Reconciling approaches to climate change adaptation for Colombian agriculture

Julian Ramirez-Villegas[1, 2, 3, *] and Colin K. Khoury[1, 4]

[1]International Center for Tropical Agriculture (CIAT), Cali, Colombia
[2]CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)
[3]Institute for Climate and Atmospheric Science (ICAS), School of Earth and Environment, University of Leeds, Leeds, UK
[4]Centre for Crop Systems Analysis, Wageningen University, Wageningen, Netherlands

* Corresponding author, e-mail: j.r.villegas@cgiar.org

Abstract

The projected impact of climate change on agro-ecological systems is considered widespread and significant, particularly across the global tropics. As in many other countries, adaptation to climate change is likely to be an important challenge for Colombian agricultural systems. In a recent study, a national-level assessment of the likely future impacts of climate change on agriculture was performed (Ramirez-Villegas et al., 2012, RV2012). The study diagnosed key challenges directly affecting major crops and regions within the Colombian agricultural system and suggested a number of actions thought to facilitate adaptation, while refraining from proposing specific strategies at local scales. Further insights on the study were published by Feola (2013) (F2013), who stressed the need for transformative adaptation processes to reduce vulnerability particularly of resource-limited farmers, and the benefits of a predominantly stakeholder-led approach to adaptation. We clarify that the recommendations outlined in RV2012 were not intended as a recipe for multi-scale adaptation, but rather a set of actions that are required to diagnose and develop adaptation actions particularly at governmental levels in coordination with national and international adaptation initiatives. Such adaptation actions ought to be, ideally, a product of inclusive sub-sectorial assessments, which can take different forms. We argue that Colombian agriculture as a whole would benefit from a better outlining of adaptation needs across temporal scales in sub-sectorial assessments that take into account both RV2012 and F2013 orientations to adaptation. We conclude with two case studies of research on climate change impacts and adaptation developed in Colombia that serve as examples of realistic, productive sectorial and sub-national assessments.

1. Introduction

The increased likelihood of the climate change signal emerging from observed variability has brought projection of impacts and planning for adaptation to the centre of contemporary scientific and political discourse. Climate change is expected to have widespread impacts on agro-ecological systems, particularly across the global tropics (Battisti and Naylor, 2009; Easterling et al., 2007; Fischlin et al., 2007). As in many other countries, adaptation to climate change is likely to be an important challenge in Colombian agricultural systems and adaptation responses will critically affect the livelihoods of Colombian farmers (Eslava and Pabon, 2001; Ramirez-Villegas et al., 2012). However, because the required responses to counter such impacts are dependent on the biogeographic and administrative characteristics of the agricultural system in question, adapting Colombian agriculture to climate change has no single ‘silver-bullet’ solution (Costa Posada, 2007; Ramirez-Villegas et al., 2012; Ruiz et al., 2012). Colombia possesses a highly diverse and complex agricultural system, owing to vast climatic and soil diversity and a long history of traditional agricultural development by a variety of ethnic groups across the Colombian Andes, the Amazon and the eastern plains (Pabon, 2003; Ramirez-Villegas et al., 2012). The system also features high rates of poverty and important land-tenure and distribution issues (DNP, 2011b), not least due to large numbers of low-input smallholders with limited technological and agricultural extension access, and the lack of organization in a number of important sectors (Deininger and Lavadenz, 2004; Ramirez-Villegas et al., 2012).

In a recent study, a national-level assessment of the likely future impacts of climate change on agriculture was performed [see Ramirez-Villegas et al. (2012), RV2012 hereafter]. The study diagnosed key challenges directly affecting the Colombian agricultural system and suggested a number of actions thought to facilitate adaptation, while refraining from proposing specific strategies at local scales. The study, which was conducted during 2009 [see Ramirez et al. (2009) for an earlier version], has contributed to a number of research and adaptation initiatives, including the Colombian Inter-institutional Climate Change and Food Security network (RICCLISA, see http://www.ricclisa.org/) and the policy document CONPES (National Council for Economic Policy) No. 3700 (DNP, 2011a). These processes have further led to the development of regional and local projects on climate change impacts and adaptation (see Sect. 6 of Supplementary Information in Ramirez-Villegas et al. 2012). Remarking on the study, Feola (2013) (F2013 hereafter) stressed the importance of “transformative” change in the rural sector (i.e. rural reform) due to the variety of major factors affecting the livelihoods particularly of resource-limited Colombian farmers, including recent free trade agreements and the ongoing armed conflict along with global change. In proposing a way forward for addressing vulnerability, F2013 advocated a bottom-up, stakeholder-centred adaptation process.

