CLIMATE CHANGE ADAPTATION IN PERU

> Climate change adaptation in Peru

The local experiences

EUROPEAN COMMISSION

PRACTICAL ACTION
Technology challenging poverty

Climate change adaptation in Peru: The local experiences

Climate change adaptation in Peru: The local experiences. Lima: Soluciones Prácticas, 2010.

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Printed by Forma e Imagen Press, Lima
Printed in Peru, February 2010

Soluciones Prácticas is the name of the Regional Office of **Practical Action** in Latin America.

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Introduction

For over five years **Practical Action** has been integrating climate change into its international programme work, including a number of initiatives in Peru. This book documents the results achieved by one of the most important projects implemented by **Practical Action's** office in Peru on climate change adaptation. *Climate Change Adaptation and Mitigation Technologies* was implemented between 2006 and 2007 in seven areas of Peru with funding from the European Commission.

Based on the premise that future climate scenarios, as published by the Intergovernmental Panel on Climate Change (IPCC), would create both challenges and opportunities for the poorest communities in Peru, **Practical Action** Latin America identified the need to establish strategies and technologies geared towards reducing the negative and capitalising on the positive impacts of climate change for these populations. Work in rural areas, particularly Andean highland regions, was prioritised for two reasons. Firstly, the Andes create unique climate conditions. Second, preliminary surveys showed that the people most affected by climate change in Peru are those who live in rural areas in conditions of extreme poverty. Typically, these people have little access to information on climate change.

The outcomes of the seven projects are a key starting point from which to propose practical answers to the global challenge of climate change. **Practical Action's** experience in Peru is undoubtedly an important milestone for the development of alternative climate change adaptation technologies using appropriate practices. Based on the learning and outcomes of the projects, **Practical Action** published the *Climate Change and Poverty* collection, which includes eight books:

Title	Content
Climate Change Adaptation: The Cold and Heat of the Andes	Synthesis of all seven experiences
Watershed Management: Adapting to Climate Change and the El Niño Phenomenon	Adaptation experiences in drought conditions in Piura, northern Peru
Agroforestry: A Climate Change Adaptation Strategy	Adaptation experiences from coffee and cocoa plantations in the San Martín rainforest
Watershed Management and Climate Change	Watershed management as a climate change adaptation measure in Yungay, the central highlands
Alpaca-raising Families Facing Climate Change	Adaptation strategies for alpaca farming in Cusco, the southern highlands
Native Potatoes Defying Climate Change	Adaptation of native potatoes in two highland areas of Cusco and Yungay
Information and Early Warning Systems to deal with Climate Change	Implementation of geographical information systems in Apurímac, Cajamarca and Piura
Conflict, Watershed Management and Climate Change	Watershed management as an adaptation strategy in the northern coastal and highland regions of Cajamarca, Lambayeque and Piura

This book contains summaries of four of the eight publications: *Climate Change Adaptation: The Cold and the Heat of the Andes; Native Potatoes Defying Climate Change; Water Management and Climate Change* and *Agroforestry: a Climate Change Adaptation Strategy.*


2 Larva
1 Huevo
ASI VIVE
EL GORGOJO
DE LOS ANDES

1 Adaptation to Climate Change: Resilience and Adaptive Capacity

1.1. Climate change and climate uncertainty[1]

Advances in climate science have enabled climate modelling to provide an unprecedented view of the future of the earth system. The impact of greenhouse gas emissions is now beyond doubt, as is warming of the global climate throughout the coming century. However, the precise implications remain unclear: predictions of rainfall rates, the likely frequency of extreme weather events, and regional changes in weather patterns cannot be made with certainty.

This uncertainty is of central importance to adaptation. While mitigation activities are rightly driven by the need to avoid dangerous climate change, adaptation planning cannot proceed without first understanding what climate change means in a particular location. Indeed, it is all too easy to assume that adaptation can and should follow climate change predictions. This can be the case where the message from current observations and predictive models is clear and unambiguous, such as for glacial melting or sea level rise (and even here, the rate of change is a subject of debate). But clear cut cases are in the minority. In many contexts there is no agreement whether, for example, rainfall is likely to increase or reduce.

What, then, should adaptation to climate change mean in these circumstances? This is the question addressed in this chapter. First, it is necessary to consider the limitations of climate predictions so that the different aspects of uncertainty can be absorbed into adaptation thinking.

The Intergovernmental Panel on Climate Change (IPCC) provides the most well known and authoritative assessments of the current scientific understanding of climate change. The body was established in 1988 with a mandate «to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature» relevant to climate change (IPCC, 1988). A creation of the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP), it conducts no new research of its own, but instead employs the services of around 400 scientists to compile reports on the 'policy relevant' aspects of climate science, impacts and adaptation, and mitigation. Each report examines data from previously published peer reviewed literature (and selected non peer reviewed reports)

1 This chapter is based on the first chapter of: Ensor, J. and Berger, R. (2009) *Understanding Climate Change Adaptation*. Practical Action Publishing, Rugby.

and is itself subjected to two rounds of expert review and one of government challenge and approval prior to publication. This approach removes controversial or spurious data and establishes a high degree of confidence in the content of the IPCC's publications.

However, when relying on the IPCC's conclusions it is important to note that the approach to knowledge gathering and sharing has the potential to be conservative. Consensus building and time constraints mean that some evidence is excluded. These decisions prevent the IPCC from reporting speculative data and allow scientifically plausible statements of certainty to be made in one report -but they also mean that low probability, high-impact events are not drawn out for public consideration. The periodic release of the IPCC assessment reports is also an important limitation: the time taken by the IPCC review process means that the evidence relied on in the reports is restricted to that published well in advance of the IPCC release date, whilst the 5 to 6 year periodicity of reports mean that the most recent IPCC assessment lags behind current scientific thinking.

Rather than undermining the IPCC conclusions or the importance of the process, these observations highlight the need to understand the limits that inevitably exist to even the most authoritative statements of knowledge. A 2008 review of the climate science literature illustrates the constraints of the IPCC process (Hare, 2008: 5-6):

> «Literature published in the past two years has identified several specific cases of higher risk than that assessed in the IPCC's AR4 [Fourth Assessment Report] … this literature is sufficiently important, credible and robust to justify presenting a view that adds to, and in some cases differs from, the IPCC assessment. The reader should be aware, also, that this paper presents the science of climate change from a risk perspective, in terms of which low-probability, high-consequence events merit the attention of policymakers at the highest level.»

For adaptation, the issue of interest is our ability to use science to predict the future. This is an obvious area for uncertainty to arise, and it does so in many forms. Fundamentally, the relationship between human activity and climate change means that assumptions must be made about the pattern of future emissions in order to generate climate predictions. Climate change predictions are mainly dependent on the greenhouse gas composition of the atmosphere in the future (predominantly carbon dioxide, methane and nitrous oxide). To address this problem, projections are made for a range of reasonably foreseeable future emissions. For example, the IPCC's best estimate for the increase in global average temperature by the end of this century is 1.8 °C assuming a low rate of emissions (referred to by the IPCC as the B1 scenario), whilst the highest foreseeable increases in greenhouse gases would yield a 4.0 °C temperature rise (the A1F1 scenario) (Meehl *et al.*, 2007: 749).

The mechanisms involved in producing predictions also introduce uncertainty. Climate predictions are significantly different from their more established cousin, weather forecasting. Climate is fundamentally different from weather in that climate refers to long term (conventionally 20 to 30 year) average weather conditions. Weather, on the other hand, refers to short term (hourly and daily) changes such as in temperature, rainfall and wind. Weather is hard to predict as its dynamics are chaotic: small changes in the current weather conditions can create large changes in the weather at a later time. Despite this, well established scientific understanding and measurement infrastructure allows predictions up to about 15 days ahead.

Seasonal forecasting has emerged more recently than weather forecasting, and is based on an improved understanding of slowly changing phenomena that have a significant impact on the weather, such as the El Niño Southern Oscillation (ENSO). Measuring this important but slowly changing phenomenon allows seasonal trends to be predicted up to around two years in advance, although confidence is greater for shorter timescales of up to around three months. Seasonal forecasts are not weather forecasts, but are more similar to climate models in that they offer a view of weather statistics, but over shorter time scales.

A typical seasonal forecast may predict daily rainfall for a particular three month period. An expression of confidence is normally included: for example, a forecast may predict with 90 per cent confidence that daily rainfall will be between 150 mm and 200 mm. The confidence captures and communicates the uncertainty in the forecast, and varies significantly with geographical location: the more weather is dominated by El Niño, for example, the more accurate the seasonal forecast. Generally speaking, predictability reduces the further a location is from the equator and from the ocean, and temperature is usually easier to predict than precipitation (Harrison *et al.*, 2007: 10).

Beyond seasonal timescales, climate models are relied for providing information on long term trends. Whilst they are able to establish with high confidence that global average temperatures will continue to increase (not least due to the levels of greenhouse gases currently in the atmosphere), more detailed changes, such as the impact of warming on wet and dry seasons, remain unclear.

The IPCC's calibrated expressions of confidence draw attention to the inherent uncertainty in climate models, which by definition are only approximations of reality, offering an incomplete representation of the full complexity of the earth system. Uncertainty -meaning that more than one plausible future can be asserted- is unavoidable. Even for a fixed rate of future emissions there is uncertainty as to the exact impact on temperature. Whilst the highest emission scenario produces a most likely average temperature increase 4 °C by the end of the 21st century, it is also possible that the increase might be as high as 6.4 °C or as low as 2.4 °C (Meehl *et al.*, 2007: 749). Currently, the impact of uncertainty can be seen most clearly in the failure of climate models to provide good agreement at the regional scale, and in particular on future levels of precipitation (Christensen *et al.*, 2007: 854).

1.2. Adaptive capacity and resilience

Vulnerability reduction is an important component of adaptation to climate change (Ensor and Berger, 2009a). An assessment of vulnerability to a particular climate change hazard, and the introduction of measures that address the causes of vulnerability are legitimate strategies. Importantly, vulnerability reduction can account for uncertainty in climate predictions as long as the measures employed are not dependant for their success on a particular climate future emerging. However, investment in these strategies inevitably requires a degree of confidence in climate change predictions. A point arises when uncertainty about the future climate increases so much that vulnerability assessments start to lose value, eventually becoming meaningless as the real possibility of unforeseen hazards emerges.

If increased rainfall is as likely to emerge as increased drought, how then should adaptation proceed? Moreover, while vulnerability reduction may be able to provide relief from the effects of climate change that are being experienced in the immediate term, how should adaptation deal with the problem of an uncertain future climate?

The remainder of this chapter focuses on how this challenge can be met through building adaptive capacity, understood as the ability to change in response to climate changes, and resilience, understood as the ability to absorb or cope with the unexpected. However, adaptive capacity and resilience should not be seen as independent of vulnerability: increasing a household or community's resilience or ability to adapt should help reduce vulnerability to the broadest possible range of possible hazards. As discussed below, adaptive capacity is also related to resilience, as building adaptive capacity is one way to support the ability to cope and recover.

Adaptive capacity refers to the potential to adapt to the challenges posed by climate change, describing the ability to be actively involved in processes of change. It encompasses the ability of actors within a particular human and environmental system to respond to changes, shape and create them in that system (Chapin *et al*., 2006: 16641). The tools that make up adaptive capacity therefore include both tangible assets, such as financial and natural resources, and less tangible elements such as the skills and opportunities to make decisions and implement changes to livelihoods or lifestyle.

Both the diversity and distribution of these components of adaptive capacity are important. For Chapin *et al* (2006: 16641) adaptive capacity «depends on the amount and diversity of social, economic, physical, and natural capital and on the social networks, institutions, and entitlements that govern how this capital is distributed and used.»

Similarly, Smit and Wandel's review of adaptation literature suggests that the determinants of adaptive capacity include both assets, including financial, technological and information resources, and the context within which these assets are held, including infrastructure, institutional environment, political influence, and kinship networks (2006: 286). Thus both Chapin and Smit and Wandel draw attention not just to the availability of assets but also to the prevailing social and political context through which distribution takes place: networks, institutions, entitlements and political influence.

Smit and Wandel (2006, 289) note that this context operates at different scales: whilst some elements of adaptive capacity are local (such as networks of family relationships), it is also important to recognise that broader and sometimes global social, economic and political forces may have the most significant influence on local vulnerabilities, such as where international free trade agreements remove supportive subsidies or price guarantees for a particular local crop. It may not be sufficient to consider only micro-scale relationships if it is 'powerful political and economic vested interests that determine the nature of the adaptation context' (Brooks, 2003: 12).

Diversity supports adaptive capacity by providing communities with options at times of stress or external change. Diversity is an attribute that offers more than simple accumulation of assets: it recognises that addressing an uncertain future requires access to a range of alternative strategies, some of which will prove viable. However, diversity is also a key pillar of resilience. Where adaptive capacity refers to the ability to influence and respond directly to processes of change, resilience is the ability to absorb shocks or ride out changes. For resilience, diversity of social, economic, physical and natural assets improves the prospects of a socio-ecological system persisting.

For example, a farm system dependent on a single crop may have low resilience to disease or climate change compared with one predicated on agricultural biodiversity. In the Peruvian context, a diversity of planting altitudes and terrains underpins the conservation of potato varieties from one year to the next, ensuring that crops survive in some locations even if they fail in others **(see chapter 3).** In the same way, resilience may also take the form of multiple (diverse) livelihoods. Whilst diversity underpins resilience, it is also important to recognise that the scale or degree must be appropriate and that a point can be reached at which assets or skills are spread too thinly to be of benefit.

In some circumstances sufficient accumulation of assets may also support resilience: reserves of financial capital, for example, can be enough to ensure a household can cope in many circumstances. Safety nets such as insurance, when available and affordable, can also form an important component of resilience and may play a role in backstopping specialisation or compensating for a lack of diversity.

Resilience and adaptive capacity are closely related, not least because both reduce the impact of uncertainty. Fostering adaptive capacity is also a mechanism for building resilience: adaptive capacity expands the options and opportunities for coping with or avoiding the impacts of climate change and thus improves a community or household's prospects of survival.

a. Elements of adaptive capacity

Adaptation requires the accumulation of skills as well as a diversity or accumulation of assets. Principally, utilising a diversity of assets to expand the range of available livelihood or coping strategies requires the ability to explore ways of employing those assets. Thus attributes of adaptive capacity also include the ability to experiment or innovate, and the capacity to learn (Peterson, 2000: 328; Chapin, 2006: 16641). Indeed, it has been suggested that the most adaptive societies are those with actors who have the capacity to experiment, and institutions in place to support them (Patt, 2008a).

For example, the involvement of NGOs and institutions in supporting farmer led research demonstrates how local adaptive capacity -and in particular the confidence to experiment- can be fostered. The provision of technical training is an important element in supporting experimentation. In **Practical Action's** work in Bangladesh, for example, NGO support for training in raft construction technologies has allowed local farmers to implement their own designs of 'floating gardens', an approach to securing food supply by growing crops in beds that float on top of rising water in regions that are prone to regular flooding (Ensor and Berger, 2009a).

Local extension services can similarly be a key element in developing adaptive capacity. However, the readiness to experiment and learn is complex and influenced by human, cultural, financial and institutional factors. The ability to put a diversity of resources to productive use may be linked to educational background and prior experience. Cultural attitudes may overlap with attitudes to financial assets to assist or inhibit experimenting and risk taking. For example, evidence suggests that there is no correlation between farmers' wealth and their willingness to adopt new management practices (Phillips, 2003; Patt, 2008b). On the other hand, the take up of insurance -a method of reducing risk and thereby facilitating experimentation- has been found to be greater amongst wealthy households. Risk averse households can in fact be less likely to take insurance, often due to their lack of experience with handling financial products (Gine *et al.*, 2007: 2).

Some social norms, if narrowly defined or deeply held, can stand in the way of experimentation. However, culture may equally support or inhibit experimentation: marginalised communities have exhibited both conservatism and experimentation as a strategy to deal with environmental change (Ensor and Berger, 2009b; Patt, 2008a).

The process of learning and adopting new strategies can be closely linked to the presence of social networks (defined in more detail below). Gine *et al* study of insurance take up amongst rural households in Andhra Pradesh (India) reveals membership of social networks to be important in determining whether a new insurance scheme is adopted, as networks provide opportunities for sharing information and advice (2007: 19). Social networks provide an opportunity for sharing experiences and as such are well placed to be effective in promoting learning, influencing changes to behaviour and stimulating collaborative innovation processes (Cross, 2004: 9). In the same way, they can help the real and perceived risk of adopting changes to livelihoods to be reduced by observing and understanding the experiences of others.

Importantly, adaptive capacity also requires the ability to access and process climate information. Climate change is an emerging phenomenon with the potential to transform environments and challenge traditional expectations of seasonal patterns and climate extremes. As adaptive capacity embodies a household or community's ability to engage with and make decisions about processes of change, some level of understanding of climate change predictions and the associated uncertainty is essential.

There is also the potential for simple climate change messages to disguise the complexity that is inherent in climate modelling. The illusion of certainty and simplicity is attractive, posing a problem for the communication of climate change information and raising the prospect of uncertainty being overlooked or underappreciated when information is exchanged.

