iied

gatekeeper

Resilience to Climate Change in Patagonia, Argentina

Rodrigo José Roveta

140: December 2008

Key highlights in sustainable agriculture and natural resource management

The gatekeeper series of the Natural Resources Group at IIED is produced by the Sustainable Agriculture, Biodiversity and Livelihoods Programme. The series aims to highlight key topics in the field of sustainable natural resource management. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions for development that are particularly relevant for policymakers, researchers and planners. References are provided to important sources and background material. The series is published three times a year and is supported by the Swedish International Development Cooperation Agency (Sida) and the Swiss Agency for Development and Cooperation (SDC). The views expressed in this paper are those of the author(s), and do not necessarily represent those of the International Institute for Environment and Development (IIED), the Swedish International Development Cooperation Agency (Sida), the Swiss Agency for Development and Cooperation (SDC) or any of their partners.

Rodrigo José Roveta has just concluded his Masters thesis in the Forest Ecology and Management Masters Programme at Freiburg University, Germany. It explored the traditional use of fire for the provision of ecosystem services in south India. He has returned to his previous position in the Forest Service of Chubut, Argentina. His interests are in the sustainable management of forest resources, ecosystem services, and the development of related policies. Contact details: Dirección General de Bosques y Parques del Chubut-Argentina, 25 de Mayo 891, (9200) Esquel, Chubut, Argentina. Email: rjroveta@yahoo.com

Executive summary

This study aims to broaden understanding of climate change and its impacts in Argentina. Most focus on climate change in Argentina has been in the north, where impacts are more noticeable. But this study shows how changes in the south, in the Patagonian province of Chubut, are also likely to be significant.

Increasing temperature and decreasing rainfall in northwest Chubut are shifting the patterns of agricultural viability. Predominant patterns of cattle and sheep farming are likely to face increasing shortages of dry season grazing. Natural forests and existing and planned plantations are also likely to face increasing aridity—exacerbating the risk of dieback, forest fires and pest and disease outbreaks. Water shortage is likely to become an increasingly pressing concern—especially with the heavy reliance on hydropower, major development plans for irrigated agriculture and forestry, heavy technological demands from the petrochemical industry for water pressure to drive oil extraction, and the importance of aquatic environments for regional tourism.

Adaptation to climate change in Chubut province is already occurring, but so far it has been rather disjointed and *ad hoc*. Livestock farmers have been reducing stocking densities of their own volition in the wake of recent droughts. Forestry agencies have implemented new protocols to monitor fire and pest and disease outbreaks. Forest plantations have been established mostly to improve or diversify livelihoods—but in some cases also to mitigate climate change itself.

A more co-ordinated approach may be necessary to specifically address the climatic risk of different forms of agriculture and forestry. Land use planning needs to take better account of the environmental thresholds of different types of agriculture or forest land use—with incentives to induce greater diversity and consequent resilience. More emphasis is also needed on insurance against different types of climate related emergency in agriculture and forestry. The management of water is one area in which an integrated approach is urgently needed. Increasing demands on the resource from a range of sectors may result in conflict unless joint decision-making procedures are introduced.

The study concludes by noting that while climate change in the south of Argentina has had less severe impacts to date, this should not be grounds for complacency. Rather it should be seen as an opportunity to plan for the future and build institutional capacity and policy coherence that better protect the population from inevitable climate change.

Resilience to Climate Change in Patagonia, Argentina

Rodrigo José Roveta

Introduction

Climate change is already affecting many natural systems around the world. Increases in temperature, changes in precipitation patterns, more frequent extreme events such as floods and droughts are well-documented examples (IPCC, 2007). In Latin America a mean warming to the end of the century is expected of between 1 and 6° Celsius (depending on the model considered). This will almost certainly lead to an increase in species extinctions, a rise in the numbers of people experiencing problems with water supply and a decrease in yields of major crops (Magrin *et al*., 2007). Argentina is not exempt from these impacts. Unusual extreme weather events and changes in natural systems have already been reported, especially in the north of the country. Together with improvements in technology, this has led to a displacement of agricultural land towards the west, causing large-scale deforestation (nearly 2 million hectares of forest were lost to farming between 1998 and 2006; UMSEF, 2007).

The aim of this report is to look at the situation in the southern part of the country in order to see whether climate change is as important an issue as in the north. It also explores the role of local institutions in this context, and makes recommendations for improving the situation.

The study area: Patagonia's western Chubut Province

This research is based on a regional review of empirical data on climate and its trends, local production system characteristics and strategies, and frameworks of local natural-resources-related organisations. Information was gathered from published and unpublished literature, government reports (specific statistics were also requested by the project), telephone and email semi-structured interviews with local stakeholders.

This case study focuses on the central northwest part of Patagonia, specifically the sub-Antarctic forest and the potential forest land[1] of western Chubut Province (Figure 1).

1. Where the land is suitable for establishing (mainly) pine plantations.

Although climate change has been influencing the area in recent decades, interviews found little in-depth understanding within the general population of those effects.

Patagonia has three main ecological zones: the Patagonian Steppe (dry grassland), the Monte and the sub-Antarctic forest. The Andes Mountains in the west and the Patagonian Steppe in the east delimit the borders of the sub-antarctic forest zone (Figure 2), which is 2,200km long and 75km across at its widest point. The most abundant trees within the sub-Antarctic forest are the broadleaved *Nothofagus* species. Conifers are also found in the region; four species are endemic to Argentina and Chile. Of these, *Araucaria araucana*, *Pilgerodendrum uviferum*, and *Fitzroya cupressoides* are protected under the Convention on International Trade in Endangered Species (CITES). In Chubut, *N. pumilio* covers most of the higher altitude watersheds and is the most important species in terms of forest management. At mid-altitudes natural forests include *N. dombeyi* and *A. chilensis*, and finally foothills and valleys are occupied by *N. antarctica*.