We are pleased with the constructive commentary of F2013 that suggests additional factors be taken into account for successful adaptation by vulnerable communities and in recognition that different stakeholders maintain diverse priorities for adaptation. We emphasize that these factors make no less important the recommendations outlined by RV2012. We take this opportunity to expand our discussion of the spectrum of adaptation processes necessary for the agriculture of a highly diverse country such as Colombia. In doing so, we clarify RV2012's proposal (Sect. 2) and, more specifically, the important role of the government within the adaptation planning process (Sect. 3). We then argue for a reconciling of approaches to adaptation to climate change following a very recent line of evidence [see Vermeulen et al. (2013)], and stress the importance of considering the temporal scale of the climate change impact for adaptation planning (Sect. 4). To illustrate these points we conclude with two case studies of research on climate change impacts and adaptation developed in Colombia that serve as examples of productive sectorial and sub-national assessments (Sect. 5).

2. Clarifications on RV2012's proposal for adaptation

RV2012 assessed future climate change impacts in what may be called a top-down (i.e. impacts-based, see Sect. 3 for a definition) approach (see Sect. 5 of Supplementary Material in RV2012 for methodology followed). RV2012 assessed the required responses to such impacts at the government level as well as the possible constraints to such actions. Importantly, RV2012 focused on one particular aspect of the future of Colombian agriculture, namely climate change, in large part because of the lack of recent analyses focused on the impact on particular crops and sectors within the country and therefore the subsequent inadequacy of policy enacted to understand and to address vulnerability within the agricultural system. In addition to national policy RV2012 highlighted the need for sub-sector-specific assessments, implying that a combination of sub-sector-specific actions (which need to be defined by each sub-sector, with the participation of farming communities) and government policies should lead to integrated, effective adaptation. Thus, RV2012 were inclusive of a diversity of levels where actions are necessary to identify, prioritize and actualize adaptation responses. The critical need for coordination between levels of integration for adaptation planning was included (also see Sect. 4.2 in Ramirez et al. 2009) in recognition of the necessity of government policy grounded in local reality, as well as sub-sector action encouraged, rather than hindered, by enabling policy. One of the limitations in RV2012, however, is that it lacked a clear definition of the specific role of the actors in the adaptation process, to which F2013 has provided important insight. Here we further delineate the role of the government (Sect. 3), as well as that of other actors in the adaptation process (Sect. 4).

3. The role of the government

In climate change adaptation a government will ideally enable understanding, coordination and action, especially within sectors identified as key priorities, such as agriculture in Colombia (Ramirez et al., 2009). Here, the debate is not what the current Government is capable of doing, but rather what are the actions that the Government should be taking to safeguard food security and rural livelihoods. The task of a government under adaptation is to intervene when required resources are lacking, when insufficient coordination precludes actions from being taken, or when enabling policies are required (Rickards and Howden, 2012). In this sense, policies should be put in place and funds for research and development released for sub-sectors to diagnose climate change impacts and to adapt. The creation of the climate change CONPES is probably the clearest example of a needed government action directly specifically toward counteracting the negative effects of global change (DNP, 2011a). Government-level mobilizations should not stand isolated from local and/or sectorial actions (DNP, 2011a, b; Smith and Stern, 2011) and thus they ought to be grounded in the context of the agricultural sector, particularly in recognition of its particular strengths and vulnerabilities. RV2012 proposed a framework within which both sub-sectors and the government have complementary roles. Sub-sectorial organisation has proven to be of paramount importance for sectors such as coffee, rice and sugarcane in Colombia (Arguello and Lozano, 2007; Norton and Balcázar, 2003). Under climate change, diverse sectors more than ever must capitalise on opportunities for funding, research and development, and use their complementary knowledge and capacities to bridge traditional and expert knowledge to form an integrated response. Coordinated responses prove important especially within diverse countries such as Colombia, where stakeholders within and between communities may vary widely in the degree of awareness of broader sectorial, political, and economic change. Likewise government and scientific recommendation may lack critical information key to the success of interventions particularly in rural communities, and in the absence of dialog such interventions are less likely to receive the support of the intended stakeholders, may not correlate well with local priorities, and in the worst case may drive mal-adaption and exacerbate vulnerability (Agrawal, 1995; Kok et al., 2011).