However, an appreciation of complexity and uncertainty is essential if maladaptations or futile efforts at vulnerability reduction are to be avoided. Some form of institutional support is necessary for information dissemination, as climate change science and predictions will be beyond the reach of most poor communities. It is the responsibility of national governments to assimilate and communicate short and long term weather and climate change information, and to identify and facilitate the filling of gaps in knowledge where they exist. Moreover, information should be grounded in the livelihood context of those who are most vulnerable to climate change, and targeted at these groups in a form and with content that is appropriate to their needs.

b. Social networks

Social networks can be of significance to adaptive capacity and resilience. Both demand a degree of collective action and depend on the particular web of relationships that determine power, resource and information distribution in any situation involving multiple stakeholders. The focus of social networks is on the nature of these relationships. This distinctive perspective has given rise to key concepts that can be used to analyse and understand the connections between different actors, including that (Wasserman and Faust, 1994: 4):

- Actors and their actions are interdependent rather than independent, autonomous units
- Relational ties (linkages) between actors are channels for transfer or flow of resources (either material or nonmaterial)
- The network structural environment provides opportunities for or constraints on individual action

In the network view it is the relationships that tie actors that are central rather than the individuals as and of themselves. Actors are interdependent, and it is through their relationships that they create opportunities for resource and information exchange, and form the social, economic and political structures that define how they as individuals or groups may act.

Network analysis reveals the nature and extent of the interconnections between actors within the network (Hawe *et al.*, 2004), drawing attention to the power and interests that define the nature of the relationships between actors, and identifying the direct and indirect connections that channel flows of resources and information.

As discussed above, a community or household's social network plays a role in adaptation by supporting learning, experimenting and innovating. However, in the best case, a community's network will also yield a productive, open and democratic relationship to the state, enabling policy to be informed by community experiences and information to reach communities (Adger, 2003: 394). For adaptation, such a relationship between the state and community or civil society networks might facilitate the two-way flow of information, upwards from household and community to improve policy understanding of the local socio-economic and environmental context, knowledge and needs, and downwards in the delivery of relevant and current science.

Local social networks also offer marginalised groups an opportunity to develop adaptive strategies in the face of emerging climate risks. This use of networks is evidenced where local farmer groups become agents of change at the community level, such as where farmer-farmer networks have enabled the sharing of experiences of on-farm variety research, spreading experiences of adaptation from village to village (for an example from Sri Lanka, see Ensor and Berger, 2009a). Moreover, social networks are known to be relied on for coping during times of stress, most clearly through kinship ties but also in reciprocal arrangements between members of a network (Adger, 2003: 399).

An important aspect of the process of building adaptive capacity may therefore be extending existing social networks. Depending on the context, this may be through working with local networks with a view to enhancing and sharing community based adaptation activities. Alternatively, it may be through supporting civil society organisations to pressure different levels of government into participating in new (or existing) institutions so that the need for climate information and adaptation resources can be articulated. Supporting one approach can also yield gains for the other: for example, local social networks can simultaneously provide the foundation for influence in local governance institutions, while also being significant for local learning and knowledge sharing. Importantly, a greater degree of connectivity between communities provides increased opportunities for both activities.

The ability of communities to engage with governance and decision making can also improve resilience. In this context, resilience is manifested in the opportunity for communities to tone down proposed policy development: by preventing the introduction of inappropriate policies that would damage communities or the environment on which they depend. Communities are often well placed to play this role as their knowledge of their local environment will usually exceed that of an outsider. For example, the input of local land users into natural resource management and enforcement institutions can have a stabilising effect, reducing the likelihood of unsustainable land use changes (Chapin *et al*., 2006: 16642; Adger, 2003: 398).

The institutions, forums and relationships within social networks can also go some way towards converting climate knowledge transfer from top-down information provision to more effective, experience-based communication approaches. For example, Patt (2005) reports that farmers in Zimbabwe who attended workshops to learn about seasonal forecasts were significantly more likely to adapt farming methods in response to forecast information. By engaging farmers in the process of developing a forecast, this approach attempted to make technical information accessible to farmers' and ensured that the forecasting information was relevant to all stakeholders.

Establishing workshops is one approach to building networking capital to overcome the problems of communication and relevance of scientific information. Cash (2006: 4) recommends the use of «boundary organisations», this is, institutions that work as an intermediary between actors, whilst Patt (2008: 64) describes the forming of 'partnerships' between scientists and users. In each case an essential feature is the investment in social networks to build bridges between the knowledge systems and priorities of different communities. However, it is important to recognise that effective communication of weather and climate information is not guaranteed by the development of networks alone.

Significant problems remain with understanding the needs of farmers and other users of climate data, generating sustained institutional support and a favourable policy environment, and, fundamentally, appropriate and effective communication of data for decision making. Understanding the needs of communities is essential. Patt (2005: 12623) reports how success in the use of forecasting in Brazil was undermined through the dissemination of one poor forecast. Elsewhere, Patt notes an important barrier to communicating abstract, long term climate change information: «[i]t is hard to develop effective partnerships between climatologists and users in the absence of a problem to be solved» (2008: 64).

c. Power

Social networks are significant in part because «adaptation is mediated and interpreted through the lens of perceived opportunities» (Balstad, 2008: 173): expanding poor peoples' knowledge base and decision making capabilities is thus an important function of networked institutions. However, the lens of perceived opportunities can be refocused through the control of information and the motivations of stakeholders.

Peterson *et al*. (1997) point out how «management agencies often suppress scientific dissent in order to present a unified, certain front to the outside world, thereby consolidating the political power of the agency.»

Such misrepresentation can easily gain traction due to the attractive simplicity of the message and may gain the active support of actors who benefit from a particular view of the future. This scenario is pertinent to climate change, where the suppression of uncertainty may clear the way for commercial, technical fix solutions. For example, a diagnosis of a drying climate may facilitate the introduction of proprietary 'drought resistant' seed varieties, whereas an appreciation of the uncertainty associated with the prediction may instead lead to efforts to build the knowledge base of agricultural extension officers and ensure that a sustainable diversity of seed varieties is available.

Access to knowledge and information sources is therefore a necessary component of adaptive capacity, but insufficient without critical engagement. Network analysis provides an important tool for this process, enabling the chain of relationships between actors to be visualised and ensuring the social, political and economic foundations of those relationships is assessed.

Different aspects of social networks may prove particularly important for adaptation. Moser suggests that greater attention be paid to understanding the «social dynamics that underpin (motivate, facilitate, constrain) on-the-ground adaptation strategies and actions» in decision making institutions, and specifically to address the «value judgements and power dynamics embedded in adaptation decisions» (Moser, 2008: 188). Jennings similarly draws attention to «historically embedded and implicit power relations» and in particular notes the failure of indigenous or local environmental knowledge to penetrate bureaucratic ways of knowing (2008: 141).

Ultimately, any local or NGO led action, however positive, can be undone by a policy environment that is outright hostile to or simply lacks a focus on marginalised or poor communities. Moser summarises her discussion of decision making as a call to «stop hand waving about adaptive capacity and increase our understanding of, and our ability to use or create more effective governance structures to realise it.» (Moser, 2008: 189).

Networks of institutions, decision making bodies and governance structures must, then, be subject to analysis -who represents whom, with what knowledge, with what motives?- if the translation of adaptive capacity into adaptation is to be pro-poor. In reality the dynamics of knowledge creation and decision making are politicised and must be recognised as such. Techniques can be employed to support and embed these aspects of social network analysis. Coupe *et al*. (2005) describe **Practical Action's** use of farmers' juries in Zimbabwe to enable smallholder farmer learning on genetically modified crops through the production of witnesses for and against the technology. The same process enabled open and informed dialogue between farmers and senior government and Zimbabwe Farmers' Union (ZFU) officials, revealing major shortcomings in existing smallholder farmer policies and the deep dissatisfaction of farmers with how their interests were being represented by the ZFU. Alternatively, the use of on farm research circumvents power holders by enabling farmers, rather than outsiders, to decide on the best crop varieties for their lands.

1.3. Conclusion: Social networks, knowledge and adaptation

Table 1 summarises the three elements of adaptation, of which adaptive capacity and resilience have been focused on in this chapter. Social networks are the binding glue between many of the elements of adaptive capacity and resilience. They draw attention to the relationships between actors, and can be visualised as a web of connections that link diverse individuals and institutions, either directly or via other actors. For example, a household may be connected to other families in a village, a producers' association, a school, and a political party.

In turn, each of these actors has relationships with other parties that the household is able to indirectly access. The nature of these relationships will determine the household's knowledge of adaptation options, and its ability to send or receive goods, services and influence across the network. In this way, the analysis of social networks reveals a complex structure that governs the flow of material and nonmaterial resources: the connections describe the access that different actors have to each other, whilst each link draws attention to the quality of relationships (including social, political, cultural and economic resonances and barriers) and the interests or motives of the different actors.

Table 1. Approaches to adaptation

Approach	Comments
Vulnerability reduction	Vulnerability to climate change is assessed in reference to a particular hazard (for example vulnerability to flooding, considers underlying human and environmental factors) Vulnerability reduction targets a particular hazard, and should aim to be 'no regrets': meeting short term needs whilst addressing potential climate change
Strengthening resilience	Defined as the ability to absorb shocks or ride out changes Reduces vulnerability to a wide range of hazards Supported by diversity of assets or livelihood strategies User input in decision making supports resilience by reducing the chance of damaging policy developments
Building adaptive capacity	Defined as the ability to shape, create or respond to change Strengthens resilience and reduces vulnerability to a wide range of hazards Amount, diversity and distribution of assets facilitates alternative strategies Requires information plus the capacity and opportunity to learn, experiment, innovate and make decisions

Policy measures can limit or extend the reach of networks through, for example, setting the rules and norms that govern institutions, and controlling the freedom to form new relationships. However, individuals are also important and the skills held by community members play a role in defining access to and activities in a network. Education in particular can underpin decision making, interpreting information, and leadership potential. Literacy in particular can be important.

NGOs can be a crucial part of a household or community's network, bringing knowledge, ideas, experiences and resources from the outside. Significantly, NGOs are also able to stimulate the growth of local networks by building contacts and relationships between previously unconnected actors, and by building the local capacity to interact with and access different actors and networks.

Opportunities, lessons and resources for adaptation are accessed through social networks, often via indirect relationships (for example, through policy influence). Whilst the ability to access and interpret climate change information is influenced by levels of education in particular, the information itself is mediated through social networks. The proportion of the currently available climate change knowledge that reaches a community will be defined by its social network, as will the complexity, accuracy and relevance of the information received.

Working through networks can therefore improve access to climate knowledge in two ways: through extending the networks so that connections are built with holders of climate knowledge; or by exerting influence through the network to generate climate information that is more closely related to the lives and livelihood strategies of the community. Existing climate knowledge that is relevant but unknown to the community will (if it comes to pass) manifest itself as an (avoidable) shock: increasing the extent or relevance of climate knowledge thus reduces the possibility of these shocks.


¡Soy la amenaza del mundo!
¿Estás prevenido?

2 Climate Change Adaptation: Cold and Heat in the Andes

Climate change is one of the biggest problems facing our planet today. The consequences of climate change are already being felt across the globe and there is an urgent need for drastic reductions in green house gases emissions which are a major contributing factor to global warming.

Climate change affects local ecosystems, and predominantly those in which vulnerable populations live. Increased frequency and intensity of extreme weather events, prolonged drought and processes of desertification, longer periods of heavy rainfall and increased risk of flooding are just some of the impacts of climate change affecting the world's poorest populations. In addition to a global response to climate change, local solutions to micro-climate changes are now required. Mitigation and adaptation measures which help reduce the vulnerability of poor communities to the new climatic scenarios they face are vital components of the global climate change agenda.

2.1. Problem Statement

It is important to differentiate between the different types of problems related to climate at a global level:

- Global change: the combination of current environmental, social, economic and cultural transformations. Environmental problems cannot be separated from these other dimensions which constantly interact and impact on one another. Global change also incorporates changes in natural cycles of matter (carbon, oxygen, water etc.) and energy
- Global warming: a phenomenon involving rises in the average temperatures of the Earth's atmosphere and oceans resulting from burning of fossil fuels
- Climate change: attributed directly to human activities that alter the composition of the atmosphere on the one hand and the planet's natural cycles on the other, climate change relates to statistically relevant alterations in average climate conditions over tens of years

For over four billion years the Earth has experienced a huge number of significant changes in its climate. Although the average global temperature has only ever varied five or six degrees between one climatic period and another, these changes have led to the disappearance of entire ecosystems and mass extinctions of animal and plant life. Explanations regarding these cyclical climate alterations have evolved over time and continue to be a subject of discussion. However, confirmation from the world's top scientists that human actions are a key contributing factor to climate change has been one of the most important evolutions in this debate.

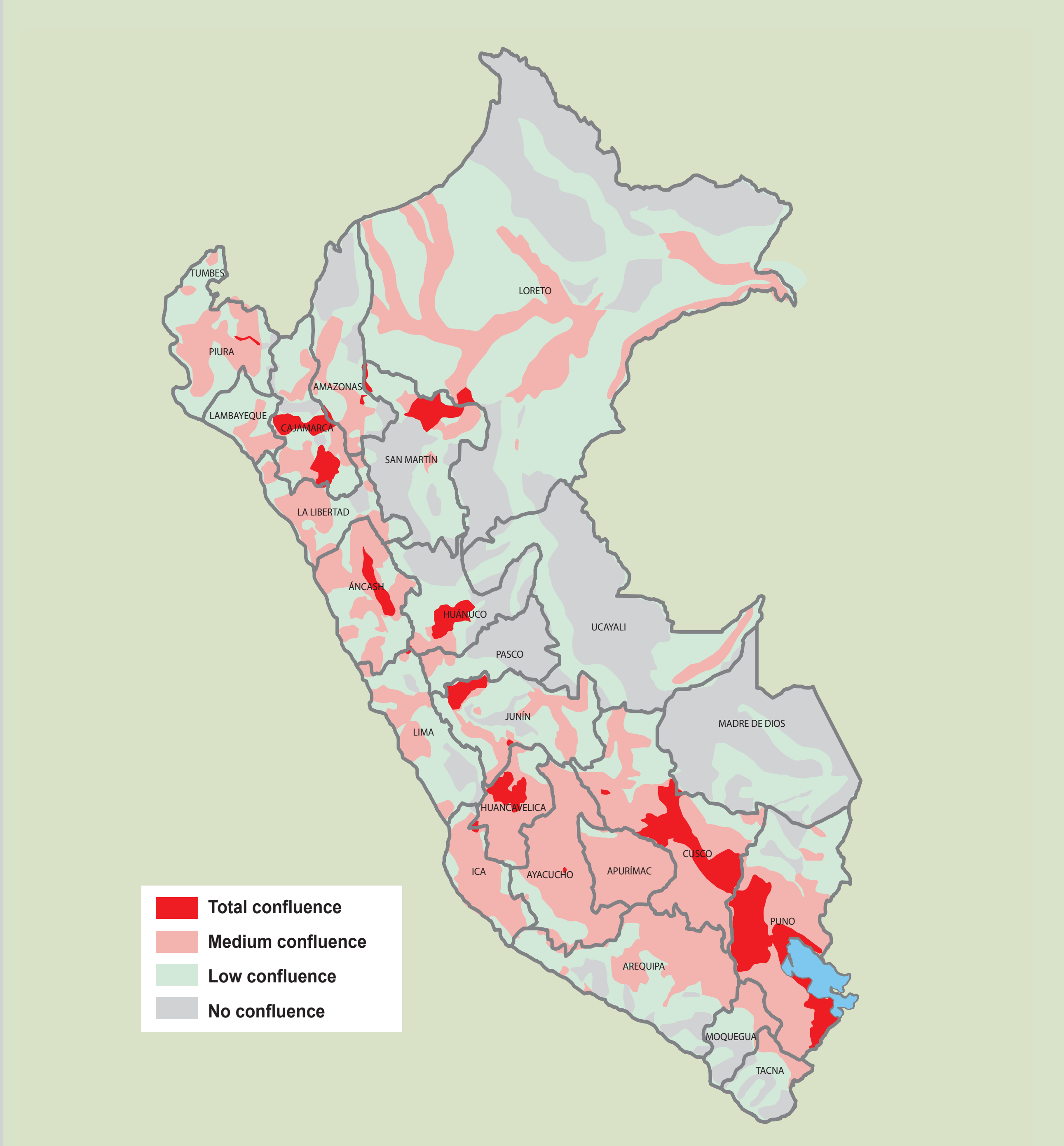
The earliest evidence of climate alterations caused by mankind was presented at the first World Climate Conference held in Geneva in 1979. In 1992, the United Nations Framework Convention on Climate Change was published, setting out the urgent need to reduce global warming and put in please measures to tackle inevitable increases in temperature. In 1997, world leaders included an appendix to the Convention, known as the Kyoto Protocol, which contains legally binding greenhouse gas emissions reductions targets. This agreement entered into force in February 2005.

In Latin America, climate change is negatively impacting on water resources, agriculture, ecosystems –particularly biodiversity and forests–, coastal regions and urban areas where water management is a key issue. Increasing temperatures are causing glaciers to retreat and hydrological cycles to alter, reducing the productivity of crops and biodiversity of plants and animals in forest and marine areas, increasing occurrence and altering the distribution of plant animal and human plagues and diseases, disturbing ocean currents and fish stocks, causing more frequent and intense extreme weather events and loss of farm land to flooding.

In Peru, climate change is characterized in terms of two key impacts: i) retreating glaciers, which have reduced by a total of 22% in the last 30 years restricting water supply in coastal and highland regions by around 7 million cubic metres of water, and ii) the El Niño phenomenon, fluctuations in surface water temperature of the Pacific Ocean which impact on atmospheric cycles leading to both heavy rains and droughts. The El Niño Phenomenon has shown high variations of intensity during the last decades, magnifying the impacts of climate change. However, research has at present failed to identify whether climate change is responsible for changes to the magnitude or frequency of the El Niño Phenomenon.