FIGURE 1. LOCATION OF THE STUDY AREA

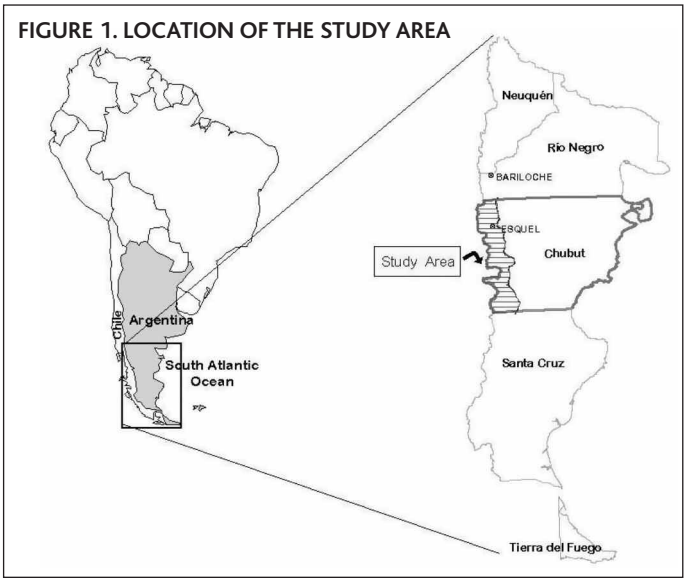
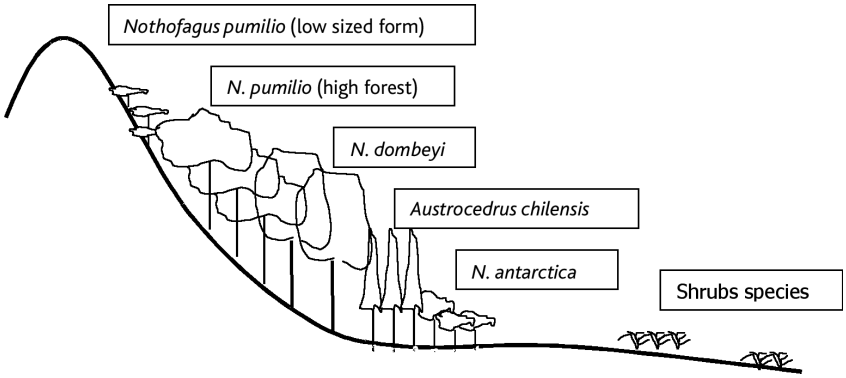


FIGURE 2. SCHEMATIC DIAGRAM OF THE STUDY AREA'S MAIN VEGETATION TYPES ALONG A WEST-EAST TRANSECT



Climate

The Andes Mountains play a key role in the area's climate by forming a barrier to the wet winds (westerlies) coming from the Pacific Ocean. Most of the rainfall is discharged on the Chilean side of the mountains, and then a drier mass of air flows to the Argentinean regions. This leads to a strong west-east gradient in precipitation (Paruelo *et al*., 1998), with rainfall reaching more than 1,000 millimetres annually over the Andes Mountains (up to 3,000mm in some places), while just 100km to the east it can be 200mm (Barros *et al*., 1980). Throughout the region precipitation is concentrated in winter and autumn (73% of total rainfall, Jobbágy *et al*., 1995), causing a significant water deficit in summer. The area is defined as a cool temperate region (Paruelo *et al*., 1998), with mean annual temperatures of between 8 and 10°C (SMN, 2007a).

Natural resource use

Farming

Livestock is the most important local land use, and grass production for cattle feed the main crop. Some vegetables are cultivated in the north (mainly for local consumption) as well as fruit, especially cherries and berries (such as blackberry and strawberry). Cattle farming dominates the areas with better grasses and water availability; sheep are kept for meat and wool in drier areas not suitable for cattle. A common practice is to graze the cattle/sheep within the forest; this extensive livestock farming has been practised over the last 120 years. Cattle are transported to warmer valleys during winter and to the forest for grazing in summer. In some cases, agroforestry systems have been established to augment summer grazing. These are mainly located in areas with *N. antarctica* natural forests, where forests are used for firewood and rural timber products as well as for livestock protection and grazing.

In the eastern dry steppe grassland where sheep are more common, stocking levels have historically exceeded the ecological carrying capacity of the pasture.[2] Consequently one of the biggest environmental problems (although mainly outside the study area) is desertification (see Del Valle, *et al*. 1998).

According to official data (CNA, 2002)[3], small landholdings (less than 100ha) are the most frequent (25%), although there is a concentration of land in large properties (around 75% of the land belongs to properties larger than 5,000ha). Seventy-seven percent of farms have less than 100 head of cattle. Medium-sized farmers represent 20% of all farmers but their stock accounts for 42% of the total.

Forestry

Natural forests are an important source of wood for local sawmills and firewood, as well as other products for rural communities. Firewood is the main forest product in terms of volume produced per year, followed by logs for use in sawmills.

2. This may be because the decision-making process, at management unit scale, usually follows economic variables, such as wool prices, rather than ecological indicators.

3. Note that these values represent an area larger than the study area, because of data aggregation in the census.

Forestry can be divided into three main activities: roundwood for timber use, firewood and plantation forestry.

- **Roundwood for timber use.** There are two main native species used for timber, *N. pumilio* (broadleaf) and *A. chilensis* (conifer). *N. pumilio* forests are logged via group selection cuts of uneven aged stands. This is driven by the ecology of the species as well as climatic conditions. To reduce impact, forest law only allows felling in autumn and winter. As *A. chilensis* is affected by a disease known locally as *mal del ciprés*, logging in this kind of forest is legally restricted to salvage cuts. Another obstacle to felling in *A. chilensis* forests is the high risk of forest fire in summer. Both kinds of forests are also subject to livestock grazing.
- **Firewood.** Though several species are used for firewood, the main one is *N. antarctica*. Felling of these tree species is limited to autumn and winter to allow them to resprout as coppice. This economic activity is less controlled by the government and some areas are facing high pressure because of intensive firewood use and subsequent cattle grazing (which damages seedlings as well as coppices). Firewood is mainly used for heating and cooking in rural areas. However, recent investments in the natural gas network, which is being expanded to rural areas, are expected to decrease this consumption. Some firewood is traded, providing an important source of cash for rural people. Nevertheless, it is always a complementary activity and not the main livelihood source.
- **Plantation forestry.** In drier lands without natural forests, afforestation (mainly with Ponderosa pine, *Pinus ponderosa*) has been promoted.[4] The government is the main driver of this economic activity, providing subsidies for plantation establishment. The harvesting season is limited by the fire season and the presence of the woodwasp (Box 1). When the wasp is flying, tree cutting is banned (to decrease the stand's susceptibility to wasp attack due to stress induced by harvesting practices). Most of the areas currently being planted belong to large landowners. However some attempts have been made recently to include more small landowners in order to diversify their livelihoods.

BOX 1. THE WOODWASP AND FORESTRY

In the past, several forest plantations had been established in areas cleared of natural forests. Some areas were left unmanaged. The consequences have been seen 30 years later with the infestation by the woodwasp, *Sirex noctilio*, which accidentally appeared in the area. This wood-boring wasp attacks many pine species and may kill them. Environmental factors such as drought or excessive overcrowding make trees more susceptible to attack. Important economic losses have been caused by the woodwasp in the area. In response, the Forest Service has established a special programme for pest and disease monitoring and management.