4. An adaptation framework for Colombian agriculture

In this section we propose a framework for identifying risks and define potential roles of farmers, sub-sectorial organisations and the government in adaptation planning. At the sub-sector level, it is critical to determine the scientific approach to adaptation. Here, we introduce the concepts of 'top-down' (i.e. impacts-based) and 'bottom-up' (i.e. capacity-based). In short, impacts-based approaches aim at developing model-based future projections of climate change impacts to then identify adaptation measures that are subsequently tested at field scales and which affect government-level policy actions (such as those outlined in RV2012). On the contrary, capacity-based approaches focus on diagnosing existing vulnerabilities and adaptive capacity typically on household or community levels to then develop measures that increase local resilience. Defining these approaches, identifying the specific contexts in which the approaches are most useful in developing adaptation strategies and placing the approaches in the time scales appropriate to climate change adaptation are critical to understanding the analyses and the recommendations presented by RV2012 and F2013.

Figure 1 illustrates the response of a biophysical indicator (e.g. crop yields) in time under a given future climate scenario. The blue line represents the mean response of a cropping system under a variety of plausible circumstances (i.e. uncertainty, light blue shading). As time passes, the impacts signal emerges from observed variability (illustrated by the yellow box), crossing tolerable limits [see Dow et al. (2013) and red vertical lines in Fig. 1], hence forcing more substantial changes to the production system (see Fig. 2 for the types of changes). It is thus critical to identify the magnitude of the risk involved in failure to respond, which varies spatio-temporally.

Climate impacts at very short time scales are usually within the experience of farmers and sub-sectorial organisations (i.e. within observed variability, yellow area in Fig. 1). In these cases, a capacity-based approach is generally successful (Feola, 2013; Vermeulen et al., 2013). Changes in sowing dates, in timings and amounts of fertilizer, irrigation and fungicides are generally the type of coping responses at these scales (Fig. 2). With a more pronounced climate signal (dark yellow area in Fig. 1), coping strategies (and thus capacity-based adaptation) may, however, fail in delivering their intended objective. In these cases, more systemic alterations may be needed. Changes in crop rotations, increasing on-farm diversity and crop improvement are examples of adaptation strategies at these scales (Fig. 2). There is, however, a level of climate change at which a cropping system may no longer be viable (orange area in Fig. 1). Transformational change (e.g. changing livelihood and/or land-use) is in such cases warranted (Fig. 2).

<Figure 1 here>

RV2012 reported that most major crops are likely to be negatively impacted across the country, confirming the need for agricultural adaptation. Importantly, however, the study also highlighted significant uncertainties which suggest relevant predictability limits on impacts, particularly if water availability and precipitation play a role (see Fig. 1g and the ensemble spread in Fig. 2b of Ramirez-Villegas et al., 2012). In this particular case, the impacts-based approach where science informs policy and/or field-scale decisions is thus useful in identifying both the key processes involved in the impact and the levels of predictability (Vermeulen et al., 2013). As in other impacts-based approaches [see e.g. Challinor et al. (2010); Osborne et al. (2013)], limitations may arise when the degree of predictability is too low (i.e. high uncertainty), or when the complexity of the socio-economic system precludes desired adaptation measures from being implemented (Vermeulen et al., 2013). On the other hand, a purely stakeholder-based approach may fail to foresee required transformational changes or capitalise on longer-term benefits, especially when resilience requires action at greater scales than local or community levels (see e.g. the case studies presented by Vermeulen et al., 2013). We thus argue that both impacts-based and capacity-based approaches for adaptation are needed, and that the important question is not ‘what is the best approach?’ but rather ‘in what context should each approach be considered?’

Under this framework, the role of impacts-based science is thus not only one of identifying the thresholds of future risks (Dow et al., 2013), but also contributing to adaptation strategies that may help in countering the negative effects. The livelihood transformations identified by

Vermeulen et al. (2013) in their case study of coffee in Nicaragua, as well as those proposed by Jones and Thornton (2009) exemplify how model-based projections can help developing adaptation strategies. However, because 'impacts' science outcomes cannot be isolated from field-level decision processes (Feola, 2013), stakeholder dialogue and institutional trust is critical for adaptation to actually happen (Claessens et al., 2012). For a more complete analysis of adaptation under uncertainty the reader is referred to Vermeulen et al. (2013). For a complete review on transformational adaptation the reader is referred to Rickards and Howden (2012), Howden et al. (2007), and Moser and Ekstrom (2010).