The principal climactic hazards in Peru are both man-made and natural. Natural hazard (including desertification) are the result of changing weather conditions –droughts, heavy rainfall, frosts and hailstorms and hailstones– and of human activities, such as the poor management of natural resources and large contaminating industries, in particular mining activities over recent years **(see figure 1).**

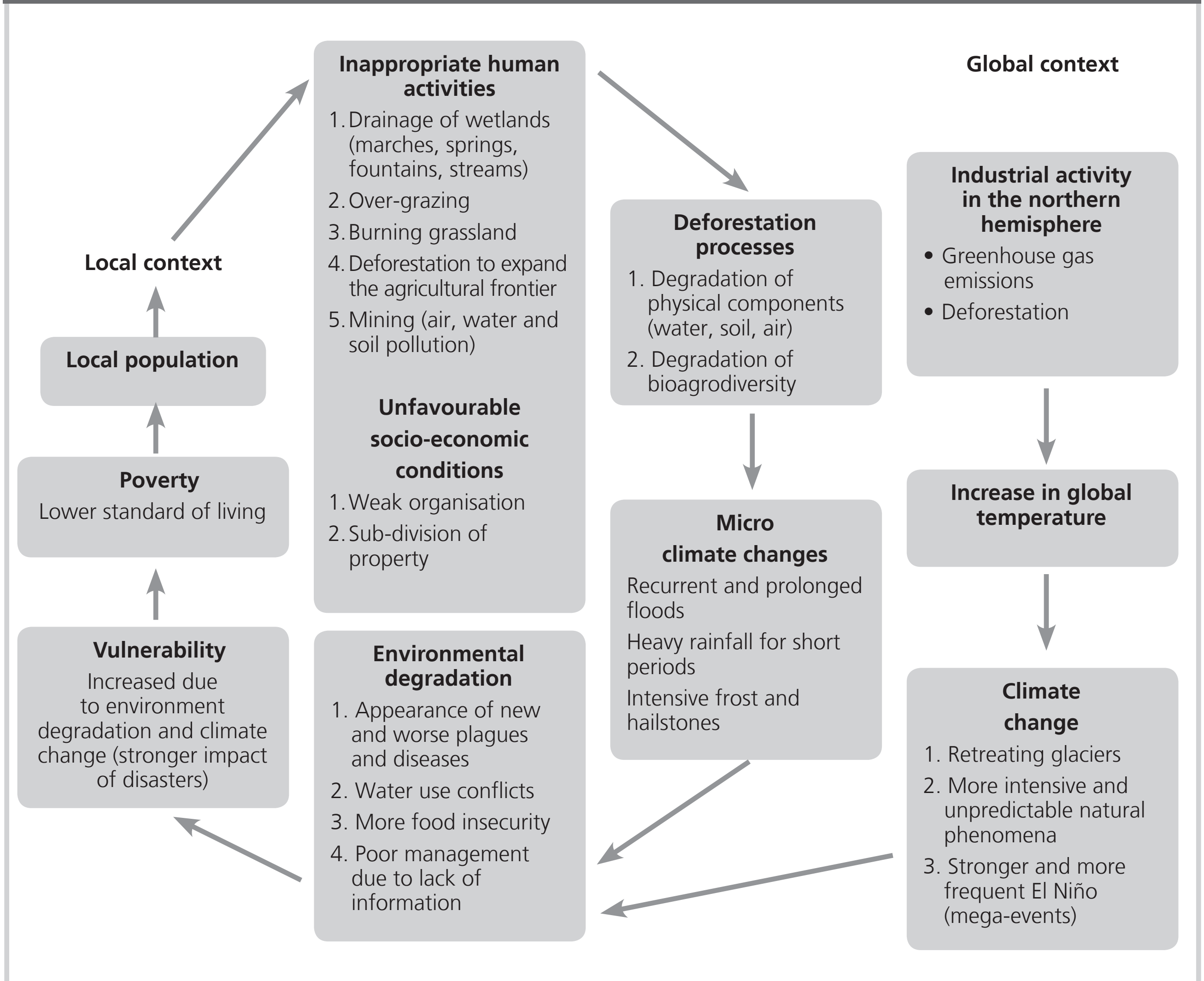
Figure 1. Map of climatic hazards, biodiversity, desert encroachment and poverty in Peru



In addition to environmental hazards, Peru is also a socially vulnerable country. A large proportion of the population lives in conditions of poverty and find their livelihoods severely affected by climate change (especially farmers), the majority of towns are situated in arid areas and are thus prone to water shortages and adaptive capacity to extreme phenomena is very low because people neither have the information nor the resources to do so.

Risks associated with the hazards and vulnerabilities described above increase in fragile ecosystems with a limited resistance to climate change, and particularly in areas where local populations have low capacity for disaster prevention and mitigation **(see figure 2).**

Figure 2. Variability and climate change in the tropical Andean mountain ecosystems of Peru. The local problem



Changes in local weather conditions are considered a working circumstance rather than a problem. In Peru, the climate possesses unique characteristics defined by the Andes mountain range, a large tropical mountainous ecosystem in which extreme meteorological events like droughts, snowstorms and freezing weather conditions occur regularly and persistently.

The relationship between Andean cultures and climate variability is not new. For over 5,000 years, communities living in the Andes have demonstrated an ability to adapt to the changing environment around them. Nevertheless, these communities must now face up to a new challenge: man-made climate change. **Practical Action** believes that Andean people are well placed to adapt to this challenge given that over thousands of years they have incorporated prevention and adaptation techniques into traditional social organisation and technology practices in response to observed climate phenomena. Despite the passage of time, Andean communities still take note of changes in the climate using traditional indicators **(see boxes 1 and 2).**

Box 1. "The climate is changing…"

This changing climate has also driven some animals away. For example, snakes have disappeared, lizards are missing, water frogs are missing, farm frogs are missing, 'pichaco' birds – things are not like they used to be. Now there are a lot of rats and plenty of flies. It looks as though there may be no water at any time. We are ready and waiting, we are already experimenting. Now then, if we wait until there is no water first before we start thinking of what to do, then we are not doing too well.

Leoncio Támara Leando, age 76 (Áncash)

In Peru, the process of raising public awareness regarding the dangers of climate change officially began in 1993, with the creation of the National Climate Change Commission (known by its initials in Spanish as CNCC). The key purpose of the CNCC is to coordinate the nationwide application and regulation of international agreements on climate change. In 2001, the CNCC prepared the first national communication regarding climate change and established the national climate change strategy, which considers the state of greenhouse gas emissions and mitigation actions and proposes climate change adaptation initiatives.

At a regional level, strategies are geared towards investigating levels of vulnerability to climate change and incorporating adaptation measures into regional policies and development plans. Regional governments are also encouraged to raise the awareness of their populations regarding the risks and global causes of climate change.

2.2. Micro-climate Changes and Desert Encroachment

One of the characteristic traits of mountain ecosystems is the large number of micro- climates and, consequently, large variety of soils and lifestyles, forming very fragile landscapes prone to desert encroachment processes.

Desert encroachment is caused by a number of farming practices, such as the expansion of agricultural frontiers (farmlands) in areas unsuitable for farming, over-grazing, drainage of wetlands, burning grassland and deforestation. Combined with global climate change, these practices are the cause of imminent changes in the climate at a local level. Testimonies from *campesinos* (peasant farmers) substantiate that climate variability in Andean micro-basins has been occurring since the seventies and that the difference between cold and hot temperatures has never been as great as at present. This has led to the coining of an expression in Quechua[2] *chirimanta ruphaymanta*: the cold and heat of the Andes.

These changes in climate could have been predicted but due to a lack of awareness, concern and relevant studies, they were detected too late when global climate change and alterations in local ecosystems had already occurred. Furthermore, while the scientific community was concentrating on solving global problems, local populations were suffering the local effects **(see box 2).**

Box 2. "The climate is changing…" (II)

The climate that most affects us is the heat, and the community cannot protect itself from that. Before there was a snow-capped mountain we could see, called Cceccera Loma; now it isn't there, the temperature has made it disappear. Large towns are the cause of this change. In large cities there are many factories that harm our sky and that is affecting us a lot, in addition to the cars and the trucks, the smoke they release smells bad and that is affecting us.

Before this area was colder, the alpaca used to grow well here, but now that it is hotter, it is not so good, alpacas like the cold. We never used to grow eucalyptus trees, now they grow well. It is more like the climate in the valley.

Eusebio León Huantura, age 45 (Cusco)

2.3. Objective

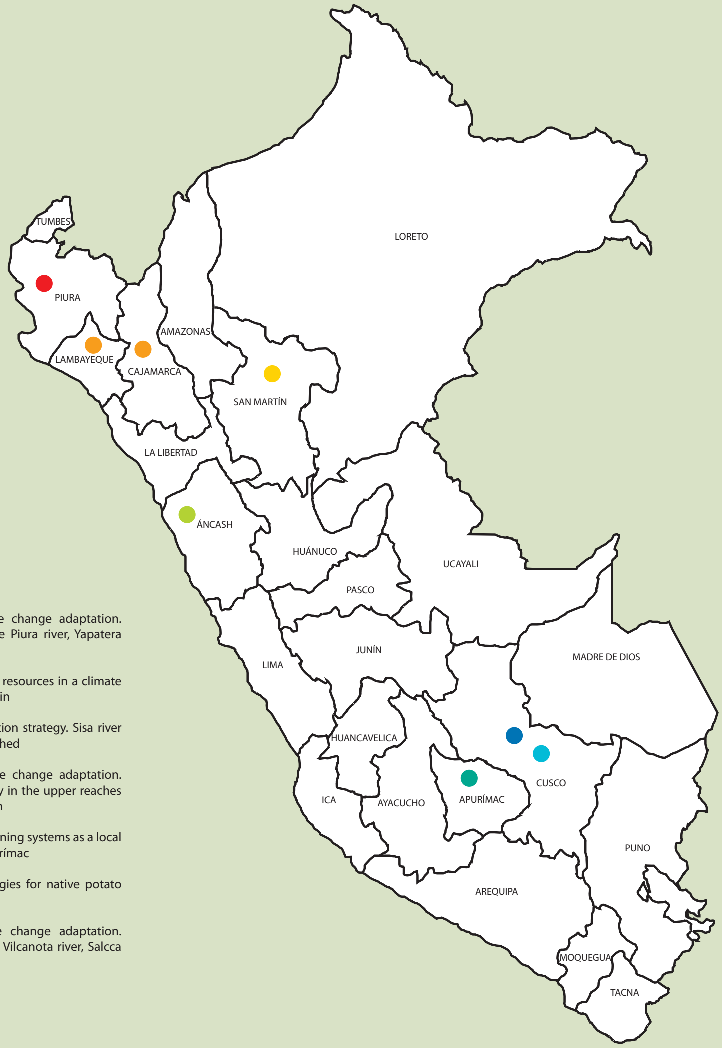
In recognition of the local dimensions of climate change in Peru, **Practical Action's** project *Climate Change Adaptation and Mitigation Technologies* was designed to propose and test technology, information, social organisation and conflict management strategies for climate change adaptation in tropical mountainous ecosystems, particularly focussed on Andean highland populations.

2.4. Methodology

The work took place in seven locations within three mountainous ecosystems in Peru: i) the inter-Andean valleys (Cajamarca, Áncash, Apurímac and Cusco); ii) the western slopes (Piura and Lambayeque), and; iii) the eastern slopes (San Martín). **Figure 3** shows the project locations and **figure 4** shows a cross-section of the distribution of the working areas.

2 Quechua is a native South American language spoken extensively throughout rural populations in Peru.

Figure 3. Location of the projects



1. Rural populations and their climate change adaptation. Capacity-building. Upper reaches of the Piura river, Yapatera sub-basin

2. Management of conflicts over natural resources in a climate change scenario. Jequetepeque river basin

3. Agro-forestry. Climate change adaptation strategy. Sisa river basin, middle of the Huallaga river watershed

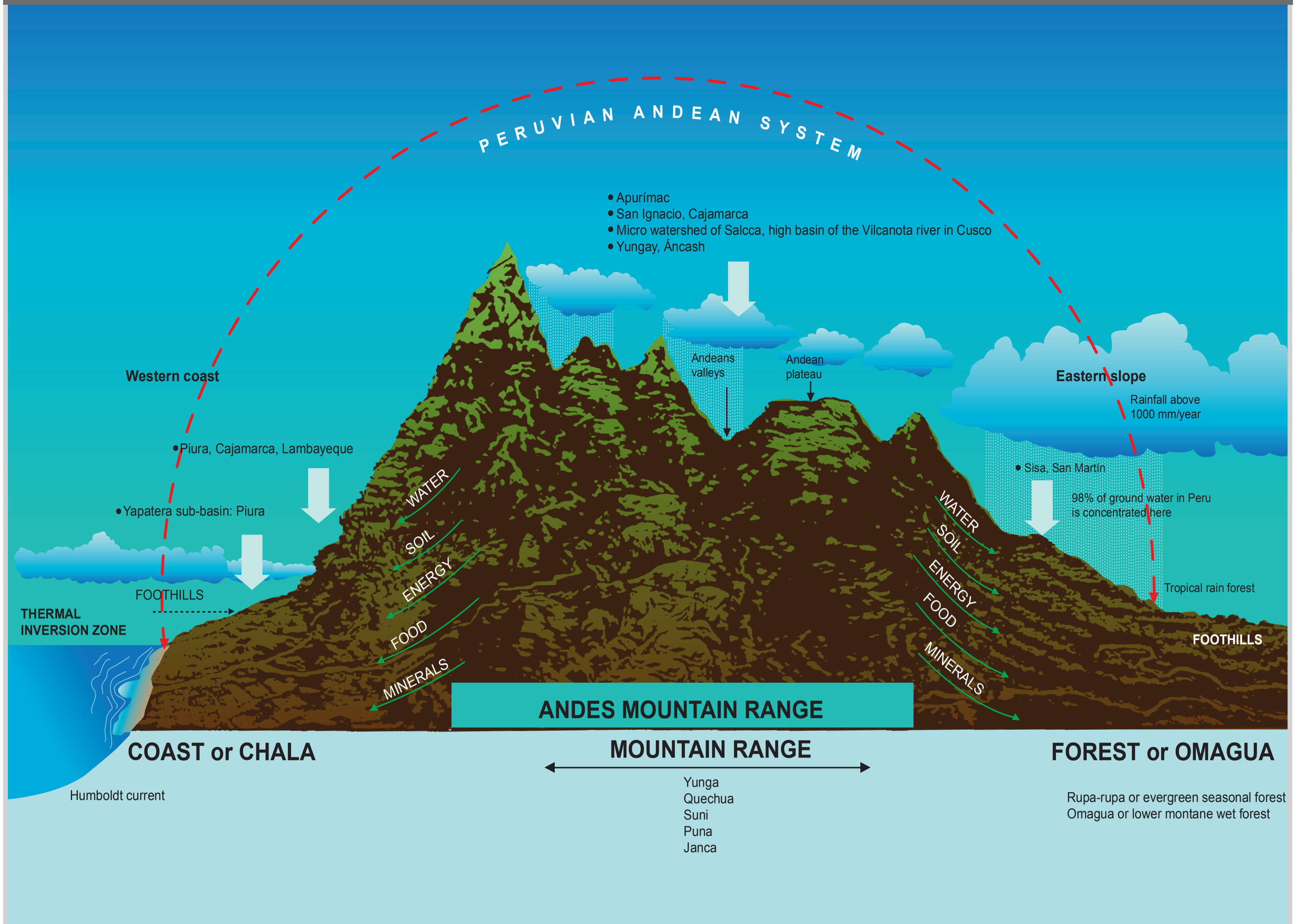
4. Rural communities and their climate change adaptation. Capacity-building to reduce vulnerability in the upper reaches of the Santa river, Santo Toribio sub-basin

5. Proposals of information and early warning systems as a local climate change adaptation strategy. Apurímac

6. Climate change adaptation technologies for native potato crops in high mountain ecosystems

7. Alpaca-raising families and climate change adaptation. Capacity-building. Upper reaches of the Vilcanota river, Salcca micro-basin

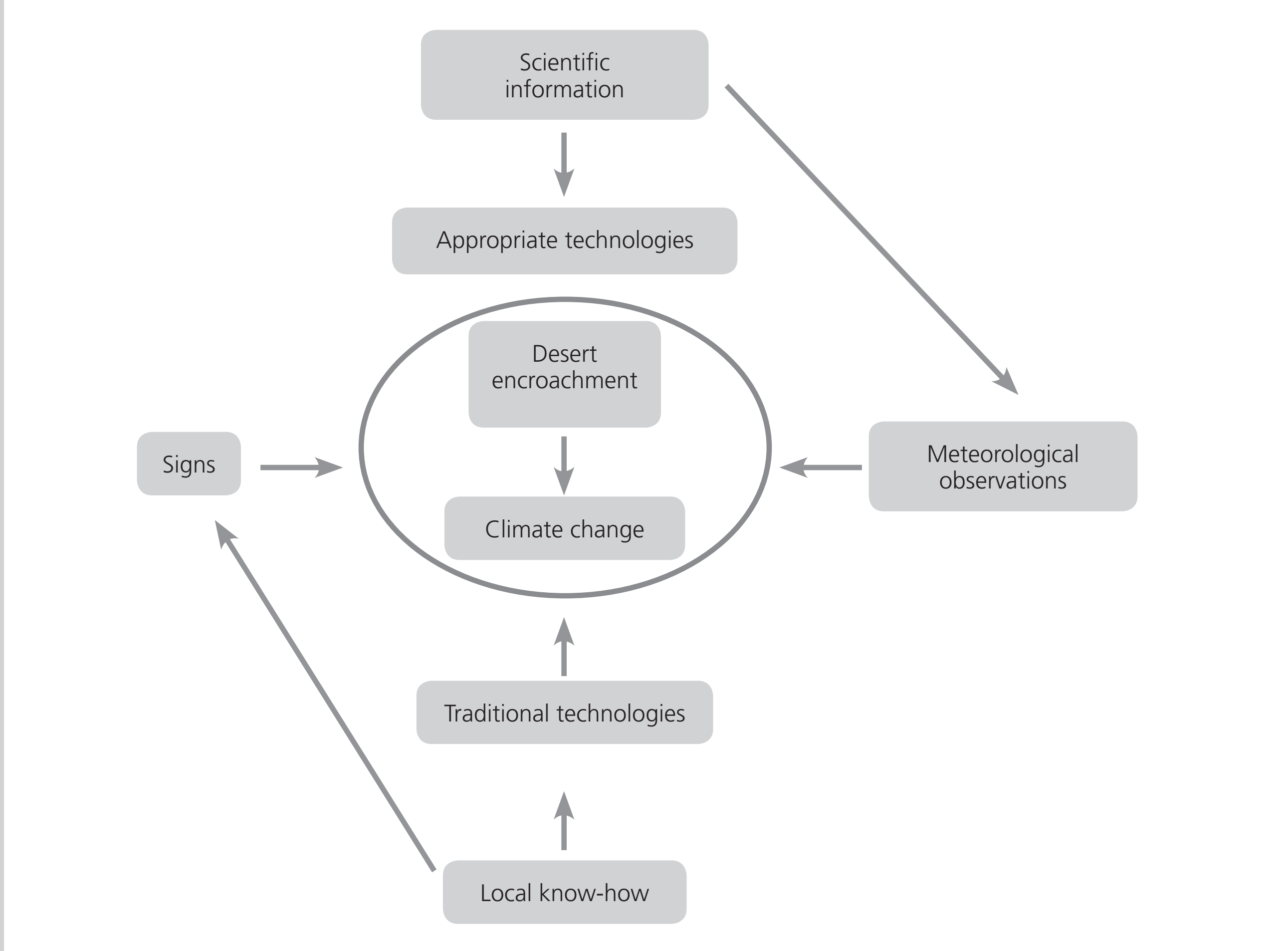
Figure 4. Climate change and adaptation in Peru. Location of working areas



The projects proposed the development of appropriate technologies for climate change adaptation in seven areas within the tropical Andes mountain ecosystems. Although these are unique, they share characteristics with other mountainous ecosystems around the globe. Consequently, the results and recommendations from these projects can be taken into consideration as a reference for interventions in neighbouring Andean countries (Ecuador, Colombia, Venezuela and Bolivia) as well as other mountainous countries (specifically in Meso-America, Africa and Asia).