4. Previously forest plantations used to replace native forests. This is no longer allowed in Chubut.

Ecosystem services

Ecosystem services such as the production of water for human consumption, recreation, irrigation, hydropower and industrial use are very important in the region. All water for the larger urban settlements (on the Atlantic Ocean coast, 700km to the east) comes from these forested catchments. Irrigated agriculture and forest plantations are growing rapidly in downstream areas. For instance, in 2006 a new irrigation system was inaugurated in the 16 de Octubre Valley (where Trevelin town is based), making 2,000ha of land available for agriculture. Energy for both local and distant urban settlements is predominantly based on hydropower (for example the Futaleufú hydropower plant). New extraction technology in the petrochemical industry requires large volumes of water to pump out oil reserves (e.g. the Repsol YPF company takes water directly from Senguerr River in the south of the province—outside the study area).

Another important ecosystem service is landscape beauty, which is the main source of increasing tourism development in the region. Within some parts of the region tourism is a very important source of income. There are two national parks in the area (Los Alerces NP and Lago Puelo NP) which, in addition to their conservation importance, play a key role in attracting visitors to the region.

The social context

Most of Chubut's current population is derived from immigrants from within Argentina as well as from other countries, such as the Welsh colony established in 1865 on the coast which has been a key factor in the region's development. Nearly 90% of Chubut's population live in urban settlements. The study area's main city is Esquel, followed by Trevelin and Lago Puelo (31,200; 7,000 and 5,250 inhabitants respectively). Indigenous people make up 1.9% of the total inhabitants in the study area (SEP, 2007). Approximately 27% of the study area's population is below the poverty threshold (SISCOM, 2007); this value is similar to the national average.

Key natural resource institutions

Several natural resource institutions work in the area (Table 1). Their work is dominated by current regional priorities, but each of them has some responsibility for areas likely to be affected by climate change. Their future activities are also likely to be increasingly affected by the need to adapt to climate change. For example, improving forest management (especially near water bodies) and designing risk-free forest plantations may require an increasing understanding of climate change. Farmers can seek advice on forestry, livestock and agriculture from these local institutions, and such advice may also increasingly respond to climatic threats. Existing support institutions for farmers are mainly governmental agencies and research institutions.

There are some overlaps between different jurisdictions. For example, land tenure is managed by the Land Colonisation Commission (IAC), whereas the Forest Service (DGByP) governs forest management. This overlap between two institutions with different aims has led to conflicts among forest companies and farmers. Such conflicts may grow if climate change affects the economic viability of different land uses.

TABLE 1. MAIN LOCAL NATURAL RESOURCE INSTITUTIONS/ORGANISATIONS	
Institution/organisation	**Description/role**
Agriculture and Livestock Office (DGAyG) (government sector)	Development of the province's agricultural and livestock sector.
Andean Patagonian Forest Research and Extension Centre (CIEFAP) (government sector)	Forestry research and dissemination.
Forest Service (DGByP) (government sector)	Protecting forest resources, defining and controlling management practices as well as promoting afforestation. Provincial protected areas (in forest lands) are managed by this institution. An advisory board (involving key stakeholders) was created as a model of conflict management in one of these protected areas.
Futaleufú Hydropower Plant (HF) (private sector)	Located within Los Alerces National Park. It delivers energy to an aluminium factory based on the coast, as well as to several cities and towns in Chubut.
Land Colonization Commission (IAC) (government sector)	Promotes land occupation throughout Chubut and determines land ownership. Livestock are central to its activities.
Ministry for the Environment (MAyCDS) (government sector)	Promotes environment management and sustainable practices.
National Institute for Agricultural Technology (INTA) (government sector)	National research and extension agency that has close contact with local farmers on agriculture, livestock, agroforestry and forestry.
National Parks Authority (APN) (government sector)	The national authority for nature conservation. In Chubut there are two national parks.
Social Agricultural Programme (PSA) (government sector)	A national programme under the Agriculture, Livestock, Fishing and Food Secretariat (SAGPyA). Promotes small farmer organisation.
Rural Society of Esquel (Sociedad Rural Esquel) (NGO)	A traditional entity in Argentina with an important voice in agriculture and livestock production debates.
Water Office (DGARH) (government sector)	Water management: regulating its use and any development that could affect public water use.
Other organisations	Farmers associations, such as the Los Alerces Farmer Association (APLA); the Honey Producers' Association (AACLA); the Los Andes Farmer Association (ALAPA), which mainly represents fruit producers; and small farmer groups formed through PSA projects.

Climate change in the study area

An important source of information for this study has been the *Second National Report on Climate Change*, which includes a special briefing on Patagonia (FTDT and ITDT, 2006). Some key points extracted from that report include the following:

- In the northwest of Chubut, annual precipitation appears to be declining, although there is high variability within decades. Most of this decline is occurring in the winter. For instance in Esquel, the downward trend observed was -4mm/decade (between 1967-1998, values with non statistical significance) (Figure 3).
- A decline in the frequency of extreme rainfall events has also been observed, related to the declining trend in annual precipitation.[5]
- Near Esquel, the mean annual temperature rose by 0.2°C over each ten year period between 1961 and 2000, whereas for summer that increment was 0.33°C.
- The 0°C isotherm has been moving up (in altitude) across the region. This has caused glacial melting and decreased the recharge of snow. Glaciers are receding between the latitudes of 37 to 55° south (with some exceptions).

Variation in impacts from east to west

As mentioned above, of the different climate parameters, changes in precipitation patterns are clearest in the study area. In the drier eastern meteorological station of

BOX 2. LOCAL PERCEPTIONS OF CLIMATE CHANGE IN CHUBUT PROVINCE

NORTHWEST - J. Nuñez is an organic farmer living in Lago Puelo for the last 20 years. He perceives the climate to be windier, colder and with longer winters than in the past.

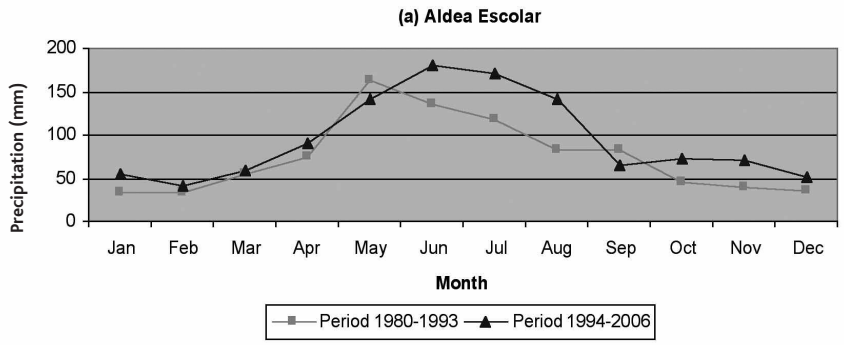
NORTHEAST - J. Simeoni has been farming in Paso del Sapo for the last 23 years. He comments that rain is less frequent and less intense. P. Gonzalo, president of Esquel Rural Society, has lived in Esquel for 50 years. She thinks that 20-30 years ago the winter season used to be stronger and longer than nowadays and the seasons more clearly demarcated. In her words *"...a long time ago, strong snow storms occurred in winter that led to floods in spring time. Nowadays summers are drier and windy, and it is more common to see thunder-storms, a phenomenon that was not often seen before."*

H. Jones (69) has lived all his life near Trevelin, where he is a small cattle farmer. He shows scepticism when talking about climate change; his perception is that we are faced with cyclical periods. As well as P. Gonzalo, he sees less clear seasonality, *"in the past, the summer was warmer and it lasted three months"*. He also comments that: *"perhaps people have the perception that past winters were stronger, but the thing is that there was a change in the living standard of rural people (e.g. transportation, telephone) that makes current winters seem not as strong as they used to be"*.