<Figure 2 here>

5. Case studies of sectorial adaptation

The first case study explored here is that of the Agriculture, Vulnerability and Adaptation (AVA) project, led by RICCLISA (Navarrete et al., 2013; Peterson et al., 2012). For AVA, international funds from the Climate and Development Knowledge Network (CDKN) were accessed by a multi-institutional network. Researchers from various national and international research centres as well as universities led the design of a methodology to diagnose current and future vulnerabilities across the upper-Cauca River basin. Even though the methodology can be classified as 'impacts-based', all stakeholders (including scientists) had equally important (but complementary) roles in diagnosing the impacts (Peterson et al., 2012). A better understanding of the local issues was gained through a stakeholder-led process, and then used as part of the inputs to a regional analysis of vulnerability that allowed the identification of current vulnerability, adaptive capacity, and future impacts and adaptation needs. Communication and feedback at local levels from groups of farmers occurred throughout the process, and this allowed a cohesive and robust analysis framework with field-validated, grounded conclusions. The use of scientific and traditional knowledge in conjunction with spatially explicit information allowed the disaggregation of impacts on a crop and municipality basis, thus allowing the generation of local- and regional-level information critical for both the local and policy dimensions of adaptation (Navarrete et al., 2013).

The above example illustrates the use of international funds for local and regional adaptation actions in Colombia. This second example illustrates the use of national government funds for reducing vulnerability at local levels through (1) the improvement of local practices through a stakeholder-centred site-specific agriculture program, and (2) the generation of model-based scientific knowledge. The Colombian government through the MADR signed an agreement with the International Center for Tropical Agriculture (CIAT) to reduce vulnerability to climate change across the country. Even though CIAT is the leader of the program, a number of universities and sub-sectorial organisations are involved in the design and execution of the nearly 12 m USD project, of which at least 40 % is executed through national organisations. Four multi-disciplinary components are part of the major research and development effort: (1) climate variability and climate change impacts, (2) identification of promising germplasm for adaptation, and (3) eco-efficiency and ecosystem services. In this program, stakeholder participation takes place in a direct form through the transversal action of a national-level site-specific agriculture component, which is planned to bridge farming communities and science through the development of a stakeholder-centred experimental network and learning process. Stakeholders may also be involved indirectly by means of national research organisations involved in individual components. The three project components thus take advantage of science outputs and farm-level knowledge and interaction to develop and ground their outcomes. The program, which is the first of its kind in Colombia, is expected to be completed by mid-2014, and is probably the clearest result of needed government actions stressed in the CONPES No. 3700 (DNP, 2011a).

5. Conclusions

We stress that impacts, vulnerability and adaptation assessments at the full range of scales are critical to adaptation in the mega-diverse country of Colombia. We discuss a framework for adaptation and clearly define the role of the government as an enabling agent. Importantly, we clarify that the recommendations in RV2012 were not meant as prescriptions for multi-scale adaptation, but rather a set of actions that are required to diagnose and develop adaptation actions, particularly aimed at Governmental levels. Such adaptation actions ought to be, ideally, a product of sub-sectorial assessments, which can take different forms and/or use different approaches. These also need to ensure farmers' inclusion in the adaptation process, as well as a clear definition of adaptation strategies at different temporal scales. The two case studies presented in Sect. 4 exemplify productive steps toward the goal: (1) multi-institutional actions in the face of climate change with government participation, and (2) needed government-level policies and actions to enable adaptation through both a combination of both science- and stakeholder-centred processes.

Acknowledgments

Authors acknowledge the support of the CGIAR-ESSP Research Program on Climate Change, Agriculture and Food Security (CCAFS). JRV thanks Prof. Andy Challinor from University of Leeds for insightful discussions on signal-to-noise ratio and adaptation. Authors thank Caitlin Corner-Dolloff from CIAT for discussions and literature related to transformative societal change.

References

Agrawal A (1995) Dismantling the Divide Between Indigenous and Scientific Knowledge. Development and Change 26:413-439.