The majority of rural communities involved in the project are members of Andean cultures, the exceptions being the agroforestry project with settlers in San Martín and the water management project with *mestizos* (people of European and native Peruvian descent) in Piura. Despite possessing great cultural and technological traditions, these populations have undergone cultural erosion processes over the centuries. Given these circumstances, the methodological approach to the project incorporated both scientific information and local knowledge **(see figure 5).**

Figure 5. Methodological approach



The work was carried out according to the methodology shown in **figure 5.** The following were the most important stages:

- Identification of the problem and preparation of work proposals
- Implementation of projects in partnership with local and regional networks and institutions
- Analysis and documentation of results, including expert discussions
- Production of qualitative and graphic models

2.5. Strategies

The global response to climate change consists of mitigation and adaptation strategies to reduce the causes of climate change and related phenomena and modify the livelihoods and means of sustenance of communities that are vulnerable to climate change. Mitigation activities are carried out mainly by countries in the northern hemisphere that have historically produced the most greenhouse gases (more than 90%), whereas countries in the southern hemisphere have contributed less than 10%. These activities have received much greater priority in global climate change negotiations to date, to the detriment of developing countries that are already suffering from the impacts of climate change and have fewer resources with which to develop adequate adaptation strategies.

The national climate change adaptation strategy proposed by the National Environment Council (known by its initials in Spanish, CONAM)[3] proposes incorporating adaptation into regional and state policies and development plans. According to this strategy, the state is responsible for protecting its citizens against the impacts of climate change and for establishing new laws regarding the environment. The national strategy includes the application of risk management strategies such as the improvement of climate observation systems, the drafting of a national research agenda for technological development and innovation, development of estimates and climate change scenarios. The end goal of these practices is to improve the country's management of resources and greenhouse gases without compromising its sustainable development progress.

In Peru, Government programmes are implemented in accordance with political divisions and income-based budgets in each region (including factors like productivity). This often means that the people most in need of support miss out. For the *Climate Change Adaptation and Mitigation Technologies* project, **Practical Action** prioritised locally based approaches and developed specific measures targeted at reducing the vulnerability of the poorest populations. One of the key benefits of community-based climate change adaptation actions is that knowledge and technologies can be transferred and adapted to the actual requirements of a particular population. The people most vulnerable to climate change can be identified and risks prioritized, based on the severity of potential impacts **(see box 3).**

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3 During the analysis and documentation of the projects, the Environment Ministry was created. It is anticipated that the National Climate Change Strategy will be revised in the near future. However, it is too soon to speculate what the new policies will be.

Box 3. Some conclusions regarding adaptation

- **The objective of climate change adaptation in developing countries should be to reduce the vulnerabilities of the poor**
- **The adaptation strategy must build up adaptation skills and improve resilience**
- **The objectives of adaptation policies and approaches must be distributed appropriately through participatory processes involving stakeholders at all levels**
- **The corner stones of the adaptation process are the strategies that combine risk management, livelihood diversification and a larger supply of assets to create more resistance, livelihood diversification, a larger supply and diversity of assets to enhance resilience, and the development of local adaptive capacity**
- **Adaptation must form part of development, both in terms of policies as well as the actions carried out by the communities**

Following the framework described in **chapter 1,** three basic concepts were incorporated into the design and implementation of **Practical Action's** climate change adaptation strategy:

1. Strengthening resilience through diversity management: The variety of climates, soils, biology and culture are some of the most important characteristics of Peruvian ecosystems. Embracing this diversity is a fundamental trait of development and planning efforts in Peru and entails a broach range of alternative approaches
2. Reducing vulnerability: In view of the uncertainty created by climate change in Peru, reducing the potential risks of droughts, floods, desert encroachment, food insecurity and conflicts over the use of natural resources, by means of planned, concerted, participatory and comprehensive processes is an essential tool to reduce vulnerability **(see box 4)**
3. Building adaptive capacity: Developing the capacities of Andean highland communities with respect to scientific and traditional climatic change indicators, technologies and social organisation is fundamental to successful climate change adaptation initiatives

Figure 6. Proposed local climate change adaptation strategy

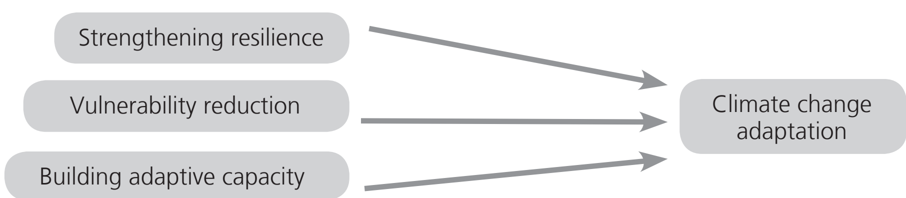


Table 2. Local climatic variability and climate change strategies				
Location	**Prioritized strategic areas**	**Components**	**Appropriate technologies**	
			Traditional	**Modern**
Yapatera sub-basin, upper reaches of the Piura river (Piura)	Training	Community	√	√
	Organisation	Local governments and civil society	√	√
	Technologies	Soil conservation and efficient use of water	√	√
	Information system	Ethno-climatic	√	√
Sisa river basin (San Martin)	Agroforestry	Forestry enhancement Organic production Climate	√	√
	Marketing	Entry in qualified external markets Entry in local markets Profitability	-	√
	Organisation	Improvement Integration in participatory budgets	Traditional organisations	Modern organisations
Santo Toribio sub-basin, middle of the Santa watershed (Ancash)	Water	Efficient irrigation	√	√
	Farming	Pest management	√	√
	Know-how	Climatic variability Water management Farming practices	√	√
	Organisation	User boards Leaders	Traditional organisations	Modern organisations
Salcca sub-basin, upper reaches of the Vilcanota (Cusco) Native potatoes	Research	Research to determine the tolerance to abiotic factors	-	√
	Conservation	Conservation of the biodiversity of native potatoes	√	√
	Training	Training on productive chain techniques	√	√
Salcca sub-basin, upper reaches of the Vilcanota (Cusco) Alpacas	Climate	Monitoring of and information on micro climatic changes	√	√
	Water	Organised use of water	√	√
	Pastures	Pasture management	√	√
	Alpacas	Alpaca health	√	√
	Organisation	Organisation	Traditional organisations	Modern organisations

Box 4. "The climate is changing…." (III)

My coffee farm is situated at 1600 m.a.s.l., surrounded by tall woodland which allows us to have fresh air during the day and heat on cool nights, it is a favourable climate for my plants. In 2007 we had less rain than in other years, my harvest dropped 20%; I would have earned more if my harvest had not diminished. What was beneficial for me this year was the good price.

The drought affected many low and middle parts; my house is in the lower part, where I have some citrus trees and cocoa crops recently installed; the majority of my seedlings died due to a shortage of water. I planted some more in November, but again some shoots died due to the frequent rain during the last three months of the year. My neighbours who have their coffee farms in the lower parts did very badly.

Jacinto Ruiz Guevara, age 54 (San Martín)

2.6. Results

The results were analyzed according to six criteria that were found to be significant across the different project sites: vulnerability, scenarios, local knowledge, adaptation measures, policies and a national agenda for rural areas.

a) Vulnerability

In the areas of work, populations are highly vulnerable due to social (poverty, exclusion etc.) and environmental factors (desertification, frosts, glacial retreat etc.). More frequent and extreme weather events and constant climate variability leaves people and their livelihoods highly exposed to climate risks and hazards. This has been made evident by events such as the El Niño phenomenon that severely affected a large percentage of the rural population in Peru.

b) Scenarios

Climate change scenarios predict an increase in the global average temperature. Based on this information, adaptation strategies were developed to help the population prepare for and adequately deal with extreme weather phenomena in the following stages: disaster preparation, actions during the event and the mitigation of its impacts once the event has concluded. Social organisation is a key factor to the success of disaster planning, prevention and response.

c) Local knowledge

Local knowledge based on folklore, myths and the history of Andean highland people is extremely valuable to the process of observing, recording and predicting changes in the local climate. However traditional know-how, which had been an adaptation instrument for centuries, has gone through a severe process of erosion during recent decades, resulting in a gradual loss of traditions, a decrease in the use of native languages, social exclusion and discrimination. Nevertheless, local knowledge can still contribute significantly to the risk management efforts. The added benefit of this approach is that the cultural heritage of the people involved is promoted and maintained.

d) Adaptation measures

Appropriate technologies are solutions that not necessarily include expensive modern techniques. Climate change adaptation in tropical Andean ecosystems is principally a question of adapting affordable and replicable technologies to local uses. Often these technologies are already available locally and require only slight adaptations to maximise their effectiveness.

Box 5. "The climate is changing…." (IV)

The Practical Action technicians have taught us a lot during the field days held in Chapichumo, here in the community and also in Palccoyo. There was participation in workshops on risks of hailstones and frost and my other mates participated in preparing the land, preparing biol, controlling plagues; that is how we learnt and we liked those subjects. Now we are organising ourselves to gather stubble to protect ourselves from hailstones. The best protection against hailstones and frost is to do it in an organised manner; when you try to defend yourself on your own it is not very effective; when we all protect ourselves it is better.

Eusebio León Umpiri, age 50 (Cusco)

It is important to clarify the relationship between diversity and risk reduction as part of the climate change adaptation proposals: with more diversity, there is less risk.

Table 3 shows the adaptation measures applied in all seven project areas.

The climate change adaptation model **(see figure 7)** is the result of the analysis of seven projects and over two years' work in seven areas of the tropical mountainous ecosystem in the Peruvian Andes. The model identifies adaptation measures that could be applicable in mountainous Andean ecosystems in the region (Colombia, Venezuela, Ecuador and Bolivia) as well as in other mountainous ecosystems of the world, including Meso-America, Ethiopia, Nepal, India, China and Tibet, amongst others.

e) Policies

There are two legal frameworks relating to climate change in Peru: i) the National Climate Change Strategy and ii) a Law specifying the environmental obligations and duties of local and regional governments **(see table 4).**

Regional climate change strategies dictate that regional governments should understand the level of vulnerability to climate change in their region and incorporate adaptation measures into policies and developments plans. Likewise regional governments should promote awareness amongst the population regarding the risks associated with climate change.

f) A national agenda for rural areas

Through working specifically with rural communities over the two years of this project, it is clear that a national agenda with a specific focus on rural areas is urgently required. This agenda should place an emphasis on themes of particular relevance to rural areas, such as sustainable natural resource management, watershed management, disaster management and food security.

Table 3. Adaptation measures implemented in the areas of involvement				
Location		Appropriate technologies	Adaptation measures	
Yapatera sub-basin, upper reaches of the Piura river (Piura)	Watershed management	√	Technologies	Water: irrigation and optimization Water storage and conveyance facilities Soil: management and conservation Alternative crops Pastures: efficient development of harvest waste Forests: management and forestry production
		-	Conflict management	Adequate management of water-related conflicts
		√	Information systems	Development of an ethno-dynamic information system based on bio-indicators
		-	Organisation	Through management committees and local governments, the local climate change adaptation strategy was established, which was validated with the approval of municipal authorities and development boards. Measures were prioritized and included in the participatory budget and finally, the strategy was incorporated into the concerted development plan Organisational structures already exist, such as the association of ecological producers, the association of livestock-raisers and the irrigation commission Awareness-raising and involvement of authorities and the population through workshops; subsequently, institutional links were established between local governments, grassroots organisations, local development boards, peasant patrols and Cepeser. At a regional level, an agreement was signed between the Piura regional government and Senamhi (peruvian meteorological system)for the integration of bio-meteorological stations in the Piura river early warning system
		-	Capacity-building	Community, formation of peasant promoters Capacity-building for poor rural populations
Sisa river basin (San Martín)	Watershed management	√	Agro-forestry technologies	Production: forest enhancement, pruning, live and dead barriers, recycling, organic production Post-harvest: gathering points
		√	Marketing	Cocoa: insertion in the domestic and international markets Coffee: insertion in the international market
		-	Organisation	Organisation of cocoa and coffee farmers Incorporation of individual farmers in associations and registration in public registries, forming committees acknowledged by local governments Coordination between committees and associations with local governments was achieved Training was provided on participatory budgets, accountability, local management and economic development
		-	Capacity-building	Development of technical and organisational skills of poor rural people

Location		Appropriate technologies	Adaptation measures	
Santo Toribio sub-basin, middle of the Santa watershed (Áncash)	Watershed management	√	Technologies: water and farming	Efficient irrigation Plague management Crop rotation
Santo Toribio sub-basin, middle of the Santa watershed (Áncash)	Watershed management	-	Organisation	Organisation established in the Cordillera Negra despite the lack of water Weak organisation in the Cordillera Blanca due to the inadequate water supply After the process and the project's experiences a climate change adaptation plan was proposed and incorporated into the development plans
Santo Toribio sub-basin, middle of the Santa watershed (Áncash)	Watershed management	-	Capacity-building	Capacity-building for rural communities Training on climatic variability, water management and farming practices Postgraduate climate change proposal
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	√	Technology	Conservation of the biodiversity of native potatoes
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	√	Research	Determine the tolerance to abiotic factors of native potato crops
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	-	Capacity-building	Through the climate change adaptation strategy, overall plague management
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	√	Technologies	Water: resource optimization, more availability, irrigation systems Pastures: Improvement, conservation and recovery Alpacas: health management, reproductive management
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	√	Information	Climate: monitoring climatic variability and climate change Local knowledge of the climate and early warning systems
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	-	Organisation	Training on the subject for local authorities Strengthening of producers' organisations, shepherds, peasant communities, communal enterprises and communal herds Participatory rural surveys were conducted Creation of community risk management committees
Salcca sub-basin, upper reaches of the Vilcanota (Cusco)	Watershed management	-	Capacity-building	Capacity-building for alpaca-raising families to reduce their vulnerability to climatic hazards
La Leche river basin (Lambayeque)	Watershed management	-	Conflict management	Adequate management of water-related conflicts
La Leche river basin (Lambayeque)	Watershed management	-	Capacity-building	Capacity-building for poor rural producers and their organisations, for adequate conflict-management purposes

Location		Appropriate technologies	Adaptation measures	
Upper reaches of the Jequetepeque river (Cajamarca)	Watershed management	-	Information systems	Information and early warning systems as a climate change adaptation strategy
		-	Conflict management	Adequate management of water-related conflicts
		-	Organización	Awareness-raising and involvement of authorities and the population through workshops, local institutional coordination between local governments and **Practical Action** At a watershed level, the information and early warning system was coordinated with the development coordinator of the Jequetepeque river basin by means of a commitment certificate guaranteeing the sustainability, monitoring and utilization of the system
		-	Capacity-building	Capacity-building for poor rural producers and their organisations, for adequate conflict-management purposes
Apurímac region	Watershed management	-	Information systems	Information and early warning systems as a climate change adaptation strategy
		-	Organisation	Awareness-raising and involvement of authorities and the population through workshops Since the beginning of the project, the implementation of a geographical information system was included in the economic-ecological zoning project developed by the regional natural resource and environment management The main institutional coordination mechanisms were geared towards including the Apurimac regional government in the process. The project participated actively in the technical groups on desert encroachment and economic-ecological zoning of the regional environment commission An inter-institutional cooperation agreement was signed with the regional civil defence committee in order to strengthen it and include droughts and desert encroachment into the regional disaster prevention and management plan

