Improving soil quality and fighting erosion in the Andes

RIU

Validated RNRRS Output.

Work has been ongoing in the Andean valleys of Bolivia to find ways of combating soil erosion and falling soil fertility levels—problems which affect similar semi-arid areas throughout South America. These problems hit poor subsistence farmers particularly hard and are forcing people to migrate from the country into cities. One of the main reasons that soil fertility is degrading is the fact that fields are not being left to lie fallow for sufficiently long. Options identified to combat this include the use of grasses and leguminous cover crops like woolly pod vetch. These act as barriers, protecting bare uncropped land from erosion and also boost the fertility of the land they are grown on.

Project Ref: **LPP15:**
Topic: **4. Better Water Harvesting, Catchment Management & Environments**
Lead Organisation: **Simms, B. (Independent), UK**
Source: **Livestock Production Programme**

Document Contents:

Description, Validation, Current Situation, Current Promotion, Impacts On Poverty, Environmental Impact,

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Description

LPP15

A. Description of the research outputs

Research into Use
NR International
Park House
Bradbourne Lane
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UK

Geographical regions included:

Bolivia,

Target Audiences for this content:

Livestock farmers,

1. Improved soil and water conservation practices in hillside production systems I the Andean valleys of Bolivia.

2. RNRRS Programme: Natural Resources Systems Programme (NRSP).

3. Project code R6621. Lead institution in the UK: Silsoe Research Institute (Project leader: Brian Sims). Partner institutions in Bolivia: San Simon University (UMSS), Faculty of Agronomy, Cochabamba (contact Emigdio Céspedes); and the Tropical Agriculture Research Centre (CIAT) Santa Cruz (contact Miguel Eid).

4. Project R6621 was initiated in August 1996 and was completed in September 1999. The Project included complementary components from the University of Reading, UK (R6447 and R6638).

The principal problems that the Project addressed were **soil erosion** and **declining soil fertility.** These are recognised as serious problems throughout the semi-arid valleys of the **inter-Andean zone** of South America, having a particularly strong impact in areas of subsistence agriculture, contributing to poverty inducing processes through land degradation and declining productivity. Rural income decline coupled with population growth has given rise to rural-urban migration, which in turn has had increasingly damaging consequences for the rural poor.

The mid-Andes area (approximately 1500-4000 masl) includes Cochabamba and parts of Santa Cruz in Bolivia, which are typical of the inter-Andean zone which is characterised by a multitude of microclimates. These hillsides areas suffer from extreme rural poverty often associated with soil erosion and declining soil fertility. Of particular concern has been a rapid decline in the time that land is left in natural fallow as more land for crop production is used. The opportunity was therefore seen for the use of **vegetative or live-barriers and leguminous cover crops** to control erosion and improve soil fertility to increase productivity thereby **reducing poverty**.

The **outputs** resulting from the Project's activities can be grouped as follows:

i. Assessment of the **potential for adoption of soil and water conservation** (SWC) practices indicates that a number of pre-conditions need to be met before adoption is considered. These include farmers recognising land degradation problems, security of tenure and profitability of farming as well as viable SWC options which themselves can contribute to increased productivity. SWC systems need to be low cost, provide quick returns, be multi-functional with all stakeholders involved in their development, if adoption is going to be widespread.

ii. **The effectiveness of live-barriers and cover crops species** [1] in improving SWC and soil fertility was confirmed. Grass species (especially *Phalaris tuberoarundicaea*) are effective in erosion prevention and provide fodder for livestock. Widespread adoption of *Phalaris* occurred during Project implementation in preference to other species. However in areas of low rainfall with no irrigation, live-barriers are less suitable. Tarw*i* (*Lupinus mutabilis*) and woolly pod vetch (*Vicia villosa* ssp *dasycarpa*) were identified as the best cover crops with the greatest potential for yield increases for subsequent crops. However more research was identified as being required on cover crop management in Bolivia.

iii. **Socio-economic evaluation** of these SWC practices indicated viability with greatest potential for adoption of grass species as live-barriers, especially where there was the additional benefit of fodder production. In less intensive systems they are less viable and less likely to be adopted.

iv. **EUROSEM,** a mathematical model, was successfully used to **predict soil loss scenarios** of different soil conservation measures. Although EUROSEM was seen to have some potential for use as a land-use planning tool, it has limitations due to the extreme soil and micro-climate variability in hillsides systems.

v. **Promotion of Outputs** has been undertaken through training workshops, publication of refereed papers and distribution of extension material. The involvement of key stakeholders throughout the project cycle has promoted uptake with DFID-SRI receiving an award by the Bolivian Institute for Agricultural Engineers for contribution to research in the country.