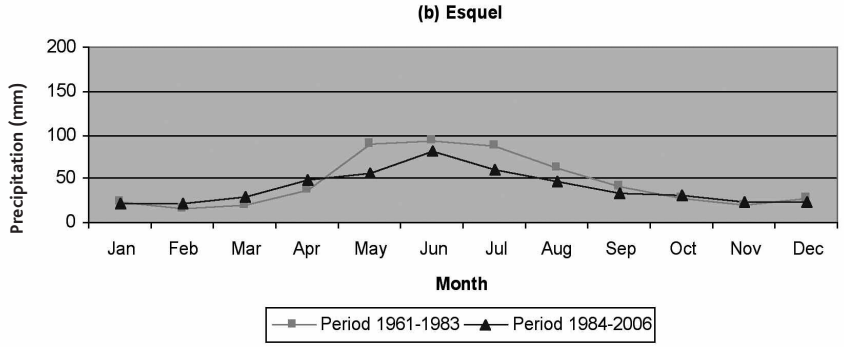
SOUTHWEST - R. Acinas is a cattle farmer and forest producer living in Aldea Beleiro for the last 42 years. Over the last 15-20 years he has noticed a delay in seasonality. *"Years ago, in May there was always snow. Nowadays the snow comes in July until October, and we never know when"*. In addition he feels that there may be a little less precipitation and that summer is cooler and less stable.

5. The opposite has been observed on the Atlantic coast of Chubut Province.

FIGURE 3. TRENDS IN MEAN MONTHLY PRECIPITATION THROUGHOUT THE YEAR, 1961-1983 AND 1984-2006



(a) Aldea Escolar. Source of data: Campo Experimental Trevelin, INTA EEA Esquel, 2007.



(b) Esquel (note that the periods covered are different). Source of data: SMN, 2007b.

Esquel, a decrease of 86mm in mean winter precipitation (April–September) is observed when comparing 1961-1983 with 1984-2006 (Figure 3b). In the wetter western meteorological station of Aldea Escolar the pattern is not the same (Figure 3a). It appears that here the winter rains are somewhat delayed but last for longer than before. Unfortunately this second meteorological station has no continuous data series from earlier than the 1980s. These trends are borne out, however, by the observations of several interviewees in the study area (Box 2).

Future projections of climate change

Future projections for Patagonia show that mean annual temperature is likely to increase by 0.5°C by 2020 and, in the worse case, up to 2.4°C by 2080 (FTDT and ITDT, 2006; Figure 4). According to FTDT and ITDT (2006), precipitation modelling in the area is complicated by the high spatial and altitudinal variability. Nevertheless, a continuous decrease in rainfall is expected in future years, caused by the displacement of the Pacific

anticyclone towards the south. This pressure system is responsible for blocking precipitation systems on the way to the continent (FTDT and ITDT, 2006).

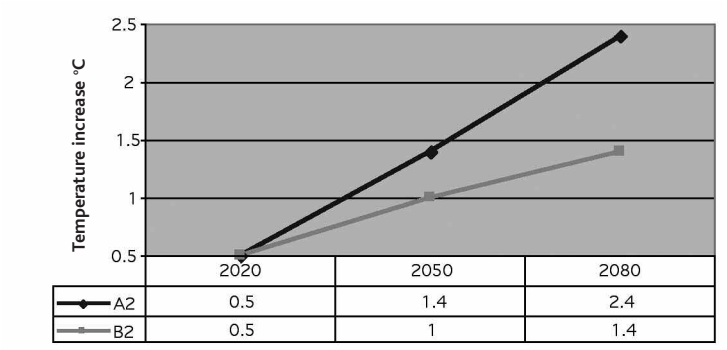
Impact of climate change on resources

According to FTDT and ITDT (2006) some changes are expected to occur in the study area:

- Decreasing annual rainfall may lead to encroachment of shrubs on the forest, especially in the transitional areas ("ecotone") between the sub-Antarctic forests and the steppe. Moreover, as precipitation declines, less commercial production could be expected from forest plantations already established in this ecotone.
- A decline in precipitation would also lead to an increasing risk of forest fires across the area.
- In general, stream flow in Patagonia's main rivers is declining. Within the study area this was reported for Chubut River,[6] the water source for the populations on the northeast coast. Due to the low population densities, most of the water consumed is currently allocated to irrigation in that area.
- Most of the energy produced in Argentina comes from hydropower plants. A decrease in stream flows is leading to a decrease in energy production. In the study area there is one plant on the Futaleufú River and another one on the Chubut River. Although this latter plant is located outside the study area, it is nevertheless under its influence.

Some of these changes would be exacerbated by activities such as overgrazing in the steppe and forests (21,154 ha of high forests have been degraded by this practice; Bava *et al*., 2006); overexploitation of marginal forests for firewood production; intentional forest fires (36,604 ha of high forests have been degraded by fire; Bava *et al*., 2006); and failure to take into account future water requirements when planning afforestation

FIGURE 4. PROJECTED TEMPERATURE INCREASES FOR THE STUDY AREA, 2020-2080.



	2020	2050	2080
A2	0.5	1.4	2.4
B2	0.5	1	1.4

Based on MM5/CIMA model and pattern-scaling techniques, projecting from period 1981-90 using the Intergovernmental Panel on Climate Change's A2 and B2 scenarios. Source: FTDT and ITDT, 2006.

6. However, it was not statistically significant (FTDT and ITDT, 2006).

expansion. Decreasing water yields may introduce new conflicts among major water uses such as human consumption, irrigation, hydropower and industrial use.

Changes in livestock farming and downstream agriculture

The ratio between meat and wool prices over the last 15 years has seen farmers changing from sheep to cattle wherever possible. It is difficult to say whether such decisions will be affected by climatic factors.