Arguello RC, Lozano MC (2007) Agricultural sector and competition policy in Colombia. Universidad del Rosario, Facultad de Economía, Bogotá, Colombia.

Battisti DS, Naylor RL (2009) Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat. Science 323:240-244.

Challinor AJ, Simelton ES, Fraser EDG, Hemming D, Collins M (2010) Increased crop failure due to climate change: assessing adaptation options using models and socio-economic data for wheat in China. Environmental Research Letters 5:034012.

Claessens L, Antle JM, Stoorvogel JJ, Valdivia RO, Thornton PK, Herrero M (2012) A method for evaluating climate change adaptation strategies for small-scale farmers using survey, experimental and modeled data. Agricultural Systems 111:85-95.

Costa Posada C (2007) La adaptación al cambio climático en Colombia. Revista de Ingeniería 26:74-80.

Deininger K, Lavadenz I (2004) Colombia: Política agraria en transición. En breve. World Bank.

DNP (2011a) Documento CONPES 3700: Estrategia Institucional para la Articulación de Políticas y Acciones en Materia de Cambio Climático en Colombia. Departamento Nacional de Planeación, Bogotá, Colombia.

DNP (2011b) Índice de Pobreza Multidimensional (IPM-Colombia) 1997-2010 y meta del Plan Nacional de Desarrollo para 2014. Departamento Nacional de Planeacion (DNP); Dirección de Desarrollo Social (DDS); Subdirección de Promoción Social y Calidad de Vida (SPSPV), Bogotá, Colombia.

Dow K, Berkhout F, Preston BL, Klein RJT, Midgley G, Shaw MR (2013) Limits to adaptation. Nature Clim. Change 3:305-307.

Easterling WE, Aggarwal PK, Batima P, Brander KM, Erda L, Howden SM, Kirilenko A, Morton J, Soussana J-F, Schmidhuber J, Tubiello FN (2007) Food, fibre and forest products. in Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds.) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 273-313.

Eslava JA, Pabon JD (2001) Proyecto: proyecciones climáticas e impactos socioeconómicos del cambio climático en Colombia. Meteorología Colombiana 3:1-8.

Feola G (2013) What (science for) adaptation to climate change in Colombian agriculture? A commentary on “A way forward on adaptation to climate change in Colombian agriculture: perspectives towards 2050” by J. Ramirez-Villegas, M. Salazar, A. Jarvis, C. E. Navarro-Racines. Climatic Change this volume.

Fischlin A, Midgely G, Price J, Leemans R, Gopal B, Turley C, Rounsevell MDA, Dube P, Tarazona J, Velichko A (2007) Ecosystems, their properties, goods and services. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel of Climate Change (IPCC). Cambridge University Press, Cambridge, UK, Cambridge, UK.

Howden SM, Soussana J-F, Tubiello FN, Chhetri N, Dunlop M, Meinke H (2007) Adapting agriculture to climate change. Proceedings of the National Academy of Sciences 104:19691-19696.

Jones PG, Thornton PK (2009) Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change. Environmental Science & Policy 12:427-437.

Kok K, van Vliet M, Bärlund I, Dubel A, Sendzimir J (2011) Combining participative backcasting and exploratory scenario development: Experiences from the SCENES project. Technological Forecasting and Social Change 78:835-851.

Moser SC, Ekstrom JA (2010) A framework to diagnose barriers to climate change adaptation. Proceedings of the National Academy of Sciences 107:22026-22031.

Navarrete C, Nowak A, Lavado A, Bustillos C (2013) Agricultura, Vulnerabilidad y Adaptación (AVA): Desarrollo compatible con el clima en el sector agrícola del Alto Cauca Colombiano. Reporte Final. Alianza Clima y Desarrollo, CDKN. Cali, Colombia, p. 31p.

Norton RD, Balcázar AV (2003) A study of Colombia’s agricultural and rural competitiveness. Report to United Nations Food and Agriculture Organization, The World Bank and United States Agency for International Development, Washington DC, USA.

Osborne T, Rose G, Wheeler T (2013) Variation in the global-scale impacts of climate change on crop productivity due to climate model uncertainty and adaptation. Agricultural and Forest Meteorology 170:183-194.

Pabon JD (2003) El cambio climático global y su manifestación en Colombia. Cuadernos Geográficos 12:111-119.