Figure 7. Qualitative climate change adaptation model

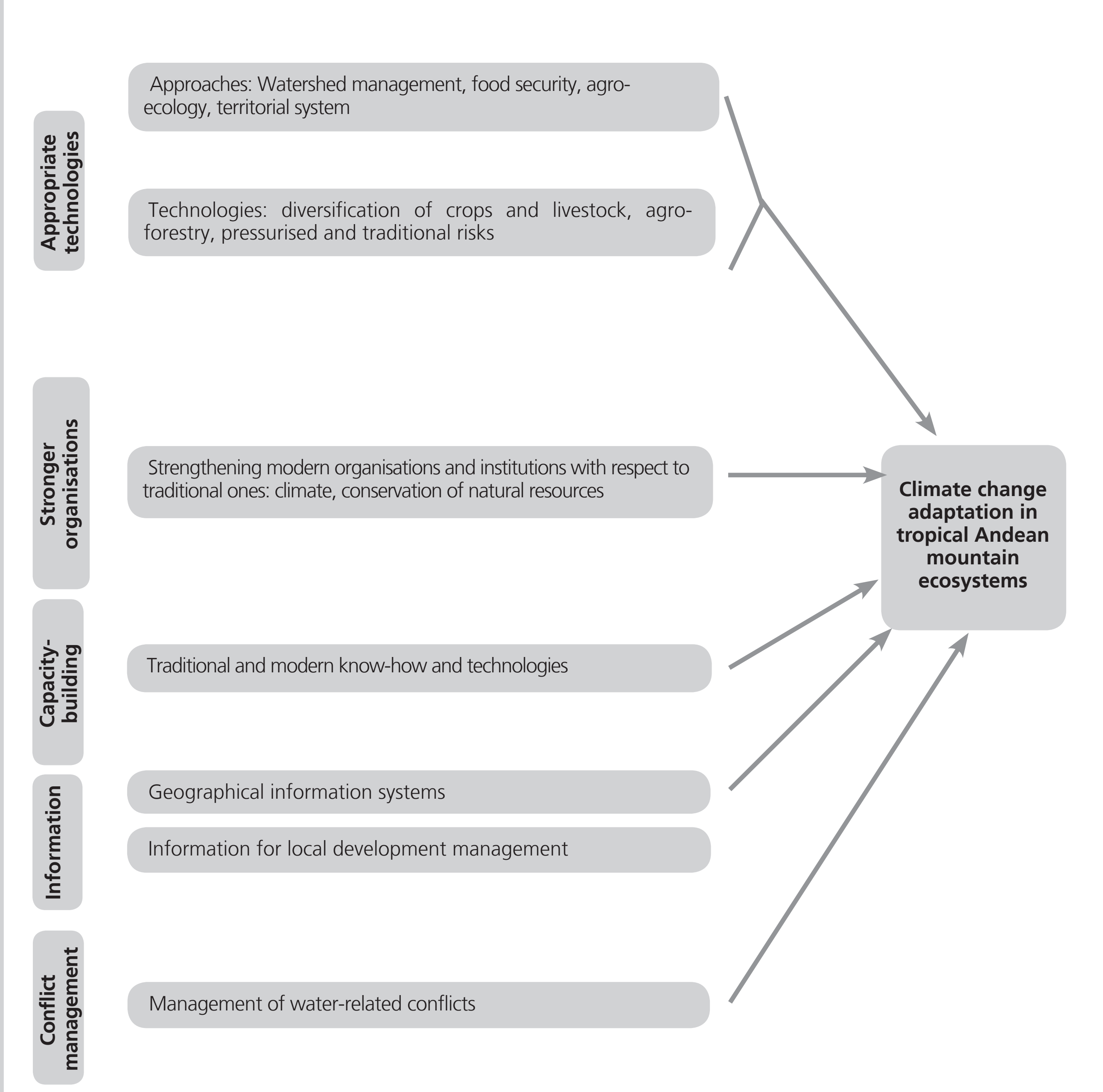


Table 4. Legal framework on climate change	
National climate change strategy. Supreme Decree No. 086.2003-PCM	Article 2; The enforcement of the "National Climate Change Strategy" is obligatory and must be included in the policies, plans and programmes of sectors and regions, in accordance with the provisions established in article 53, item c) of Law No. 27867, the Regional Governments Act and the institutional commitments established therein" 2nd Strategic Line: "Promote policies, measures and projects to develop the capacity to adapt to the effects of climate change and reduce vulnerability"
Regional Governments Act Law No. 27867	Article 53, item c): "Draw up, coordinate, conduct and supervise the application of regional strategies regarding the biological diversity and climate change, within the framework of the respective national strategies"

2.7. Conclusions and Recommendations

a) Conclusions

The following conclusions were reached regarding changes in micro-climates and adaptation technologies.

Micro-climatic changes

- In the mountainous ecosystem, desert encroachment is the main cause of micro- climatic changes
- Local Andean cultures have a 5,000 year-old tradition of adaptation to climatic variability. Therefore, the ability of these populations to adapt to the challenges of climate change is promising. However, given that rural communities are highly vulnerable in terms of social factors such as poverty and cultural erosion, the new climate change scenarios present serious risks to their survival

Adaptation technologies

- Existing traditional and modern technologies for coping with climate variability can be employed as climate change adaptation practices in tropical Andean mountain ecosystems
- Diversity management (increasing resilience), risk management (reducing vulnerability) and building adaptive capacity are fundamental factors for the development of a climate change adaptation strategy
- The management of conflicts related to the use of natural resources, especially water, via creation of social organisations and institutions is a key factor given the likely future water shortages in Peru
- With regards to technological climate change adaptation approaches, watershed management, territorial zoning, ecological farming, social organisation, training, information and early warning systems and conflict management have been most effective
- The technological adaptation measures promoted can be considered successful as they have increased production, do not contribute to desert encroachment, have promoted food security and income generation and are accepted by local populations
- Participatory information systems, meteorological stations, the identification of bio-indicators and signs and early warning systems are fundamental elements in the climate change adaptation process

In order to synthesize the conclusions, **Practical Action** has drawn up a national climate change adaptation agenda **(see box 6),** taking into consideration research aspects as well as climate change policies and dissemination, placing priority on inter-cultural education.

Approaches

- Watershed management
- Territorial zoning and ecological farming
- Food security
- Conflict management
- Organisation
- Training
- Agroforestry

Technologies

- Cultivation of diversified native species
- Breeding of diversified native species
- Sustainable use of natural resources (water, soil and biological diversity)
- Information and early warning systems

Box 6. National climate change agenda for Andean rural areas in Peru. Proposed topics

1. Capacity-building: climate change adaptation based on appropriate and traditional technologies in order to reduce the vulnerability of populations with low standards of living, along the following lines:

- a. Overall watershed management
- b. Management of the agro-biodiversity (vegetal and animal: on site conservation)
- c. Food security
- d. Risk management

2. Organisation and participation: strengthening traditional and contemporary organisations to deal with climate change, with the participation of local populations

3. Policies and institutionalism:

- a. At a regional level, implementation of existing regional provisions on climate change
- b. At a local level, inclusion of the climate change problem in participatory budgets and in local agendas in the long term
- c. Strengthen the institutions involved in climate change problems

4. Inter-cultural education:

- a. Knowledge about climate change from different cosmovisions
- b. Paradigmatic changes, a new relationship between nature and society
- c. Climate change in schools and higher education establishments

5. Research:

- a. Local climate and adaptation know-how
- b. Climatic research (differentiation between climatic variability and climate change, glaciers)
- c. Climatic scenarios
- d. Simulations
- e. Information and early warning systems
- f. Relationship between desert encroachment, biological diversity and climate change

6. Dissemination:

- a. Andean peasant farmers
- b. School and higher education students
- c. Teachers
- d. Technicians and scientists
- e. Leaders of local and regional governments and peasant communities
- f. Rural and urban populations

3 Native Potatoes Defying Climate Change

Native potatoes are one of Peru's most important crops. Not only in terms of the significant volume produced annually, but also due to high national consumption rates and the contribution native potato farming makes to the preservation of traditional practices. Indigenous varieties of potatoes domesticated by ancient Peruvians, who produced small volumes for local consumption purposes, are nowadays referred to as native potatoes. There are at least three thousand varieties of these ancestral potatoes still being grown in Peru. Native potatoes are grown on almost three hundred thousand hectares of land and around three million tons are produced per year, providing sustenance to upwards of 600 thousand families. Potatoes are the primary crop grown by highland peasant farmers, and as such constitute a key element of their staple diet and a main source of income. Peasant farmers use traditional sowing and harvesting practices, incorporating rituals and techniques that date back hundreds and perhaps even thousands of years.

The book *Native Potatoes Defying Climate Change* documents one of the seven projects implemented under **Practical Action's** *Climate Change Adaptation and Mitigation Technologies* initiative. The project was implemented in two areas of the Peruvian highlands –- the Yungay province in Áncash and Canchis in Cusco– with an approach that places priority on adapting agricultural farming systems the challenges and opportunities presented by climate change. The book provides an analysis of the relations between climate change, native potato cropping and peasant farmer poverty, and illustrates how vulnerability to climate change can be reduced in particular contexts. In recognition and celebration of International Potato Year in 2008, **Practical Action** used the publication to promote the conservation of and appreciation for native potato farming in Peru.

3.1. Introduction

The Andean region is traditionally a farming area, where over the centuries local people have developed ways of adapting to the changing weather conditions inherent to the multiple climate systems that exist. Nevertheless, during the last century, greater changes in weather conditions have occurred due to both natural cycles and climate change. These pose significant threats to the societies that depend on the use of natural resources, particularly farmers.

Increases in temperature are evident in events such as the rapid reduction of glaciers in high mountain areas and extreme climate conditions. Intense frosts and extended periods of drought are also now occurring more frequently. These changes threaten the ability of certain plant and animal species to adapt. Such is the case of native potatoes. Evidence now shows that potatoes previously grown in agroecosystems with moderate climates up to 3,600m above sea level can no longer survive at these heights due to increases in temperatures and changes in other climactic and agricultural conditions, such as rains and soil quality, in the lower Andean zones. In response, these potatoes have adapted naturally to the conditions of higher mountain areas and can now be cropped up to 3,800m above sea level.

The diversity of potato varieties in the high Andean mountains, particularly in Cusco, is providing food security and encouraging the use of ancestral know-how amongst rural populations. In potato farming communities, social structures are being reinforced through the sharing of crop-related rituals, symbols and practices, which in some cases provide valuable information such as ethno-meteorological indicators (natural weather forecast indicators) used to calculate sowing and harvesting times, the potential of cropping seasons, etc. Farmers also base weather predictions on plant growth, the appearance of crop diseases, animal behaviour, and astronomical observations.

This chapter summarizes the findings of the book *Native Potatoes Defying Climate Change* which provides and analysis of traditional and modern adaptation strategies to deal with climate change in native potato farms and Andean highland ecosystems.

3.2. Methodology

The project was implemented in two provinces between September and November 2007; in Yungay in the Department of Áncash, central Peru and Canchis in the Department of Cusco, southern Peru **(see figures 8 and 9).** Interviews were the primary sources of information gathered and **Practical Action** reports and publications were the secondary sources. The work in Canchis involved eleven potato farming communities in four districts: San Pablo, Combapata, Checaupe and Sicuani. The work in Yungay involved three districts where potato irrigation systems were installed: Shupluy, Yanama and Cascapara **(see tables 5 and 6).**

Figure 8. Location of the working area. Yungay

Figure 9. Location of the working area. Canchis

Table 5. Peasant communities involved in native potato actions. Canchis

Province	District	Community	Activity
Canchis	San Pablo	Santa Bárbara	Native potatoes
		Pata Tinta	Native potatoes
	Combapata	Paru Pata	Native potatoes
		Tiruma	Native potatoes
	Checacupe	Palccoyo	Native potatoes and alpacas
	Sicuani	Chapichumo	Native potatoes and alpacas
		Patacalasaya	Native potatoes and alpacas
		Pata Anza	Native potatoes and alpacas
		Accoacco Phalla	Native potatoes and alpacas
		Asociación Los Andes	Native potatoes and alpacas
		Condorsenca	Native potatoes and alpacas

Table 6. Communities involved in irrigation systems and potatoes. Yungay

Province	District	Community	Activity
Yungay	Shupluy	Supluy	Potato irrigation systems
	Yanama	Yanama	Potato irrigation systems
	Cascapara	Cascapara	Potato irrigation systems

Surveys were conducted in rural areas during which mainly qualitative information was sought from interviewees. The informants were selected based on their high ranking and leadership status in the area. In the majority of interviews, translations from Quechua to Spanish were required. The questionnaires were based on the following main topics:

- The effects of changing weather conditions attributed to climate change
- Evaluation of local response to disasters
- Relevance and replicable nature of technological adaptation solutions
- The contribution of local knowledge to adaptation efforts
- Potato production and management technologies

3.3. Adaptation Strategies

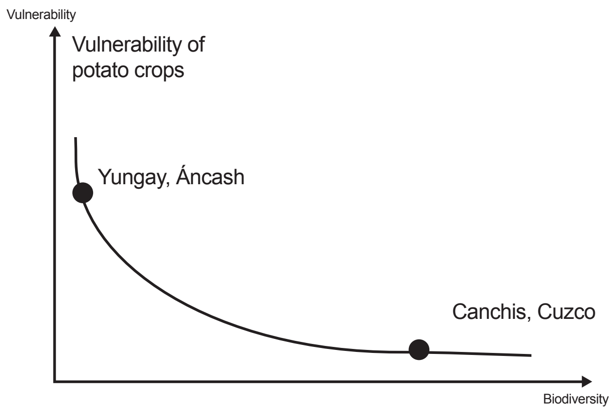
"As it will take years to recover all of the native varieties, potato farmers and their families treasure each and every one of the varieties they possess."

a. Biodiversity

These wonderful words were used by a local farmer to describe the importance of the biodiversity of native potatoes to the farmers who grow them. In the Andean region, the International Potato Centre (IPC) has catalogued more than four thousand species of potato, of which at least 2,500 are Peruvian crops grown in Andean highland communities. Some families grow as many as fifty varieties. This diversity is an important aspect of Andean highland culture and has become a crucial factor in both the economic survival and the identity of potato-farming communities. With a number of varieties at risk or considered lost, many farmers believe that the recovery of wild varieties is a fundamental task to the conservation of native potatoes in Peru.

The vulnerability of potato crops, i.e. their susceptibility to adverse weather events, is greater in Yungay where fewer varieties exist. Farmers typically grow between one and four mixed varieties in their plots, that is, a combination of improved (through selective breeding) and commercial native potatoes. The opposite occurs in Canchis, where farmers grow between 20 and 50 varieties per family. Of the provinces covered by the study, Canchis is the least vulnerable due to a greater genetic base or diversity of species **(see figure 10).**

Figure 10. Relationship between vulnerability and biodiversity in potato farms



b. Traditional knowledge

Local knowledge is used to identify varieties of native potatoes that can withstand factors like frost, droughts, hailstones, etc. Furthermore, traditional know-how is also useful for predicting future weather conditions –whether or not there will be regular or irregular rain, whether yield will be high or low, etc. The indicators most used by farmers are called *mayu lacco, ccotto, atocc wacca* and *mayu chuya* or *wallata*. Below are some testimonies from interviewed farmers:

> «…we look at the stars[4] [ccoto] in the sky on St. John's day (24th June). We have to look at them at about three o'clock in the morning; if the stars look dull or small it will not be a good year. Something else we look at is the *mayu chuya* [ducks]; these birds are born in August and by September they are out with their mothers, but they must be in pairs. When a single pair goes out it means it is not a good time to sow, so we have to delay the sowing season; when two or three pairs go out, however, it will be a good year with no problems. Another thing we look at is the *mayo lacco* [river weeds], that usually grow in the river. When these are burnt by frost it is not a good time to sow, so the sowing season must be delayed; however, if they continue growing normally and are not affected by the frost, it will be a good year. In August we also listen to the howling of the *atocc huacca* [fox]; when it is a short howl it means it will be a bad year but when it is a long howl that sounds like laughter, it will be a good year.»
>
> Viviana López Poma, *kamayoq* potato farmer

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4 The stars observed are the Pleiades star cluster.

Eusebio León Huantura, *kamayoq* potato farmer[5], compares ethno-meteorological signs. According to his testimony, in ancient times Peruvian ancestors[6] used many indicators to understand the climate and forecast changing weather conditions. These indicators have disappeared or have become unreliable, so there are very few useful ones remaining today **(see table 7).**

Table 7. Most useful indicators

Indicator	Date	Favourable production	Unfavourable production	Reliability
Mayo lacco or lacco (river weeds)	August to September	When they are a bright green colour it will be a good year and a normal sowing season	When they do not appear until the end of September and turn yellow as though burnt by frost, the sowing season will be delayed	Reliable, used frequently
Ccotto (star cluster)	June 13th for some, 24th for others	When the star clusters are large, particularly the first one, it will be a good year and a normal sowing season	When the star clusters are small, particularly the first group, it will be a bad year and the sowing season will be delayed.	Reliable, used frequently
Atocc waccac (crying fox, singing fox)	August to September	When it is a long howl that sounds like laughter, it will be a good year with normal rainfall	When it is a short unfinished howl it means it will be a bad year with irregular rainfall and low production	Used frequently, although it sometimes fails
Mayu chuya wallata (birds)	August to September	When a bird gives birth to four or more chicks in September, it will be a good or average year	When a bird gives birth to only two chicks, it will be a bad year with a low potato production	Reliable, used frequently

The use of these indicators has started to decline in some regions a result of cross-culturalism, that is a mixing of Andean and *criollo,* or *mestizo* (people from the coast with mixed European/Peruvian blood) cultures. Although Eusebio Leon Umpiri and his fellow *kamayoq* Domingo Nina Avanasocco assert that the fox howl is the surest sign of a good or bad farming season, they don't hesitate to add that "nevertheless, the fox sometimes fails".