There are some initiatives for irrigated agriculture outside the study area. At the moment a potential dam on the Senguerr River is being considered by the government to increase the water supply for coastal settlements; as a result of the dam another 15,000 ha of land could be made available for agriculture purposes.

Changes in the incidence of forest fire

Forest fires have shown high variability in terms of the area affected over the past 29 years. In the study area, most fires are man-made (less than 1% are caused by natural events such as thunderstorms). Nevertheless, drought influences the number of fires and their intensity. Kitzberger *et al*. (2001) found that in northern Patagonia there is a correlation between the major fire years, El Niño and La Niña events. According to these authors, El Niño events stimulate the production of fine fuels, which are then dried by La Niña conditions, leading to widespread fires.

Changing patterns of forest plantation

In terms of afforestation, big efforts have been made to develop the forest sector. Although pine plantations are the most significant in area planted, recent years have seen a growth in projects with irrigation requirements,[7] such as poplars. Two main points require consideration:

1. Some areas that are only marginally suitable for pine plantations would be lost if precipitation continues to decrease.
2. The decrease in stream flows would be exacerbated by the development of huge irrigated poplar plantations.

In dry years, some forest plantations and some native forests have shown damage (mortality) directly related to climate, and indirect effects (predisposition to pest attacks, see Box 1). The severe drought in 1998-99 coincided with a strong La Niña event (Suarez *et al*., 2004). It caused high mortality of *N. dombeyi*[8] as well as (perhaps) creating a pool of trees susceptible to future drought episodes. Bran *et al*. (2001) reported that 42% (44,400 ha) of the *N. dombeyi* forests (including mixed forests) in northwest Patagonia (outside the study area) were affected. Increased mortality in Douglas fir (*Pseudotsuga mensiezii*) plantations over the same period has also been recorded, with those already established on marginal sites being most severely affected (Davel *et al*., 1999; Lanciotti *et al*., 1995).

7. These kinds of projects require special permission from the Water Office (DGARH).

8. *N. dombeyi* is a species naturally associated with wet slopes, watercourses and lakes.

Adaptations in resource management

BOX 3. LOCAL INTERVIEWEES' PERCEPTIONS OF CLIMATE CHANGE IMPACTS

NORTHWEST - J. Nuñez noticed an increase in fungal diseases on his crops (mainly vegetables) as well as a lowering of the water table, which is used for irrigation purposes.

NORTHEAST - J. Simeoni said that the current drought means less river water available for irrigating his poplar plantations. He has also noticed less grass available for livestock feeding. In recent years he has suffered losses in his sheep stock (through grass and water shortages), which never occurred before. P. Gonzalo also mentioned decreased grass availability.

SOUTHWEST - R. Acinas does not see important impacts on the forests, but he has noticed changes in grass availability and a later peak in natural grass production. He notes that droughts are usually alleviated by a rainy month in summer that also reduces forest fire risk. On the other hand, he has observed that intermittent streams are drying earlier than they used to.

National media reports back up these anecdotal observations, e.g. Castro, 2007; Guajardo, 2007.

Adaptations to livestock

There is clear evidence of farmers deciding to decrease their stocking levels in response to low grass availability in drought years. These changes have been made by the farmers themselves without external intervention, although wealthier large farms do seek professional advice. Some institutional projects to improve management practices are being carried out on several farms, but they have not been scaled up to the regional level. Moreover, these projects are not specifically designed to cope with drought. At the moment there are neither rules nor guidelines for livestock management (in terms of stocking intensity or environmentally friendly practices).

Adaptations in forestry

Increasing the number of afforestation projects[9] could have consequences for water availability in the future. But these projects have other goals:

- To decrease desertification in the area (mainly in the steppe because of overgrazing);
- To decrease pressure on native forests;
- To diversify local livelihoods; and
- To contribute to global carbon dioxide (CO_2) fixation.

Several investments have also been made in order to improve the forest fire management programme and some changes were introduced in the management of native forests; these are not based on climate change perceptions but would be useful adaptations to those changes. One example is the prescription for forest management near

9. According to official data, 311,000ha of land are suitable for afforestation in Chubut; another 400,000 ha would be suitable with irrigation (DGByP, 2007).

BOX 4. LOCAL INTERVIEWEES' ADAPTATIONS TO CLIMATE CHANGE

NORTHWEST - J. Nuñez has not changed his activities because the degree of the effects is not significant. However, his firewood consumption is higher than before, and he decided to change the kind of corn and potatoes seeds used, prioritising those with a shorter cycle.

NORTHEAST - J. Simeoni has scaled down his project to plant poplars as a windbreak in response to the water supply problems he faces. In addition, both he and P. Gonzalo have decreased their livestock because of the limited availability of grass. P. Gonzalo says that reduced stocking is not farmers' only response. In some cases low grass availability has led to an increase of grazing in native forests (especially on *N. antarctica*). She also said that in dry years, like the current one, there is less availability of lambs and calves, implying a direct impact on the regional market, where a rise in the price of meat can be expected.

SOUTHWEST - R. Acinas has reduced his stock because of lower grass availability. Last year he started to crop 20 ha of grass (*Medicago sativa*) to supplement his winter cattle feed.

watercourses in stands of *N. pumilio*, which could be beneficial not just for water protection but also for maintaining natural wildlife corridors.

There are already 24,000ha of pine plantations in the study area (DGByP, 2007) and the government's goal in 2005 was to plant another 25,000ha in the period 2006-2011. In 2006, several small farmers showed an interest in establishing poplar plantations east of the study area—not just to create windbreaks but also to improve conditions for agriculture (through the irrigation system). Activities such as these would have a positive effect on farmers' livelihoods in the future. However, it is early days and time will tell whether these projects are successful.

Adaptation involving ecosystem services

The full valuation of ecosystem services has been seen as one way to make management practices more sustainable. Recent work has been carried out in the area in order to explore the possibility of introducing some kind of forest ecosystem services market (SAyDS and UNSE, 2007). As local people increasingly recognise the effects of climate change, this option will become more important and it will become easier to implement. In September 24th 2007, a local co-operative (SCPL) in Chubut (outside the study area) sold the first certified emission reductions credits (CREs) under the Kyoto Protocol in the province.

Recommendations for improving climate change adaptation

Institutions governing livestock

- Match stocking levels to carrying capacity. Livestock institutions, such as the National Institute for Agricultural Technology (INTA), are realising the importance of this, and are advising farmers, though decisions are left to individual farmers (Box 5). DGAyG could have a crucial role to play in this. Although rigid stocking prescriptions appear

to be unrealistic, some initial steps could be taken to develop voluntary prescriptions through a participative learning process.