Peterson C, Nowak A, Jarvis A, Navarrete C, Figueroa A, Riaño N, Vargas J (2012) Analysing vulnerability: a multi-dimensional approach from Colombia's Upper River Basin. Inside Stories on Climate Compatible Development. Climate & Development Knowledge Network (CDKN).

Ramirez-Villegas J, Salazar M, Jarvis A, Navarro-Racines C (2012) A way forward on adaptation to climate change in Colombian agriculture: perspectives towards 2050. Climatic Change 115:611-628.

Ramirez J, Jarvis A, Salazar M, Zapata E (2009) Documento de Discusión Nacional acerca de Asuntos Claves en el Análisis del Sector Agricultura (Adaptación). United Nations Development Programme (UNDP), Bogotá, Colombia.

Rickards L, Howden SM (2012) Transformational adaptation: agriculture and climate change. Crop and Pasture Science 63:240-250.

Ruiz D, Martinson D, Vergara W (2012) Trends, stability and stress in the Colombian Central Andes. Climatic Change 112:717-732.

Smith LA, Stern N (2011) Uncertainty in science and its role in climate policy. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 369:4818-4841.

Vermeulen SJ, Challinor AJ, Thornton P, Campbell BM, Eriyagama N, Vervoort J, Kinyangi J, Jarvis A, Laderach P, Ramirez-Villegas J, Nicklin K, Hawkins E, Smith D (2013) Addressing uncertainty in adaptation planning for agriculture. Proceedings of the National Academy of Sciences in press.