[1] R6447(Adaptability of cover crops) identified potential cover crop species capable of germinating, flowering and setting seed within the growing season available, determined by temperature, photoperiod, and precipitation regime. Leguminous cover crops identified by this project provided species for on-farm experimentation.

5. Type of outputs.

Product	*Technology*	*Service*	*Process or Methodology*	*Policy*	*Other*
	ü		ü		

6. Main commodities.

The outputs of the Project are not, generally, commodity specific. They have been applied to a wide variety of crops across the agro-ecological zones of the mid-Andean valleys. The most important crop in the farming systems of this region is potato with pulses, other tuber crops and cereal crops also proving staple food requirements.

7. Production systems.

Semi-arid	**High potential**	**Hillsides**	**Forest-Agriculture**	**Peri-urban**	**Land water**	**Tropical moist forest**	**Cross-cutting**
ü		ü					ü

8. Farming systems

Smallholder rainfed humid	**Irrigated**	**Wetland rice based**	**Smallholder rainfed highland**	**Smallholder rainfed dry/ cold**	**Dualistic**	**Coastal artisanal fishing**
ü	ü		ü	ü		

9. Value addition through clustering.

Hillside SWC measures can be associated with almost any agricultural production activity in hillside production systems. Therefore the Project outputs (which comprise a stable, protected hillside environment for agricultural production) offer potential benefits to clustering with many other agricultural improvement projects.

The main outputs than can be promoted from this Project include: i) the use of live-barriers and leguminous cover crops in hillside environments; and ii) the participatory processes that were used. Their use is not restricted to the mid-Andean valleys where the research took place, but could be applied in other hillsides systems. The most suitable vegetative species will depend on local soils and micro-climates. Hence local adaptive research would need to be undertaken to ensure that the best local species are identified. This model could therefore be clustered with other projects not necessarily only those in Latin America, but others where land degradation through soil erosion and declining soil fertility are of concern. Three in East Africa are noted in the Table below.

In addition R6621 worked in close association with R6970 (Improved management and use of draught animals in the Andean hill farming systems of Bolivia). This project had, as its principal output, healthy, well fed animals equipped with a range of appropriate implements. It was (and continues to be) a complementary activity as small animals with appropriate associated lightweight implements offer the possibility to work better on the terraces forming between contour barriers. In fact a follow-up project to R6621, R7579 (Hillside Forage Production and Erosion Control) continued the hillside conservation work with mixed barriers of grass and legumes which provide better quality forage for farm animals.

Table. Potential clustering for increased impact of the outputs of R6621

Title	R number	Lead organisation	Lead person
CPP			
Green manure to control Striga[1]	R8436, R8194, R 7564	ARI-Kilosa, Tanzania	AM Mbwaga
Increasing food security and improving livelihoods through the promotion of integrated pest and soil management[1]	R8452, R8215	ARI-Kilosa, Tanzania	AM Mbwaga
Promotion and dissemination of integrated pest and soil fertility management strategies to combat Striga, stemborer and declining soil fertility in the Lake Victoria basin[1]	R8449, R8212	ICIPE	Zeyaur Khan
Hillside Forage Production and Erosion Control	R7579	UMSS	Félix Rodríguez
LPP			
Improved management and use of draught animals in Latin America	R6970	CIFEMA	Leonardo Zambrana

[1] Although associated with Striga and stemborer control, these projects promoted the use of live barriers (*Pennisetum* spp)

for multiple uses including rain water harvesting, soil erosion control, fodder production and stemborer control. In addition the use of green manures (Mucuna, Canavalia and Crotalaria) was promoted for both *Striga* control and soil fertility enhancement.