- Create a collaborative framework among all relevant institutions. For example, DGAyG needs to consider other government policies, such as those promoted by DGByP, when forests are involved.
- Make agroforestry practices in natural *N. antarctica* forests more sustainable. INTA has carried out several pilot projects (to improve understanding of the system as well as to improve farmers' livelihoods), but these experiences should be shared with as many farmers as possible.
- Develop practices to reduce grazing pressure on *N. pumilio* forests, where grazing is not compatible with natural forest dynamics.
- Promote agroforestry practices eastwards into marginal areas for afforestation to reduce overgrazing of the steppe and simultaneously diversify farmers' livelihoods.

The development of these practices should be carried out by research institutions such as INTA and CIEFAP in conjunction with farmers, whereas their implementation could be done by governmental agencies such as DGByP and DGAyG.

BOX 5. LOCAL VIEWS ON THE INSTITUTIONAL FRAMEWORK GOVERNING CLIMATE CHANGE ADAPTATION

P. Gonzalo: *"the decision on how to manage the stock belongs to each farmer, there are no rules for saying whether a field is overexploited or not"*. She thinks that there is a need for research to be carried out by institutions with farmers as partners, but the problem is that the information is not sufficiently disseminated. After this particularly dry year, and after the demands of rural societies and farmers to declare an agricultural emergency in the province,[10] the government decided to provide grass, grain and water for the livestock in affected areas.

All the local interviewees agreed that there is no institution working directly on climate change and local adaptation. In addition, M. Hartel (a governmental technician) said that in part the lack of belief in climate change is because of the speculation and diversity of hypotheses around the topic. Another problem is the lack of reputable information sources.

Institutions governing forest resources

- Reduce incidence of plantation monocultures. Ponderosa pine (*P. ponderosa*) is the main species promoted by afforestation projects (because it is well-adapted to local conditions), but the negative effects of forest plantation monocultures have been documented worldwide. Climate change could magnify these impacts. Diversifying the species used could help, but further research is required—such as that done by CIEFAP—and policy incentives for change are also needed.
- Take special care over species and site selection when planting in marginal areas. This also implies responsibility on the part of private individuals (farmers and technicians).

- Take into account future water requirements at the landscape scale when promoting an extensive development of the forest sector.
- Ensure that research institutions and governmental agencies work together in order to improve planning activities.

Data provision

- Improve climate data to allow for better adaptation decision-making processes.
- Improve the meteorological network via the National Meteorological Service (SMN). In the whole province there are only five stations (SMN, 2007c). The network could be improved by homogenising those stations already present and which do not belong to the SMN.
- Improve farmers' access to information and ensure clear data interpretation.

Data improvements would: (1) enable trend analysis to predict likely difficulties so that actions could be taken in advance; and (2) allow decisions—such as declaring an agricultural emergency (Box 5)—to be based on quantitative data.

Conclusions

Climate change is a reality. As the impacts of climate change in this part of Argentina are not yet as severe as in other areas, there is time to prepare, such as building institutional capacity to adapt to the main threats. Even though no institution has been recognised as competent on the topic, several examples of adaptation were found on which a strategy should be based.

Although the situation in the sub-Antarctic forests is quite different to that observed in the north of Argentina where deforestation is a huge issue, overlapping land uses in the study area, such as cattle farming and forest management, will degrade these natural forests in the long term. This situation could be accelerated by climate change, for instance if precipitation continues to decline. Specific research is needed on this topic to explore whether climate-related effects are the main drivers or not.

Finally, adaptation will require a set of policies which are coherent and co-ordinated among the main institutions. Throughout Chubut's provincial history there have been contradictions between different institutional policies, with one resource being developed without taking into account its impacts on others. Consequently, communication channels among the different institutions and other stakeholders should be improved. At the very least, it is recommended that one agency take the lead on promoting climate change adaptation and co-ordinating all other agencies in this area.

10. Declaration of an "agricultural emergency" allows for measures such as extending deadlines for taxes and loan repayments, as well as providing access to special loans. According to the law, losses must reach 50% in order to declare the state of emergency. That was not the case in the current drought.

Acknowledgments

I would like to express my gratitude to the International Institute for Environment and Development (IIED) for putting its facilities at my disposal and giving me the exceptional opportunity to do an internship in its Edinburgh office. Thanks to James Mayers for his interest, and for giving me the opportunity to collaborate in the project "Forest and Social Resilience to Climate Change" of which the present work forms a part. I want to express sincere thanks to Marie Jaecky for her continual assistance and friendship in the daily work. Special thanks go to Duncan Macqueen for his active and excellent supervision, comments, drafts reviews, and continual availability to help me throughout this research. I want to thank Sonja Vermeulen for her comments and suggestions on the final draft. Thanks to all the Edinburgh staff for making this internship a satisfying period with a friendly working atmosphere. I am deeply indebted to all of you. It is my pleasure to thank the AlβAN Programme (European Union Programme of High Level Scholarships for Latin America) for its economic support through which I was able to afford this post-graduate study (scholarship E0M100751AR). During this research, intensive collaboration was required with contacts in Argentina. I would like to express to all of them my most sincere gratitude. I would like to thank the editors Su Fei Tan for her initial comments and Fiona Hall for her great work in the final editing of this paper.

References

Barros, V., Scian, B., and Mattio, H. 1980. *Mapas de Precipitación de Chubut*. Dirección de Recursos Hídricos del Chubut. Chubut, Argentina.

Bava, J. *et al*. 2006. *Los bosques del Chubut. Distribución, estado y potencial para la producción maderera*. Consejo Federal de Inversiones (CFI) - Fundación para el desarrollo forestal, ambiental y del ecoturismo patagónico (FDFAEP) - Dirección General de Bosques y Parques de la Provincia (DGByP) - Centro de Investigación y Extensión Forestal Andino Patagónico (CIEFAP).

Bran, D. *et al*. 2001. Evaluación de poblaciones de coihue (*Nothofagus dombeyi*) del Parque Nacional Nahuel Huapi, afectadas por la sequía 98/99, a escala de paisaje (1:250.000). Informe sobre mortalidad: distribución y grado de afectación.

Campo Experimental Trevelin, INTA EEA Esquel. 2007. *Temperature and precipitation series data registered at Aldea Escolar INTA's meteorological station (Campo Experimental Trevelin)*. Period 1980-2006. Campo Experimental Trevelin, Esquel.

Castro, M.G. 2007. La sequía jaquea a la producción ovina. [No rain since last year and the sheep are dying]. In: *La Nación*, August 27th 2007 (www.lanacion.com.ar)

CNA. 2002. *Censo Nacional Agropecuario*. Instituto Nacional de Estadísticas y Censo de la República Argentina.

Davel M., Barroetaveña C. and Rajchenberg, M. 1999. Muerte del pino oregón por sequía en la region Andino Patagónica. Nota técnica. *Patagonia Forestal,* CIEFAP. Año V, N° 2.