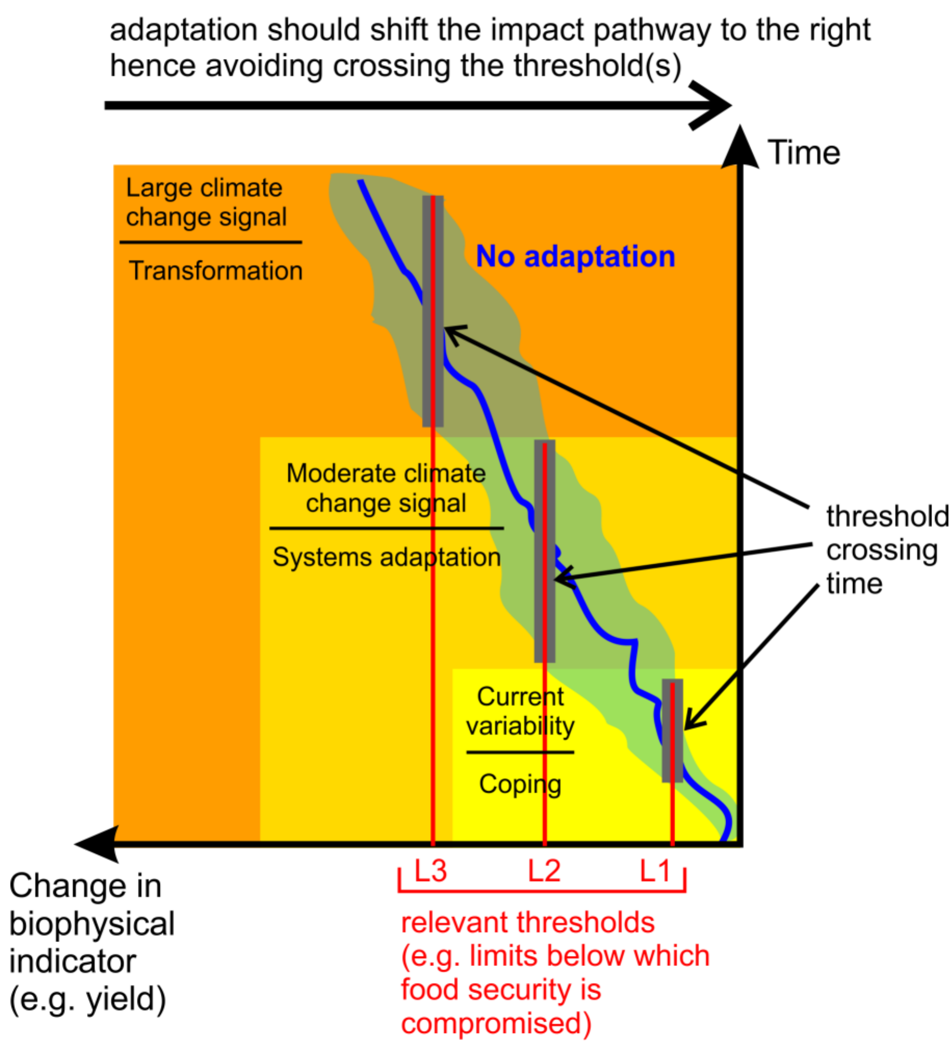

Figure 1 Response of a biophysical indicator of an agricultural system to climate change across temporal scales in climates. Continuous blue line shows the response of the system where no adaptation measures are taken at any time (i.e. no adaptation scenario). Vertical red lines (marked with the prefix "L" in the *x*-axis) indicate thresholds of the biophysical indicator that somehow affect livelihoods. These indicate moments where adaptation measures to counter the negative impact need to take place in the system (with grey indicating projection uncertainty). Coloured boxes indicate the extent of the climate change signal and the type of adaptation required in the system.

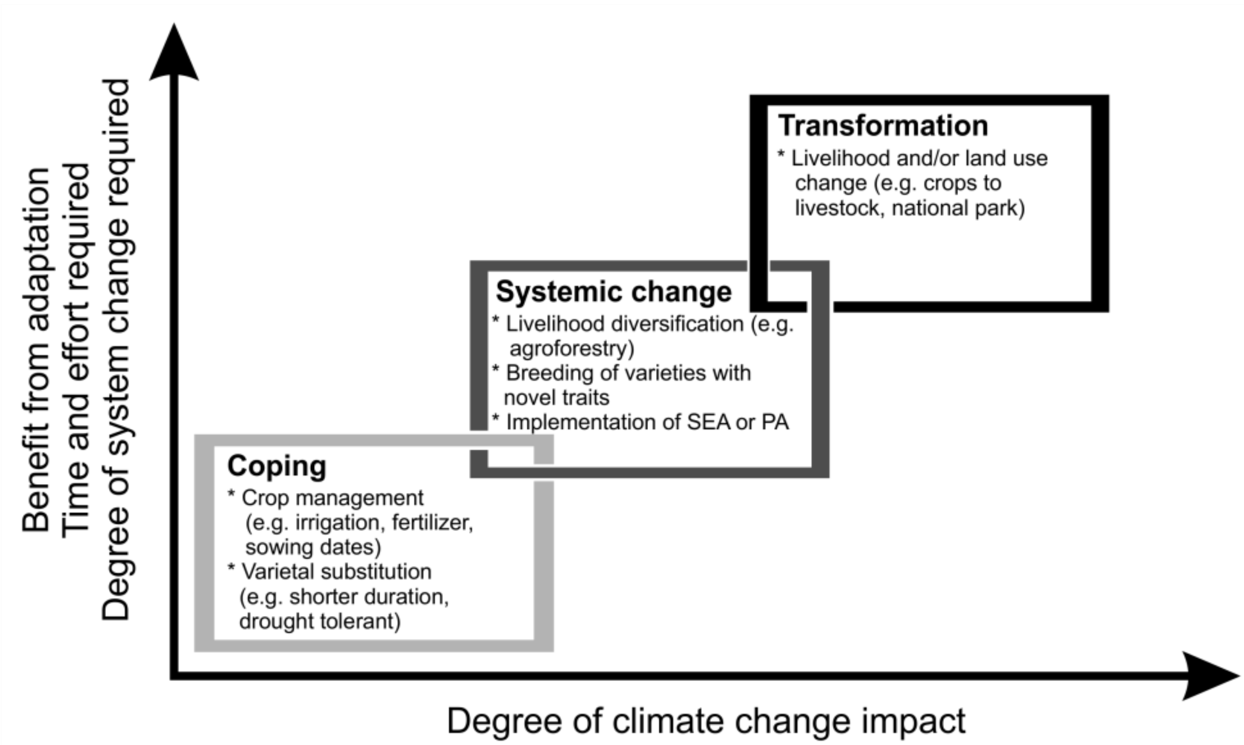

Figure 2 Types of adaptations needed in a system as the degree of climate change impact increases. Note that three different variables are given in the *y*-axis. SEA: Site-specific agriculture; PA: precision agriculture. Figure based on Rickards and Howden (2012) and Moser and Ekstrom (2010)