In the city of Sicuani in Canchis, the Toribio Quispe Kamayoq School has developed an alternative training strategy. Between 1996 and 2005, two hundred *Kamayoq* extension farmers were trained, based on an extension farming model aimed at creating and disseminating technological innovations. Potato experts, or *Kamayoq* potato farmers, received training at workshops covering various subjects, including farm management techniques, potato crop plagues and diseases, preparation and use of organic fertilizers, pest control (Andean weevils and potato moths), soil preparation and conservation practices, categorisation of native potatoes, treatment of seeds, storage of native potatoes, processing and preparation of new dishes based on native potatoes, development of small native potato businesses.

Monthly reports made by school attendees served as an instrument to study and record the main plagues affecting native potatoes. The reports were also used as an adaptation tool to assist with the development of improved soil and organic fertilizer preparation practices. **Practical Action** used the reports to identify

5 The Kamayoq are experts in farming and the sustainable management of natural resources. During the Inca Empire they were experts in specialized techniques; nowadays they share technical know-how with rural populations of a Quechua origin.

6 Ancestors are considered to be extremely knowledgeable people of ancient times to whom events of extreme importance for the cosmogony of Andean people are attributed, such as the creation of the world, mankind, dominion over nature and magical powers. The term ancient is also used to refer to the ancestors of Andean communities.

which traditional indicators were most valid for predicting climactic conditions and extreme weather events and thereby reducing the negative impacts on potato crops.

3.4. Results

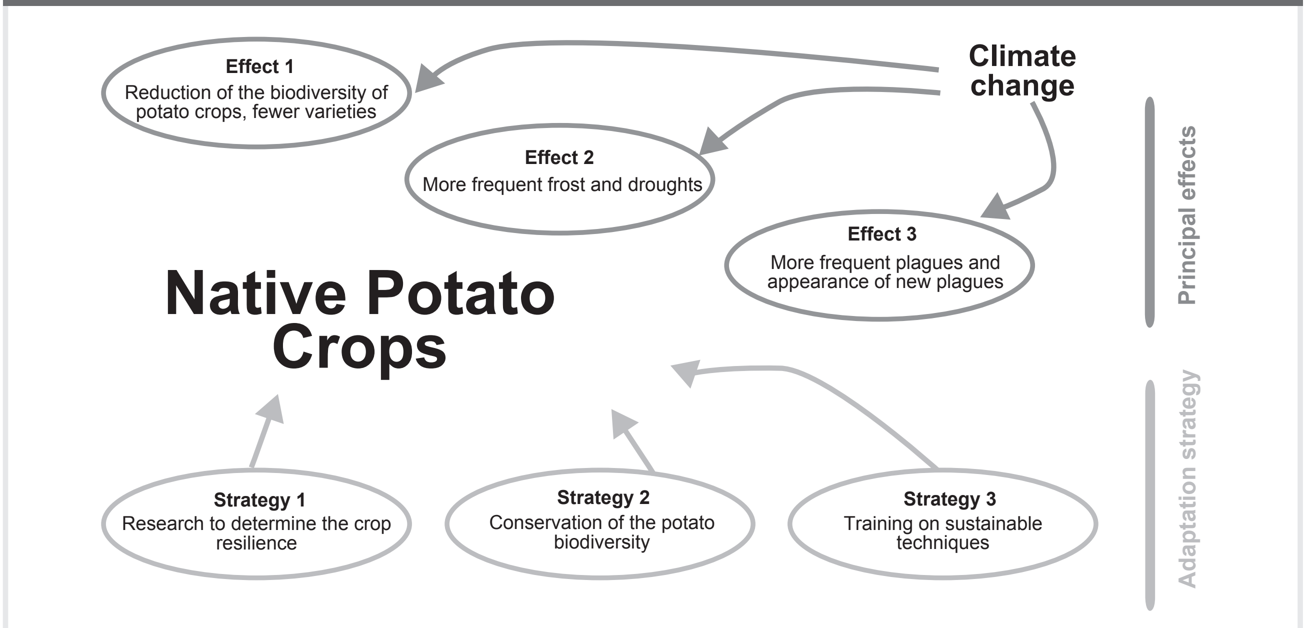
As a result of the evaluation process, the most serious impacts of climate change on potato farming communities were identified as: a) a reduction in biodiversity; b) an increase in crop losses due to more frequent and extreme climate phenomena; and c) an increase in number and severity of crop plagues. With respect to these impacts, **Practical Action** identified two possible future scenarios, one favourable and the other unfavourable.

In the unfavourable scenario, the biodiversity of native potatoes is severely reduced due to increasingly higher temperatures, more frequent frosts, hailstones and droughts, increased incidence and severity of plagues and diseases, resulting in a greater number of damaged crops. A reduction in the amount of potatoes available for household consumption directly affects the food security of thousands of rural families in Peru. A reduction in crop biodiversity results in a loss of local knowledge relating to certain species.

In the favourable scenario, native potato biodiversity is maintained via the successful application of plague management techniques. As a result, surplus crops are harvested, the use of traditional know-how is improved and access to new markets is gained, significantly reducing the vulnerability of rural communities to climate change.

Based on these possible scenarios, **Practical Action** proposed three adaptation strategies: a) research into the resilience of potato crops; b) efforts to preserve the biodiversity of potato crops; and c) technical training for peasants **(see figure 11).**

Figure 11. Climate change adaptation strategies for native potatoes



3.5. Conclusions and Recommendations

a. Conclusions

The main conclusion regarding the management of native potato crops is that their great biodiversity is maintained thanks to local knowledge that has been passed down from generation to generation. This is the most effective and important strategy for reducing the impact of extreme climate conditions on potato-farming communities. The use of weather and climate forecast indicators derived from local know-how is a system that can be captured and modified in order to help farmers adapt agricultural practices to climate change.

The use of the *Kamayoq* model regarding the dissemination of technologies that complement the know-how of local farmers with scientific data is also worthwhile. In Cusco, improved farming practices have lead to increases in yields. Since native potatoes are grown organically, higher production levels means that farmers organised into cooperatives are now accessing global organic markets and selling to Europe, Canada and the U.S. This has increased incomes and reduced poverty levels among Andean highland families.

b. Recommendations

Local knowledge must be considered as the basis of any intervention in Andean highland communities. Manifestations of this knowledge, such as ethno-meteorological indicators, have been practiced over thousands of years and explain the relationship between farmers and the ecosystem around them, including the domestication of many plants and animals. Information about native potatoes is a fundamental part of this knowledge.

Specifically, various lines of action are recommended:

- Establishment of networks on climate change and native potatoes varieties based on traditional knowledge
- Investigation into early warning systems and indicators should form part of the research work aimed at validating local know-how regarding weather forecasts
- Research into the ability of potato crops to withstand changing weather conditions
- Efforts should be made to replicate the technological adaptation strategies in other Andean highland areas, focusing on achieving food security for rural communities

4 Water Management and Climate Change

With a population of more than 60 thousand people, 40% of them living in rural areas, Yungay is one of the most earthquake-prone areas in Peru having suffered heavily from three major earthquakes over the last century. Yungay is extremely vulnerable to the impacts of climate change. The province is situated in the Cordillera Blanca mountain range, one of the main components of the tropical snow-capped Andes Mountains, and is the site where a number of important research initiatives are monitoring glacial behaviour.

Water Management and Climate Change describes one of the seven projects implemented under **Practical Action's** *Climate Change Adaptation and Mitigation Technologies* initiative. The project was implemented in the Yungay province of the Department of Áncash in Peru's central highlands. The book provides an analysis of the relationship between climate change and water management conflicts in the province and illustrates possible strategies to reduce the vulnerability of the local population to declining water supplies.

4.1. Introduction

Yungay is highly vulnerable province due a combination of social, economic and environmental factors. Statistically, Yungay has a low Human Development Index (0.453)[7]. Farming is the main economic activity and the principal crops are corn, potatoes, wheat, barley, vegetables and grasses. The cultivation of fruit such as avocados and peaches has also begun increasing recently. Local agricultural practices are characterized by inefficient irrigation, soil erosion, excessive land use leading to poor soil quality, inappropriate and indiscriminate use of chemical fertilizers, insecticides and pesticides; expansion of the agrarian frontier (farm land) without environmental conservation methods, and out-of-date crop management processes. Furthermore, traditional knowledge is gradually disappearing from farming activities, due to the cross-culturalism amongst younger generations, who also possess little knowledge of modern crop management techniques.

7 The Human Development Index is published annually by the United Nations Development Programme and is based on life expectancy, literacy, education attainment and GDP per capita. Source: United Nations Development Programme. www.pnud.org.pe. Data retrieved from the 2002 National Census.

Table 8 shows the social and economic factors that increase the vulnerability ratio.

Table 8. Socio-economic vulnerability factors	
Component	**Vulnerability**
Physical-infrastructural	Precarious and deteriorated constructions: canals, highways, housing, medical posts Limited service infrastructure (reservoirs, canals) Dangerous location of infrastructure Limited technical knowledge of safe housing construction methods
Technological	Low level of and costly access to crop production techniques (fertilization and irrigation) Low quality of fertilizers (farmers say they have been deceived, fertilizers don't work and crops don't yield) Family fertilization techniques are not very technical Animals are badly fed and not vaccinated Water loss during irrigation Inadequate treatment of plagues Weak crops susceptible to plagues and diseases Rustic crops with no standard sowing plan; they grow the same crops or the most profitable ones Lack of knowledge of soil quality for housing construction purposes
Socio-cultural	Weak organisation ("in the past, people were more organized and accomplished") Limited risk-awareness ("we felt we could do nothing about climate change, we were caught unawares") Limited access to information and lack of risk-awareness Lack of food security and health
Economic-financial	Low income rate and poverty Lack of coordination and participation mechanisms High cost of fertilizers Low prices paid for products
Institutional-political	Little support from authorities Authorities are not familiar with climate change and its impacts on the population

Surrounded by a large number of snow-capped mountains, detached ice flows, overflows, landslides, mudflows and flooding all occur frequently in Yungay. Of the 24 Departments in Peru, Áncash is the most vulnerable and within it, Yungay is the province with the most vulnerability factors: high slopes, steep cliffs, pollution, a gradual depletion of water, weak and contaminated soils, and damaged infrastructure. In addition, climate change is having a particularly harmful effect. Since the seventies, glacier retreat has been affecting water supply on the eastern slopes of the central Andes **(see table 9).** Over the last thirty years glacier mass in the region has reduced by around 30% resulting in the loss of water reservoirs that are essential for farming, not only in the upper reaches of the Santa River, but also for irrigation projects in arid lands on the Peruvian coast. The potential for social conflicts in the province has risen dramatically during the same period.

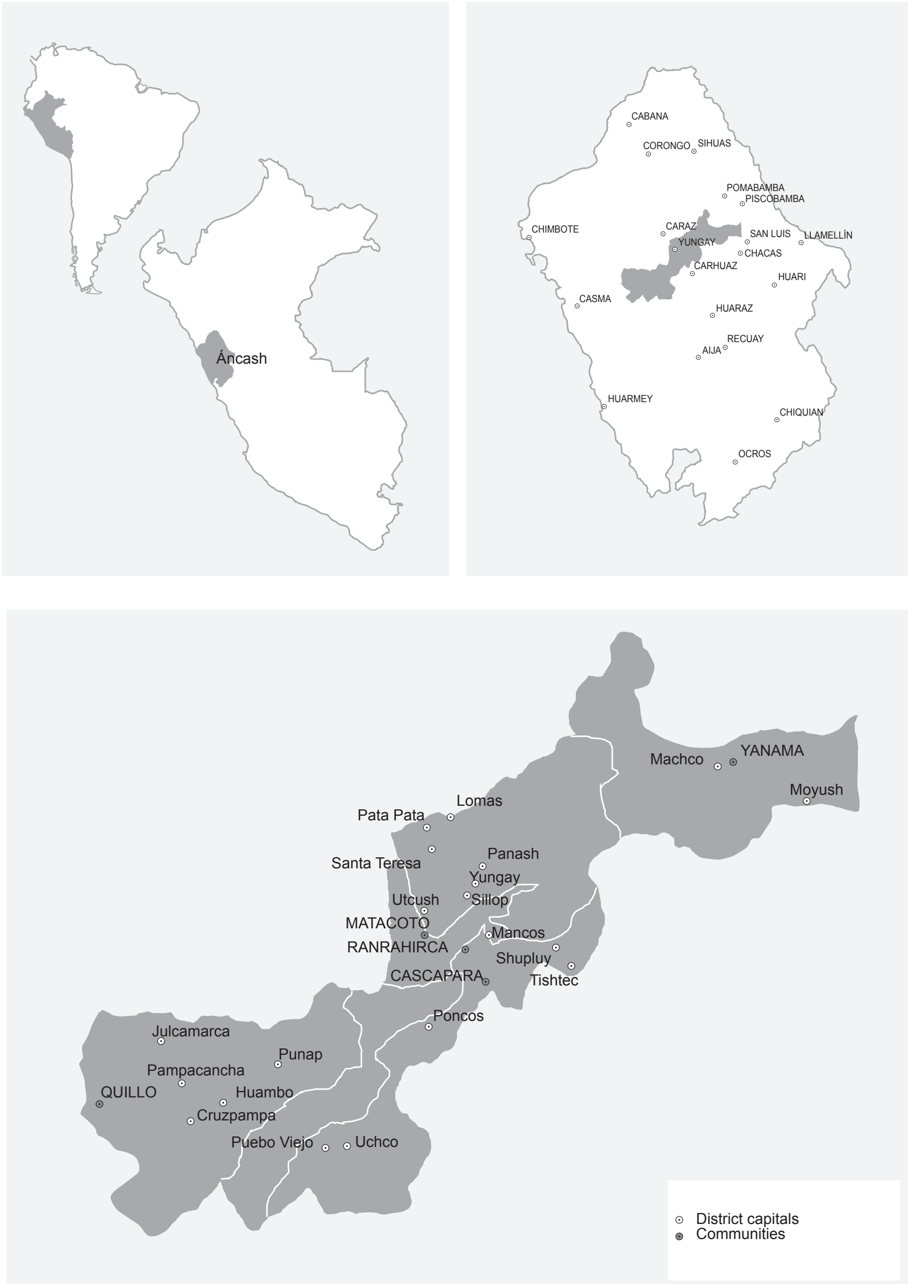
Other impacts of climate change include the appearance of opportunistic species (rodents and disease-transmitting insects) which has been one of the principal causes of the recurrence of tropical diseases that had been considered eradicated for several decades.

The most vulnerable populations are hit hardest by the negative impacts of climate change. In the case of Yungay, it is the rural communities who, in addition to their habitual struggle against poverty, are forced to adapt their livelihoods to cope with the effects of climate change. The objective of **Practical Action's** *Watershed Management and Climate Change* project was to identify ways in which rural communities in Yungay can improve their capacity to respond to the challenges presented by climate change with a focus on improving watershed management practices in the Santa River basin. This chapter summarizes the findings of that project.

4.2. Methodology

The study area covered the Santo Toribio basin in the upper reaches of the Santa River, including Yungay Province **(see figure 12).**

Figure 12. Location of the project area. Yungay



Twelve project sites were identified in the Yungay, Mancos, Ranrahirca, Shupluy and Cascapara districts. These districts are divided into three different geographical areas: the Cordillera Blanca, the Cordillera Negra and the Marañón river basin **(see table 9).**

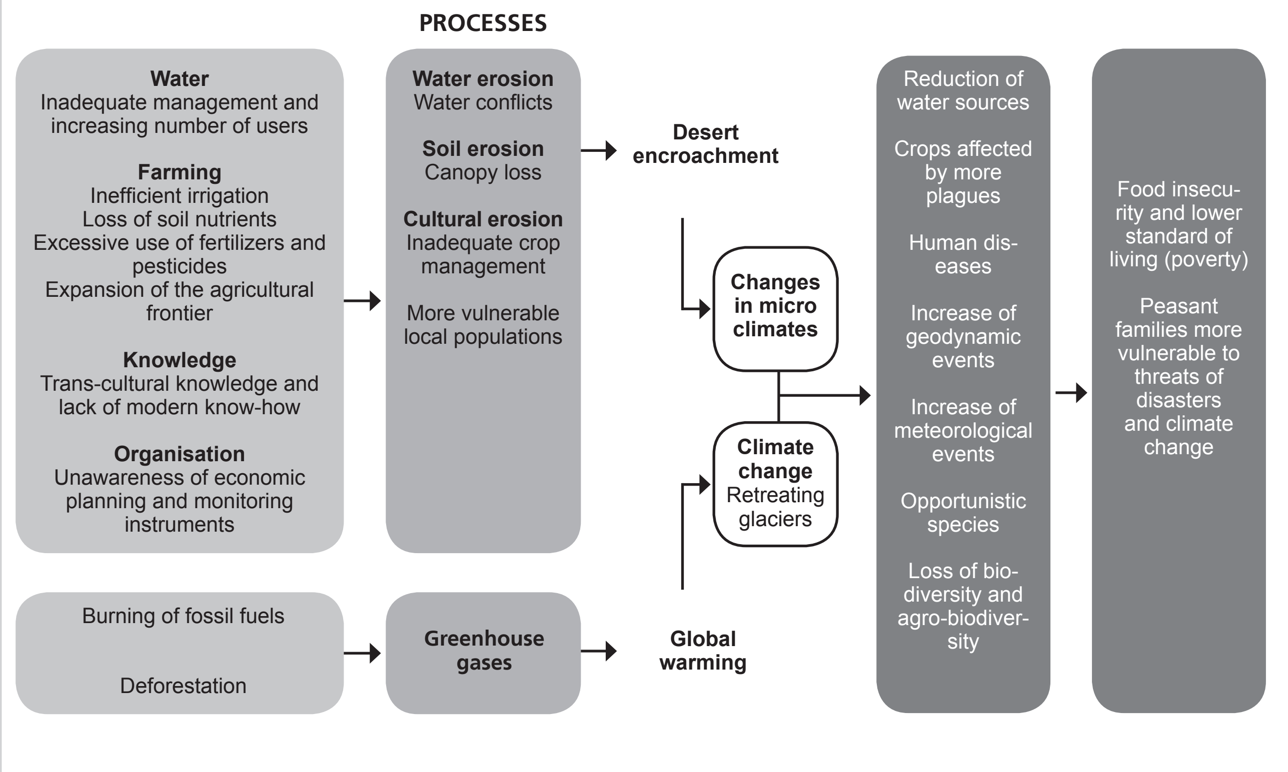
Table 9. Areas and population within the scope of the project

District	Area	Territorial classification	Houses		Population
			1993	1999	1993
Yungay	Yungay	Town	170	288	759
Ranrahirca	Arhuay, Encayoc, Independencia, Cajapampa	Settlements near the Acrarano canal	253	438	951
Mancos	Yanamito, Huashcao	Settlements near the Ulta Huascarán canal	415	376	1 339
Cascapara-Shupluy	San Damián	Peasant community	45	55	152
	Anta(1)	Settlement	61	60	212
Yanama	Ocshajirca, Llanlla	Neighbourhood on the outskirts of Yanama, organized based on the use of water from a branch of the Matcaj-Yanama canal	90	90	450
Total			**1 034**	**1 307**	**3 863**

(1) The information on Anta and Ocshajirca is estimated.