Del Valle, H., *et al*. 1998. Status of desertification in the Patagonian Region: assessment and mapping from satellite imagery. *Arid Soil Research and Rehabilitation*, 12: 195-198.

DGByP. 2007. *La política de fomento forestal en la provincia del Chubut*. Inventario Forestal y Concesiones. Dirección General de Bosques y Parques del Chubut, Argentina. Available at: http://www.chubut.gov.ar/dgbp/archives/027865.php?id=-1 [Cited: October 2007]

FTDT and ITDT. 2006. *Comunicación nacional de cambio climático: vulnerabilidad de la Patagonia y sur de las provincias de Buenos Aires y la Pampa*. Informe final. Fundación Torcuato di Tella e Instituto Torcuato di Tella. Available at: http://aplicaciones.medioambiente.gov.ar/archivos/web/UCC/File/comunicaciones_nacionales/Vulnerabilidad_Patagonia.pdf [Cited: October 2007]

Guajardo, C. (2007). En Chubut la situación es muy grave y peligran las ovejas. [Chubut suffers its worst drought in the last decade and the farmers think that they will have important losses to sheep stocks]. *Clarin*, September 1st 2007 (www.clarin.com).

IPCC. 2007. Summary for policymakers. In: M.L. Parry *et al*. (eds). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.

Jobbágy, E., Paruelo, J. and León, R. 1995. Estimación del régimen de precipitación a partir de la distancia a la cordillera en el noroeste de la Patagonia. *Ecología Austral*: 5:47-53. Asociación Argentina de Ecología.

Kitzberger, T., Swetnam, T. and Veblen, T. 2001. Inter-hemispheric synchrony of forest fires and the El Niño-Southern Oscillation. *Global Ecology and Biogeography* 10 (3), 315-326.

Lanciotti, M.L. *et al*. 1995. *El área forestal de la Patagonia Andina Central y Norte*. INTA Bariloche, Centro Regional Patagonia Norte.

Magrin, G., *et al*. 2007: Latina America. In: M.L. Parry *et al*. (eds). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.

Paruelo, J., *et al*. 1998. The climate in Patagonia: general patterns and controls on biotic processes. *Ecología Austral* 8: 85-101. Asociación Argentina de Ecología.

SAyDS and UNSE, 2007. *Consultoría para transferir experiencias internacionales de pagos por servicios ambientales (PSA) y desarrollar las bases de dos estudios de caso*. Secretaría de Ambiente y Desarrollo Sustetable (SAyDS) and Universidad Nacional de Santiago del Estero (UNSE), Argentina. Martínez de Anguita, P., Ríos, N., Sarmiento, M. and Gallardo, J. C. C. (Eds).

SEP. 2007. *Informe temático: La población de los pueblos indígenas del Chubut (Primera Parte)*. Sistema Estadístico Provincial (SEP, Dirección General de Estadísticas y Censo, Provincia del Chubut.

SISCOM. 2007. *Sistema de información de comunas y municipios*. SISCOM, Chubut. Available at: http://www.chubut.gov.ar/siscom/home.php [Cited: October 2007]

SMN. 2007a. *Mapas normales de temperatura media. Período 1961-1990*. Servicio Metereológico Nacional, Buenos Aires, Argentina. Available at: http://www.smn.gov.ar/?mod=clima&id=65&clave=Media [Cited: October 2007]

SMN. 2007b. *Temperature and precipitation series data registered at Esquel meteorological station*. Period 1961-2006. Servicio Metereológico Nacional, Buenos Aires, Argentina.

SMN. 2007c. *Listado de estaciones metereológicas de superficie*. Servicio Metereológico Nacional, Buenos Aires, Argentina. Available at: http://www.smn.gov.ar/?mod=biblioteca&id=98 [Cited: October 2007]

Suarez, M.L., Ghermandi, L. and Kitzberger, T. 2004. Factors predisposing episodic drought-induced tree mortality in Nothofagus – site, climatic sensitivity and growth trends. *Journal of Ecology* 92, 954–966.

UMSEF. 2007. *Monitoreo de bosque nativo. Período 1998-2002. Período 2002-2006 (datos preliminares)*. Actualización 2006. Unidad de Manejo del Sistema de Evaluación Forestal (UMSEF), Dirección de Bosques, Secretaría de Ambiente y Desarrollo Sustentable.

PREVIOUS GATEKEEPER PAPERS

The Gatekeeper Series has been published since 1987. Here we list the most recent titles. These, plus many earlier titles, can be downloaded free from our website: www.iied.org/pubs/

SUBSCRIBING TO THE GATEKEEPER SERIES

To receive the Gatekeeper Series regularly, individuals and organisations can take out a subscription. Subscribers receive nine Gatekeeper papers a year. Subscriptions are free. For more details or to subscribe contact: IIED, 3 Endsleigh Street, London, WC1H 0DD, UK. Email gatekeeper@iied.org Tel: +44 020 7388 2117; Fax +44 020 7388 2826, or complete the online order form at www.iied.org

OTHER IIED PUBLICATIONS

For information about IIED's other publications, contact: EarthPrint Limited, Orders Department, P.O. Box 119, Stevenage, Hertfordshire SG1 4TP, UK Fax: +44 1438 748844 mail to: orders@earthprint.co.uk

There is a searchable IIED bookshop database on: www.iied.org/pubs

114. Food Industrialisation and Food Power: Implications for food governance. 2004.
Tim Lang

115. Biodiversity planning: Why and how should local opinions matter? 2004.
Sonja Vermeulen

116. Laws, lore and logjams: Critical issues in Indian forest conservation 2005.
Madhu Sarin

117. Adapting to Climate Change in East Africa: A strategic approach 2005.
Victor A. Orindi and Laurel A. Murray

118. Facing up to Climate Change in South Asia. 2005.
Mozaharul Alam and Laurel A. Murray

119. State Policies and Land Use in the Chittagong Hill Tracts of Bangladesh. 2006.
Golam Rasul

120. Organic Cotton: A New Development Path for African Smallholders? 2006.
Simon Ferrigno, Saro G. Ratter, Peter Ton, Davo Simplice Vodouhê, Stephanie Williamson and John Wilson

121. The Market for Voluntary Carbon Offsets: A new tool for sustainable development? 2005.
Nadaa Taiyab

122. Getting the Message Across: Promoting ecological agriculture in Bangladesh. 2006.
Dipankar Datta and Kamal Kar

123. Climate Change and Development Links. 2006.
Saleemul Huq, Hannah Reid and Laurel A. Murray

124. Mysteries and Myths: De Soto, property and poverty in South Africa. 2006.
Rosalie Kingwill, Ben Cousins, Tessa Cousins, Donna Hornby, Lauren Royston and Warren Smit

