Hess 2012) as well as into differentiated resilience outcomes, including winners and losers.

Comparing various development pathways in three Andean dryland regions, Montaña et al. (2016) discuss the ways in which development models, institutional capital and governance schemes have decreased or increased vulnerability. These authors reveal the limitations of growth-oriented development models that have largely undermined the socio-ecological capacity to deal with disturbance. Chelleri et al. (2016) provide further empirical evidence for the constraining nature of growth orientation that relies upon quinoa cash-cropping and market integration. They demonstrate that although agricultural intensification and market integration has helped farmers to generate higher income, inefficient policy implementation has constrained sustainable development. While promoting alternatives to growth-oriented development trajectories, Vallejo-Rojas et al. (2016) integrate agency and power relations in their socio-ecological framework of agri-food systems. Underlining the importance of farmers' associations, indigenous culture and multi-level institutional interactions, this framework enables a systematic assessment of how agricultural policies may re-configure agri-food systems' resilience. Doughty (2016) proposes a critical perspective on development practice and how it relates to building local resilience to environmental change. She argues that local organisations have advantages over international development initiatives in building adaptive capacity since international initiatives may face limitations with regard to stakeholder engagement, understanding of local political, economic and environmental complexities as

well as long-term commitment. However, she casts doubts on local communities' capacity to sustain development initiatives and resilience outcomes should the facilitating role of local non-governmental organisations be discontinued, for example due to a lack of funding.

These papers underline the importance of development models in shaping resilience, the need for considering multiple disturbances and the role of power relations in determining resilience. They help situate the impacts of environmental disturbances in specific social, cultural and economic Andean contexts. The authors point out the potential of alternative, culturally appropriate development models for creating and maintaining the necessary diversity and connectivity in resources and social coping mechanisms, as opposed to growth-oriented development models often fostering resource traps and institutional rigidity.

Towards improved resilience

This Special Issue advances our understanding of the critical dynamics, opportunities and limitations facing socio-ecological systems in their response to variable and changing disturbances in the rural Andes. The contributions to this Special Issue provide empirical insights into the coupled and non-linear effects of diversity, connectivity and development models as three key resilience factors. These factors demand special attention in order to increase a socio-ecological system's capacity to tolerate disturbance without undergoing any deterioration in its core structure and functioning or its ability to transform and enter a new, more sustainable development trajectory. The novel insights into resilience dynamics include specific features related to the high-mountain contexts and socio-political tensions in the Andes while also encompassing interactions between more common resilience drivers and outcomes. Future research can build on this knowledge to further not only resilience theory but also methodological approaches which reflect both case-specific and generic complexity. To accelerate knowledge generation, comparison in space is crucial and may help to fill some knowledge gaps in cases where the long-term monitoring of key processes such as environmental dynamics, livelihood changes and institutional reorganisation is only just beginning. This will provide effective entry points to inform decision-making with regard to increasing socio-ecological systems' resilience in the face of intensifying global change and uncertainty in the future.

Acknowledgments We would like to thank all authors for their insightful contributions and the reviewers who helped assess the papers included in this Special Issue.

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