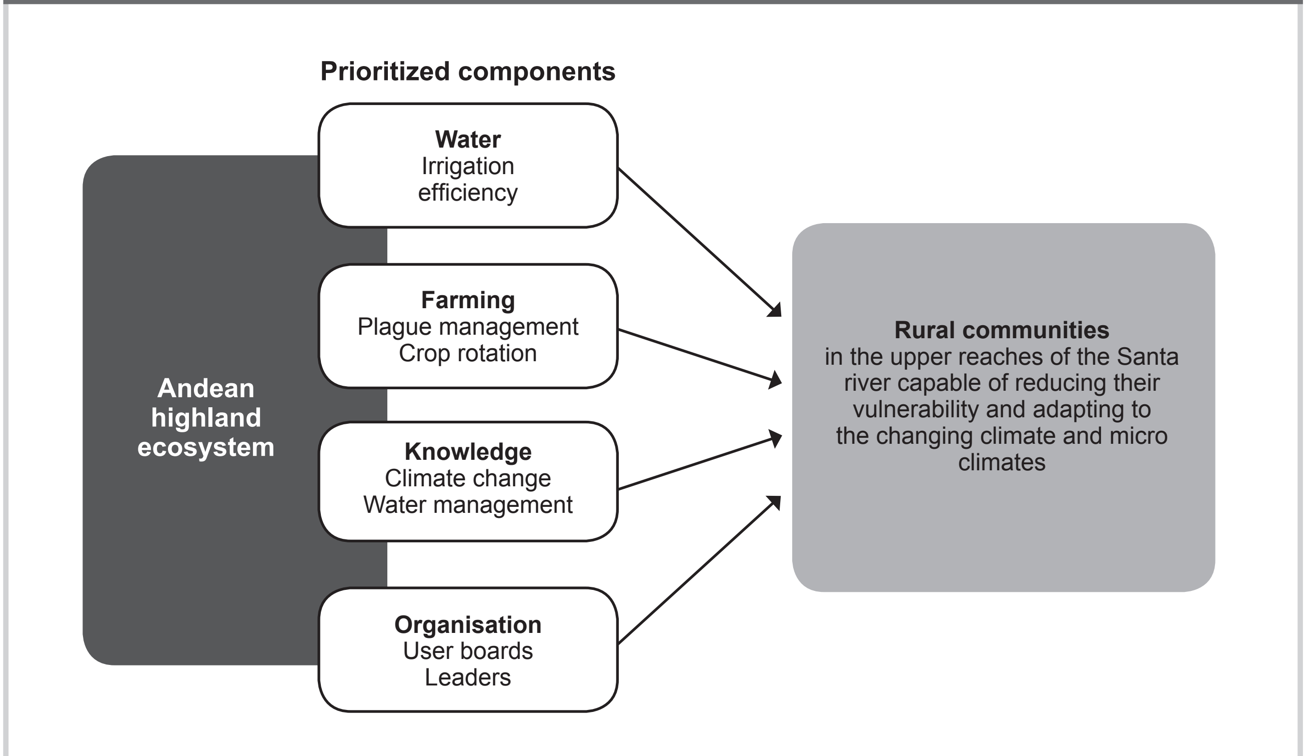
An overview of the problem is illustrated in **figure 13.**

Figure 13. Description of the problem



Components prioritized during the implementation of the project are shown in **figure 14:**

Figure 14. Capacity-building in rural communities of the Santo Toribio sub-basin



The variables studied in each project site were the duration, occurrence and intensity of extreme climate phenomena, plagues, droughts, retreating glaciers, vector-transmitted diseases, the impact of ultraviolet rays on the local population and the displacement of opportunistic species like rats, mosquitoes and cockroaches.

The research consisted of the following stages of work:

- Workshops with the target communities (including community leaders, Community-Based Organisations and local government representatives) to identify potential areas for intervention and key actors, gain an understanding of community perceptions of climate change, and identify vulnerable elements in social organisations
- Working with farmers to formulate adaptation Action Plans
- Introduction of appropriate technologies for improved agricultural practices and water use
- Implementation of test plots for pressure irrigation and disease monitoring
- Water and crop management knowledge transfer courses
- Interviews with farmers to evaluate potato production processes
- Studies into the impacts of climate change on crop diversity and water resources
- Defining and validating adaptation measures
- Lobbying local government to incorporate adaptation strategies into local development plans

4.3. Adaptation Strategies

The proposed climate change adaptation strategies are divided into four components: water, farming, knowledge and social organisation.

a) Water

Water is a key element for agricultural development and the resource most affected by climate change. The supply of water to the province is in constant decline due to the gradual disappearance of glacier masses and the misuse of water resulting from inefficient irrigation techniques. Improved water management is therefore critical to climate change adaptation efforts and encompasses improved efficiency in irrigation and management of local demand for water.

b) Farming

Increases in temperatures leading to more frequent incidences of crop diseases and plagues have resulted in indiscriminate use of chemical fertilizers, insecticides and pesticides by farmers motivated by purely commercial reasons. In collaboration with the National Service of Agrarian Health (SENASA), the Centre for Development and Participation Studies (CEDEP) and the National University of Ancash, **Practical Action** held workshops to train farmers in ecological pest management techniques.

c) Knowledge

Although over the years farmers have adapted their practices to changing weather conditions, there is a clear need to improve and update knowledge of basic farming techniques. In order to obtain quantitative data on changes in rainfall and temperature, farmers were equipped with small meteorological stations in order to record this information on a daily basis. Combined with scientific data, the information collected contributes to a more comprehensive understanding of local climate variability.

d) Social organisation

Organisation of communities into committees is a key strategy to water management as it enables water users make unified decisions and exercise greater influence on local government with regards to demand for and use of water supplies.

4.4. Results

Information regarding how people perceive the risks they are exposed to was compiled from workshops, testimonies and interviews. As shown in **table 10,** people remember events that had a significant impact on their lives, to the extent that there is a testimonial register of events that have occurred since the 1960s.

Table 10. Significant climatic events

Gender	Event	Year	Perception of event	Areas affected
Men	Torrential rain and hailstones	1965	Ruined the sowing season	Poncos, Ocshpachán
	Freezing weather conditions	1997	Burnt the crops	Bellavista, Primorpampa
	Heavy rain between January and March	1997	Destroyed roads, schools and farmland	Casacapara, Shupluy
	Shortage of rain	2004-2005	Affected the sowing season	The entire sub-basin
	Plagues of rats and mosquitoes	2004	Destroyed the crops	The entire sub-basin
Women	Prolonged drought	Antes de 1970	Shortage of water	The entire Cordillera Negra
	Drought between November and March	1989	Poor harvest and no sowing	The entire Cordillera Negra
	Heavy rain and hailstones	1995	Transport was impossible	Steep slopes
	Strong drought	2004	Springs and streams disappeared	Spring-fed farmland

The testimonies provided an insight into whether people were really aware of climate change. A survey determined that people were aware of the seasonal nature and characteristics of rain, that the rainy season in this province is between December and April (as it occurs throughout the Peruvian highlands), and that freezing weather conditions and average temperatures change according to the seasons. The two sectors most vulnerable to climate change impacts were identified as agriculture and livestock. The impacts of climate change on infrastructure, housing and health were also recognised.

As a result of the surveys, **Practical Action** proposed a number of adaptation measures to help Andean highland people reduce their vulnerability to climate change. Alterations to the farming calendar were accompanied by a group of secondary actions resulting from the need to reorganise farming practices based on the new climate and the new sowing seasons and included the construction of irrigation canals, improvement of existing irrigation systems and development of sustainable technology alternatives such as overhead irrigation. These actions were implemented as part of a community training programme on improved agricultural practices grounded in principles of environmental conservation. Although some traditional farming practices have contributed to community vulnerability to climate change, local observations of climatic events and changing weather patterns are key to adaptation processes.

4.5. Conclusions and Recommendations

a) Conclusions

Climate change adaptation implies building the capacity of the rural population in improved agricultural practices in order to reduce their vulnerability to current and future impacts. This implies monitoring and evaluation of existing techniques, as well as introduction of new technologies and social organisations to strengthen community participation in and influence over decision making processes concerned with water supply and demand.

Through the training workshops, community members have acquired basic knowledge of efficient water use practices and participated in the collection of information on water resources and changing temperatures.

Water supply has been improved with the construction of reservoirs, dams and irrigation canals. The local population is aware of decreasing water supplies and understands the requirements for improved irrigation systems which can save between one fifth and one tenth of the volume of water used with traditional methods. Although farmers indicated that at present there is sufficient water for their needs, rainfall is decreasing and the glaciers are rapidly retreating. Consequently urgent actions are required to manage water demand. Crop diversification will be essential if farmers are to adapt to reduced water supplies in the future.

b) Recommendations

Given the inevitable decline in water supply in the Yungay province, future projects should prioritise water conservation by minimising leakage and evaporation of water resources. To this end, it is recommended that water from the reservoirs be channelled through pipes rather than canals.

Irrigation companies are still undergoing water distribution problems. There is a pressing need to update water management practices of these institutions so that they can adequately deal with future water shortages.

The installation of irrigation systems should meet the following conditions to maximise benefits to the local populations:

- Priority should be placed on installing irrigations systems on communal land
- Irrigations systems should be affordable to the farmers
- Technological innovations are still required and will only be achieved through concerted efforts to conduct action research

In general, it is recommended that a territorial farming system be established for the entire Santa river basin.

5 Agroforestry: A Climate Change Adaptation Strategy

Over recent decades deforestation has become one of biggest threats to the Peruvian rainforest. National and international organisations estimate that around 125 million hectares of mountain rainforest have been cut down contributing to a gradual process of desertification. The expansion of the agricultural frontier, excessive felling and slash and burn practices in the forest for farming and livestock-raising purposes are the most destructive human activities in the eastern rainforest. San Martín, located on the eastern side of the mountainous Andean ecosystem, is characterised by heavy rainfall of more than 1,000 mm/per annum, thin soil and a large forest canopy that covers craggy slopes containing the greatest concentration biological diversity in the country. The local peasant population is highly vulnerable because their primary source of income is small-scale cocoa and coffee farming which is being threatened desert encroachment processes and changes in water cycles.

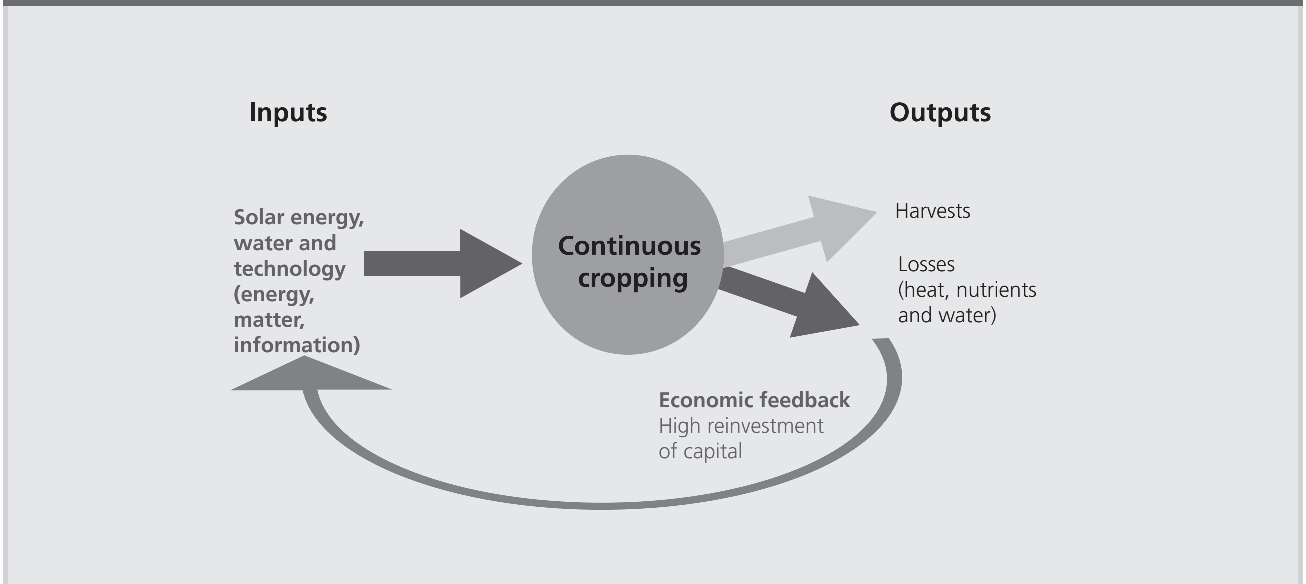
Agroforestry: A Climate Change Adaptation Strategy describes one of the seven projects implemented under **Practical Action's** *Climate Change Adaptation and Mitigation Technologies* initiative. The project was implemented in the El Dorado province of the Department of San Martín in the northern Peruvian rainforest. The book provides an analysis of the relationship between climate change, continuous cropping and poverty in the region and proposes agroforesty as strategy to increase crop productivity, promote environmental conservation and secure higher incomes for local farmers.

5.1. Introduction

Recent studies into changing weather conditions conclude that the climate in the San Martín region is influenced by both the Atlantic and Pacific Oceans. The Pacific Ocean undergoes natural changes in surface temperature of around 2-3ºC which manifest into warm and cold cycles, known as *El Niño* and *La Niña* respectively (and the *El Niño Phenomenon* combined). The impacts of these cycles include extended heavy rainfall, droughts and extreme weather events. Studies show that during the El Niño Phenomenon, water shortages reach up to 90% in some areas of the upper rainforest in Peru, whereas in the lower central rainforest shortages have been recorded at around 60%. During the same periods, droughts occur on the northern coast of Peru. The San Martín region is particularly vulnerable to declining rainfall during years affected by the El Niño Phenomenon which is further aggravated by the effects of climate change. These factors mean it is difficult to make predictions about the behaviour of the water cycle and the availability of water resources.

The climate the San Martín region is characterized by rain and humidity all year round, with temperatures varying between 22 and 34º C. El Dorado is one of the most biodiverse regions in Peru due to its varied climate and rugged topography. It is also one of the most deforested regions, in which indiscriminate felling is aggravated by the migration of new farmers from the highlands, whose farming and livestock-raising practices include continuous cropping of corn, excessive farming, and burning of grasslands. Rather than recover the natural elements produced by the forest (nutrients, crops and water), the continuous cropping system involves constant production without any allowance for soil renewal. Once the land has been fully exploited of its resources, making natural regeneration impossible, the operation is repeated on a new plot of land **(see figure 15).**

Figure 15. How a continuous cropping system works



The Sisa river basin in the El Dorado province is fundamentally a corn and cotton growing area. However, these crops are not indigenous to tropical mountain ecosystems. Large swathes of precipitous land (between 20 and 30%) have been cleared to make way for commercial corn and cotton plantations and without the trees to capture the water, heavy rainfall washes important minerals out of the soils leading to deterioration in soil quality and ultimately crop failure. These processes are generating changes in local climate conditions of watersheds in the higher rainforest area (*rupa rupa*) and in the valleys of the eastern slopes of the Andes. In addition, global climate change is causing both heavier rainfall and prolonged droughts in the region.

This chapter summarizes the findings of **Practical Action's** project *Agroforestry: A Climate Change Adaptation Strategy* which trained coffee and cocoa farmers in the Sisa river basin in sustainable forestry management and conversation techniques.