125. Working Together: Forest-linked small and medium enterprise associations and collective action 2006.
Duncan Macqueen, Sharmistha Bose, Septi Bukula, Cornelius Kazoora, Sharon Ousman, Noemi Porro and Horst Weyerhaeuser

126. Seed diversity in the drylands: Women and farming in South India. 2006.
Carine Pionetti

127. State-farmer partnerships for seed diversity in Mali. 2006.
Didier Bazile

128. Mainstreaming participatory forestry within the local government reform process in Tanzania. 2006.
Tom Blomley

129. Banishing the Biopirates: A new approach to protecting traditional knowledge. 2006.
Krystyna Swiderska

130. A People's Plan for Biodiversity Conservation: Creative strategies that work (and some that don't). 2006.
Tejaswini Apte

131. Legislators and Livestock: Pastoralist parliamentary groups in Ethiopia, Kenya and Uganda. 2007.
John Morton, John K. Livingstone and Mohammed Mussa

132. Who benefits from land titling? Lessons from Bolivia and Laos. 2007.
Susana Lastarria-Cornheil

133. Keeping CAMPFIRE Going: Political uncertainty and natural resource management in Zimbabwe. 2007.
Everisto Mapedza**133. Keeping CAMPFIRE Going: Political uncertainty and natural resource management in Zimbabwe. 2007.**
Everisto Mapedza

134. Land Reform and Rural Territories: Experience from Brazil and South Africa. 2008.
Julian Quan

135. Democratising Technology Choices? European Public Participation in Agbiotech Assessments. 2008.
Les Levidow

136. Underfed, Underpaid and Overlooked: Women, the Key to Food Security in South Asia. 2008.
Nira Ramachandran

137. Understanding and Supporting the Role of Local Organisations in Sustainable Development. 2008.
David Satterthwaite and Gabriela Sauter

137a. Association ANDES: Conserving Indigenous Biocultural Heritage in Peru. 2008.
Alejandro Argumedo and Tammy Stanner

137b. The Evolution of Casa Pueblo, Puerto Rico: From Mining Opposition to Community Revolution. 2008.
Alexis Massol-González, Avril Andromache Johnnidis and Arturo Massol-Deyá

137c: IIED-América Latina: neighbourhood credit funds in Buenos Aires, Argentina. 2008.
Florencia Almansi and Andrea Tammarazio

137d. The Organisation of Rural Associations for Progress, Zimbabwe: Self-reliance for Sustainability. 2008.
Dumisani Nyoni

137e.The Pastoral Women's Council: Empowerment for Tanzania's Maasai. 2008.
Maanda Ngoitiko

137f: The Urban Resource Centre, Karachi. 2008.
Arif Hasan

138: Public Participation and Oil Exploitation in Uganda. 2008.
Christoph Schwarte

139: Unlocking the Potential of Contract Farming: Lessons from Ghana. 2008.
Comfort Kudadjie-Freeman, Paul Richards and Paul C. Struik

140: Resilience to Climate Change in Patagonia, Argentina. 2008.
Rodrigo José Roveta

SUBMITTING PAPERS TO THE GATEKEEPER SERIES

We welcome contributions to the *Gatekeeper* Series from researchers and practitioners alike. The Series addresses issues of interest to policy makers relating to the broad area of sustainable agriculture and resource management. *Gatekeepers* aim to provide an informed briefing on key policy issues in a readable, digestible form for an institutional and individual readership largely comprising policy and decisionmakers within aid agencies, national governments, NGOs and research institutes throughout the world. In addition to this primary audience, *Gatekeepers* are increasingly requested by educators in tertiary education institutions, particularly in the South, for use as course or seminar discussion material.

Submitted material must be of interest to a wide audience and may combine an examination of broad policy questions with the presentation of specific case studies. The paper should conclude with a discussion of the policy implications of the work presented.

Style

***Gatekeepers* must be short, easy to read and make simple, concise points.**

- **Use short sentences and paragraphs.**
- **Keep language simple.**
- **Use the active voice.**
- **Use a variety of presentation approaches (text, tables, boxes, figures/illustrations, bullet points).**
- **Length: maximum 5,000 words**

Abstract

Authors should also include a brief summary of their paper – no longer than 450 words.

Editorial process

Please send two hard copies or an electronic version of your paper. Papers are reviewed by the editorial committee and comments sent back to authors. Authors may be requested to make changes to papers accepted for publication. Any subsequent editorial amendments will be undertaken in consultation with the author. Assistance with editing and language can be provided where appropriate. All illustrations and graphs, etc. should be supplied separately in their original format (e.g. as jpeg files) as well as being embedded within documents. This will allow us to modify the images where necessary and ensure good reproduction of the illustrations in print.

Papers or correspondence should be addressed to:
Gatekeeper Editor
Sustainable Agriculture, Biodiversity and Livelihoods Programme
IIED, 3 Endsleigh Street,
London WC1H ODD,
UK
Tel:(+44 020) 7388 2117
Fax: (+44 020) 7388 2826
e-mail: gatekeeper@iied.org

The Sustainable Agriculture, Biodiversity and Livelihoods (SABL) Programme coordinates the editorial process for the Gatekeeper Series. The Programme seeks to enhance and promote understanding of environmental sustainability and equity in agri-food systems and the use of biodiversity. It emphasises close collaboration and consultation with a wide range of organisations and takes a multidisciplinary approach. Collaborative research projects are aimed at identifying the constraints and potentials of the livelihood strategies of marginalised groups who are affected by ecological, economic and social change. These initiatives focus on the development and application of participatory approaches to research and development; resource conserving technologies and practices; collective approaches to resource management; the values of wild foods and biodiversity; rural-urban interactions; strengthening citizen voice and agency in policy processes, and policies and institutions that work for sustainable agriculture and biodiversity-based livelihoods.

SABL is part of the Natural Resources Group (NR Group) at IIED, which encompasses two other programmes: Drylands and Forestry and Land Use. The NR Group and its partners work to enable greater participation of marginalised groups and to promote more sustainable and equitable patterns of land and natural resource use. We build partnerships, capacity and wise decision-making for fair and sustainable use of natural resources. Our priority is the control and management of natural resources and other ecosystem services by the people who rely on them, and on the necessary changes needed at international and national level to make this happen.

ISSN 1357-9258

DEZA
DDC
DSC
SDC
COSUDE

Design: Piers Aitman
Print: TARA, an enterprise of Development Alternatives Group
100% recycled paper handcrafted by tribal women in India

tara

Sida

iied

International Institute for Environment and Development
3 Endsleigh Street, London WC1H 0DD
Tel: (+44 020) 7388 2117
Fax: (+44 020) 7388 2826
E-mail: sustag@iied.org
Website: www.iied.org