Validation

B. Validation of the research outputs

10. How were the outputs validated and by whom?

In Cochabamba the principal method of validation of outputs, in the first instance, was by means of student degree theses under close supervision from Project technical staff. Validation in Santa Cruz Department was carried out by researchers from CIAT. In most cases the validation work was highly participatory with farming communities taking a leading role in decision making. The principal evaluation methods used were:

i) Live-barriers
At each on-farm site various species of grasses, shrubs and trees were established to evaluate their performance as live-barriers.

The evaluation process allowed establishment and management practices to be determined. Researchers worked with NGOs to ensure ready access to farmer groups. The following parameters were assessed:

- Measurement of erosion and sedimentation
- Terrace formation, change of slope
- Plant development
- Soil fertility and soil moisture

ii) Leguminous cover crops (or green manures)
A crop/climate model was derived, validated, and run using six different cover crops with climate records at three experimental sites (R6647). This work was researcher designed and managed.

As a result of this work, legume species with potential for use as cover crops were used in five on-farm field trials with full farmer participation at five sites. The following parameters were assessed:

- Evaluation of soil N content
- Crop cover
- Days to flowering
- Dry matter yield
- Nitrogen content of plant tissue

iii) Simulation of the effects of live-barriers
Results from plot scale live-barrier studies on the effectiveness of live barriers for soil erosion control were used

to evaluate the EUROSEM soil loss prediction model. The model was then applied to a micro-catchment, comprising fields of varying sizes and slopes. The model was parameterized using values derived from field survey and from existing experiments in the area. A rainstorm, which would have a return period of five years, was constructed and soil erosion and runoff dynamics were simulated in the catchment. Grass barrier strips were then introduced into the simulation and the simulation results compared.

iv) Participatory evaluations

The different locations of the Project used different levels of participatory research. In Santa Cruz methods adopted were initially largely contractual in which the interested farmers provide land and labour. The design of the experiments, data recording and analysis, whilst discussed with the collaborators, were directed by scientists. In Cochabamba the style was largely consultative. Farmer collaborators gave their land and labour and, furthermore, were involved in the design and management of the experiments. From the first year a programme of consultation with farmers in the three valley provinces of Santa Cruz was initiated in a complementary project (R6638).

All communities were consulted in a final participatory evaluation involving:

- Individual and focus group discussions with farmers.
- Discussions with key informants in each area.

v) Economic analysis

The factors influencing household responses to SWC technologies were explored. This included an analysis of rural livelihood strategies, farming systems, and household characteristics to identify recommendation domains. Analysis of household decision-making based on focus group discussions and semi-structured interviews provided the basis for economic analysis using the actual costs and benefits faced by farmers.

vi) Validation through training

A significant validation process was through regional training workshops and validation plots. These frequently took place as part of separately funded extension and implementation contracts (see Q11) and had a marked impact on local validation of Project technologies.

11. Where and when were the outputs validated?

The Project validation activities during its lifetime (August 1996 – September 1999) took place in the Bolivian Departments of Cochabamba and Santa Cruz. In Cochabamba there were six sites in collaborating communities in the Provinces of Tiraque, Esteban Arce and Cercado. In Santa Cruz there were six collaborative sites in the Provinces of Vallegrande, Caballero and Florida.

Further validation, promotion (by a variety of development institutions) and adoption continued from the time of Project completion to the present and still continues today as the following examples illustrate:

Province of Tapacari (Lambramani), 2000

EU funded PRODEVAT project.

Province of Arque (Sopo Mayu), 2001 - 2002

EU funded PRODEVAT project.

Provinces of Arque and Tapacari (Municipios of Arque, Tacopaya and Tapacari)
EU funded PRODEVAT project

Province of Tapacari (Tumuyo B), 2002 – 2005
In association with the NGO ATICA.

Province of Arque (Ovejería, Larama, Challa, Sirka, Waycha) 2003
Funded by UNDP.

Provinces of Arque and Tapacarí, 2000 – 2003
As part of the European Union (EU) funded project PRODEVAT (see Q15).