5.2. Methodology

The El Dorado province is located in the north of the San Martín region, covering an area of 1,298 km^2 and comprising the middle and upper courses of the Sisa river basin which ranges in altitude from 550 to 2,000m above sea level **(see figure 16).**

Figure 16. Location of the Sisa river basin

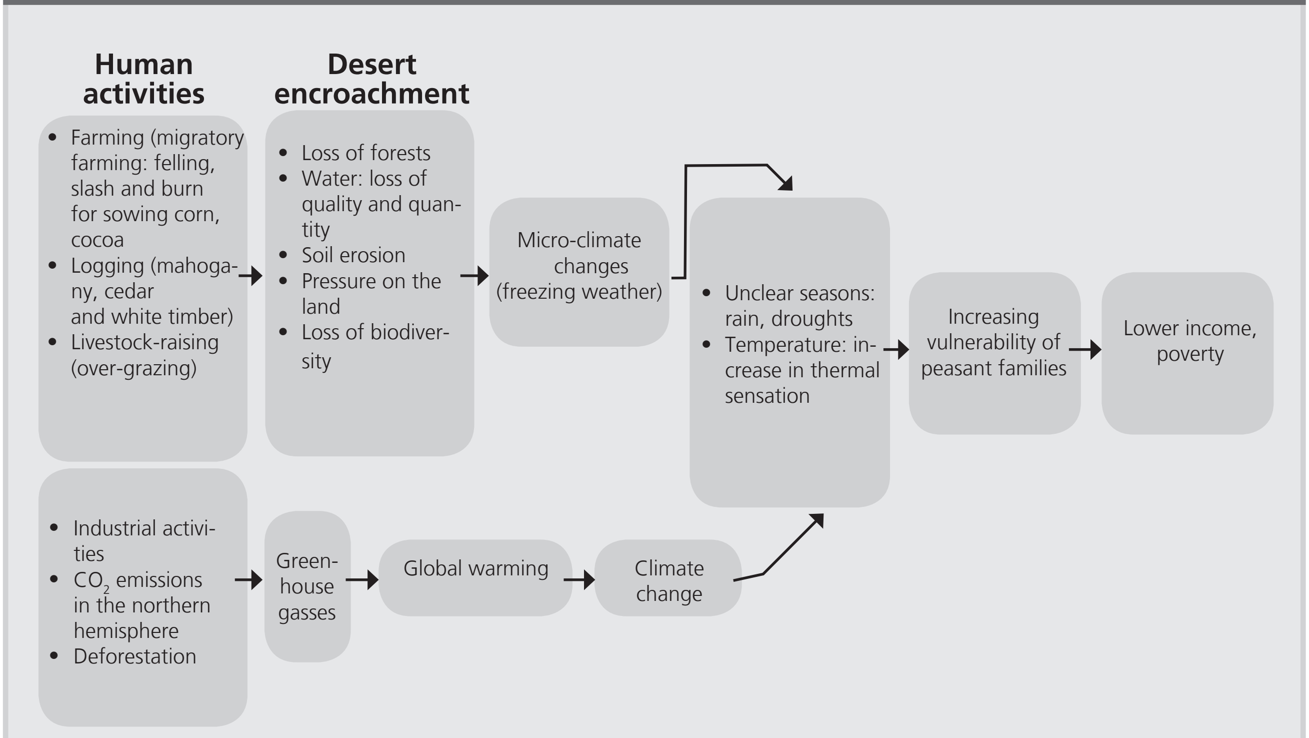
The Sisa river basin is comprised of 5 districts: San José de Sisa, Agua Blanca, Santa Rosa, Shatoja and San Martín de Alao **(see table 11).**

Table 11. Districts intervened

District	Area (km^2)	Altitude (m.a.s.l.)	Number of homes
San José de Sisa	299.90	340	2 307
Agua Blanca	168.19	300	525
San Martín de Alao	562.57	420	836
Santa Rosa	243.41	280	317
Shatoja	24.07	400	327

The main objective of the project was to reduce the vulnerability of cocoa and coffee farmers in the upper rainforest area, particularly in the El Dorado province. **Practical Action** worked with coffee and cocoa farmers to improve their technical and organisational skills with the objectives of implementing sustainable agroforestry systems, increasing access to markets and generating increased incomes as a climate change adaptation strategy **(see figure 17).**

Figure 17. Description of the problem



Specific activities included:

- Assessment of agricultural management techniques and soil productivity
- Formulation of sustainable farm management plans
- Capacity building for farmers in fertilizing, improved cropping and producing techniques
- Awareness raising around fair trade issues
- Construction of plant nurseries
- Establishment of producer committees and training in quality control stocktaking, basic administration and finance
- Setting up information sharing events for different producer groups and local authorities
- Promotion of cooperatives

5.3. Adaptation Strategies

The proposed climate change adaptation strategies are divided into three components: agroforestry, marketing and organisation. All three integrate traditional and modern knowledge in an effort to maintain the livelihoods of the local population **(see table 12**).

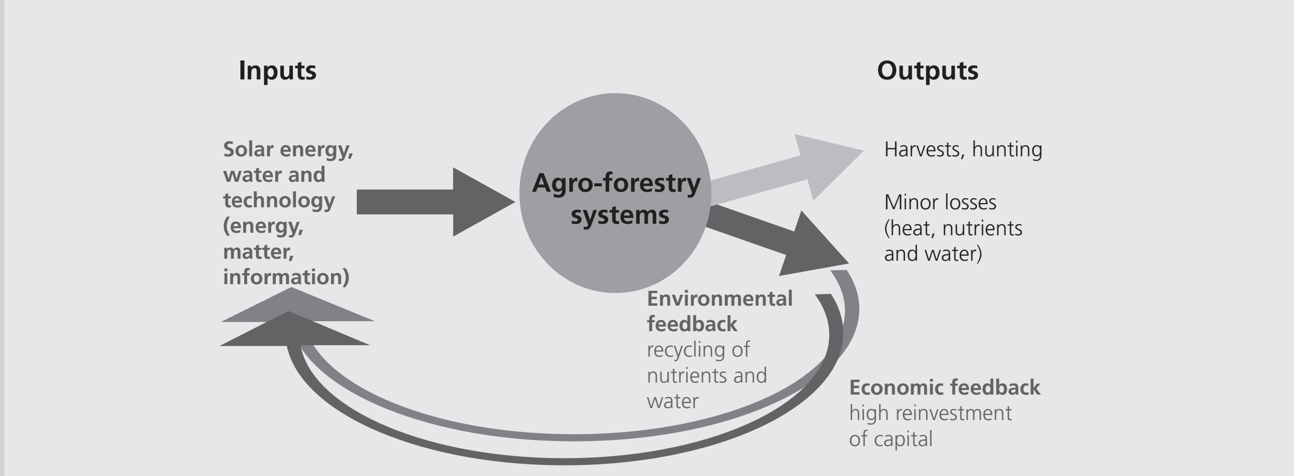
Table 12. Prioritized Strategies

Prioritized areas	Components	Local know-how	Modern technologies
Agro-forestry	- Forest enhancement - Organic production - Climate	√	√
Marketing	- Insertion in qualified external markets - Insertion in local markets - Profitability	-	√
Organization	- Improvement - Inclusion in participatory budgets	√	√

a) Agroforestry

Agroforestry involves planting highly productive crops like cocoa and coffee alongside indigenous perennial species (trees, shrubs, palms, fruit trees) and provides several benefits. The productivity of the land is enhanced as the trees provide forage, firewood and other organic materials that are recycled and used as natural fertilizers helping to maintain the mineral content and structural integrity of the soil. The trees also provide important shade for smaller crops to flourish (**see figure 18**).

Figure 18. How an agro-forestry system works



Agroforestry is a non-invasive climate change adaptation strategy, as it does not involve the use of technologies. It is an alternative approach based on the inherent adaptability of living species and its goal is to restore the original natural balance of the forest. As such, agroforestry is an appropriate approach to farming in the Sisa river basin given the highly fragile conditions that are characteristic of the area. Furthermore, agroforestry entails the cultivation of a diverse range of crops which generate important income for local farmers thereby reducing migration trends.

Farmers were able to benefit from the diversity of forestry **(see table 13),** medicinal **(see table 14)** and fruit species **(see table 15)** in the cocoa and coffee farms.

Table 13. Number of timber forestry species in coffee and cocoa farms

Group	Sown species				Native species					
	Capirona	Mahog-any	Cedar	Molaina	Pashaco	Shaina	Pumaquiro	Paliperro	Pinsha caspi	Other spe-cies
Coffee farmers	49	3	8	15	38	1	63	5	15	50
Cocoa farmers	28	20	7	61	8	7	12	6	6	42

Table 14. Average number of medicinal species

Group	Species							
	Sangre de grado	Cat's claw	Ajo sacha	Jagua	Ojé	Piñón	Chuchuhuasi	Cordoncillo
Coffee farmers	8	0	3	1	1	6	1	10
Cocoa farmers	6	3	7	2	7	5	1	45

Table 15. Number of fruit species

Group	Species						
	Citrus	Caimito	Guava	Mango	Zapote	Avocado	Pomarosa
Coffee farmers	11	0	115	4	1	2	0
Cocoa farmers	18	4	69	5	9	10	1

b) Marketing and Organisation

The organisation of farmers into cooperatives was a key strategy for gaining access to local and international markets. By selling to these markets through cooperatives with organic and fair trade certification, the farmers receive fixed higher prices for their coffee and cocoa crops.

5.4. Results

An evaluation of the vulnerability of the Sisa river basin showed that the region is at risk from flooding and soil erosion due to large-scale clearing of forest for agriculture, principally rice cropping which also requires huge amounts of water. Poverty affects large sections of the population with few opportunities for employment and low rates of income generation. The local economy is upheld by farming and livestock raising activities which receive little support from the government in terms of disaster planning and social organisation. A considerable percentage of the population lacks access to basic services such as water, sewage, electricity, and medical care.

Patterns in climate change in recent years were analysed and show that, in general terms, the summer seasons have been longer and hotter since 2000. Consequently, there has been an increase in the number of plagues and diseases affecting both crops and humans. Changes in temperature imply changes in the natural water and air cycles, altering the rainy seasons and causing stronger winds.

Direct impacts of deforestation include lower soil productivity, soil erosion, changes to the hydrological cycle and a dangerous reduction of biodiversity, as shown in **figure 19.**

Figure 19. Diversity and risk ratio

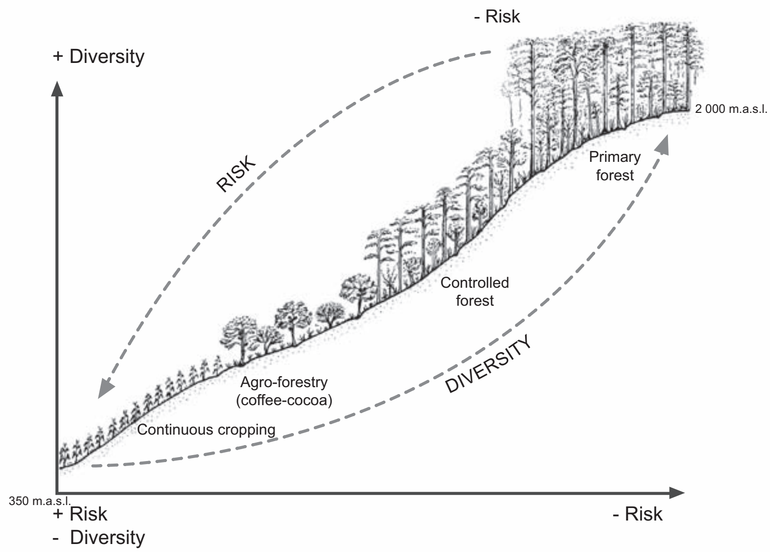


Table 16 contains figures showing deforestation in El Dorado. According to this data, deforestation will affect 68% of the watershed.

Table 16. Deforestation in El Dorado

Year	Area (ha)
1999	72 021.85
2000	73 510.79
2005	80 955.49
2010 (estimated)	88 400.19
Total area	129 814.00

An agroforestry approach to agriculture helps to ensure that during periods of prolonged droughts soil quality is retained and erosion minimized. Shade provided to primary crops by trees means that pruning can take place more often during the year.

The implementation of the agroforesty farming approach was accompanied by the integration of cocoa and coffee farmers into cooperatives. By working in cooperatives, farmers were able to negotiate better prices for their goods and avoided paying a percentage of their profits to intermediaries. Joining cooperatives gave farmers the status of organised producers, facilitating access to larger markets, and organic and fair trade certification. As a result farmers' income rose significantly.

Farmers received training on management issues, decision-making and participation in local citizen administration projects, such as participatory budget and development planning at municipal level.

Table 17 shows the main proposals for continued actions in the Sisa river basin to ensure the viability of the action plans established during the implementation of the project.

Table 17. Local policy proposals

Strategic line	Policies
Research	**Weather records** Broaden the weather records system in the region, based on the importance of watersheds and micro-basins, encouraging the participation of key agents like local universities and research centres. Include climate bio-indicators in the weather records system, regularly disseminating climate scenarios for farming
	Prevention Establish information and early warning systems in watersheds and micro basins for environmental risk management purposes
	Regulation and control Carry out economic and ecological zoning studies, including inventories of flora and fauna. Validate and implement participatory regulation and control systems for the use and protection of natural resources
	Production systems Validate and promote the use of native species in agro-forestry systems. Develop new production models in agro-forestry systems so that native products with a market potential achieve commercial values
	Biodiveristy and native crops Learn more about the habitat and native species. Identify, study and domesticate promising native crops. Establish regulation and control guidelines for their development
Capacity-building	**Territorial system** Facilitate the creation and implementation of environmental management units in 77 district municipalities in order to guarantee the adequate use of land and the application of agro-forestry systems as adaptation strategies
	Overall watershed management Promote the creation of inter-district organisations to regulate the use of water and develop natural resources for farming purposes. Scheduling and zoning of farming activities
	Risk management Improve the capacity of district and provincial civil defence committees to carry out risk prevention actions focused on watersheds
	Management of the biodiversity in forestry systems Training of professionals and mass dissemination of information on the biological diversity and fragile nature of the ecosystems, and development and exploitation strategies
	Agro-forestry Disseminate appropriate agro-forestry designs for the ecosystems. Include agro-forestry in schools and institutes as a professional training discipline. Promote forestry plantations for commercial purposes and for environmental services (carbon capture, protection of water sources, catchment areas)
Organisation and participation	**Participatory Budgets** Build up the social network to draw up agro-forestry projects to be included in participatory budgets
Education on climate change	Implement advertising strategies to raise the population's awareness and promote a responsible attitude to climate change. In the regional education project, include climate change adaptation causes, consequences and strategies

5.5. Conclusions and Recommendations

a. Conclusions

Raising awareness of environmental issues has led to farmers replacing corn with perennial crops like cocoa and coffee. By producing coffee and cocoa using agroforestry techniques, farmers are able to increase the quantity and quality of their crops.

Selling coffee and cocoa though a cooperative with organic and trade certification is a more secure option for small-scale producers. Working together farmers produce exporz volumes of high value products which can be sold on national and international markets fetching higher prices and eliminating the need for middlemen. In addition, cooperatives are generally able to negotiate better deals with buyers, and thereby regulate and stabilise prices paid to farmers.

b. Recommendations

In order to reduce vulnerability to climate change in the Sisa river basin, there is a need to convert continuous cropping farms into agroforestry systems. A zoning study of the Sisa river basin is required in order to identify soil use capacity and potential conflicts. Based on this evaluation, types of land could be defined and control mechanisms established with local population participation. As far as organisation is concerned, it is recommended that the cooperative be retained as a working model for future interventions in the area.

Other recommended lines of action include:

- Research into native forest species to identify potential products for sale on national and international markets
- Lobbying of local government and forestry authorities to simplify the legal processes for commercialisation of native wood grown in agroforesty systems
- Centralise production volumes to reduce marketing costs
- Investigate technology transfer options to support improved crop productivity
- Increase the number of training agents and build up the capacity of the farmers who will be in charge of continuing the dissemination of the agroforesty methods in the region

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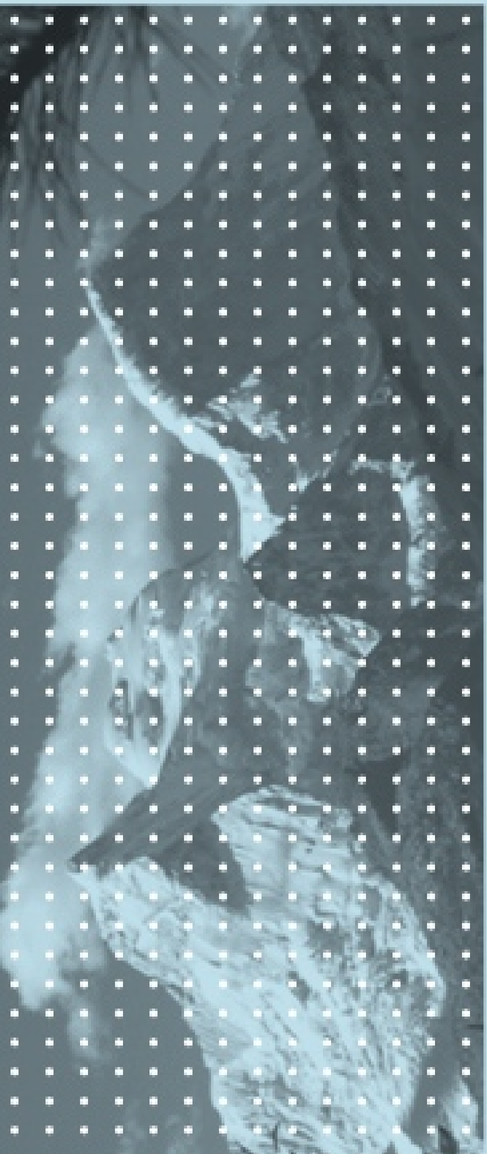



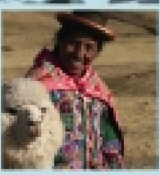

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