Chuquisaca Department (Incahuasi, San Lucas, Culpina), 2002 - 2004.
A Danish Government funded validation programme with the *Programa de Apoyo al Sector de la Agricultura en Chuquisca* (PASACH).

Los Pinos, Caballero Province, 2004.
Graciela Tejada Pinell, 2004. Evaluación participativa de la adopción de barreras vivas de falaris en la comunidad de Los Pinos en Santa Cruz – Bolivia. (Participatory evaluation of the adoption of *Phalaris* live barriers in the community of Los Pinos, Santa Cruz – Bolivia). BSc (Environmental Engineering) Thesis. Universidad Católica Boliviana San Pablo. Unidad Académica Cochabamba. 90p.

Carrasco Province (Pojo municipio), 2003-2004
Funded by ATICA and Pojo municipality.

Since 1999 the Project has survived and thrived thanks to this type of contracts for its services. Of course, the flow of service contracts is in itself a measure of the value of the products in a natural resources conservation context.

Current Situation

C. Current situation

12. How and by whom are the outputs currently being used?

The main Project output (contour barriers of *Phalaris* grass) is being used by small and medium scale hillside farmers. Such family farms have typically 1-2 ha per family with an annual income of less than $US 500. The grass is transplanted vegetatively (the seeds are sterile) and placed on contour lines usually staked out with the help of the 'A' frame level. The distance between barriers is left to the farmer, but with the recommendation that the vertical interval should not exceed one metre. The current methodology for helping farmers to use the technology is by means of training courses (including the provision explanatory materials) and the donation and/or sale of vegetative material.

13. Where are the outputs currently being used?

Phalaris contour barriers are being widely used by small scale hillside farmers in the Departments of Cochabamba, Santa Cruz, La Paz, Chuquisaca, La Paz, Oruru, Tarija and in the Chaco.

14. What is the scale of current use?

The current scale of use is many thousands (perhaps 10 000) of small and medium scale farmers in the seven Departments mentioned in Q13. The rate of establishment can be gauged from the work of Graciela Tejada Pinell (Q11). She found that, in the community of Los Pinos, Caballero Province, the number of adopters grew from the original two farmers in 1997 to 18 in 2001 (41% of the 44 families in the community) with a total of 38 fields protected. By 2005 100% of families had adopted the practice with well over 4 km of *Phalaris* barriers established.

15. Programmes that have assisted promotion

The highly successful promotion and adoption of the Project's main outputs has been assisted by the following:

i) *International rural development programmes*
The EU-funded project to develop the valleys of Arque and Tapacarí Provinces in Cochabamba Department (PRODEVAT) quickly recognised the value of *Phalaris* barriers and associated leguminous cover crops for soil erosion control and fertility enhancement. This resulted in a series of tightly focussed contracts with the Project national staff for installing live barriers and leguminous cover crops (see Q11).

The British Embassy in La Paz funded a one-year diffusion phase to the Project in 1999. This extension phase facilitated adoption of live barriers by approximately 1000 farm families.

It is interesting to note that the Project has gained an enviable international reputation with research workers seeking placement from, for example, Wageningen University (Netherlands); the Foundation for Sustainable Development (USA); Cranfield University (UK); and Swiss Federal Institute of Zurich, Switzerland.

ii) The synergistic links between associated DFID-funded R&D projects
Links with the research projects R6638, R6447 and R6970 have been mentioned in Q9. In addition case studies from not only Bolivia but also Nepal and Uganda examined factors promoting and hindering scaling up and provided useful insight to local stakeholders (R7866). The ability of such associated projects to combine their resources and to build on the successes of each has been an important factor in creating a critical mass as a platform for promotion and adoption. Of even greater importance was the follow up project R7579 which deepened knowledge of the live barrier technology and spread it to new areas. Ultimately project R8182 (Strengthening technical innovations. 2002-2005) has also had an impact on dissemination of the Project's outputs to new geographical regions in the *altiplano* and meso-thermic valleys. The clustering of R&D projects in this way has had a positive impact on output dissemination.

iii) The formation of conservation-focussed Platforms for joint action

Two Platforms have been created which bring together organisations interested in the promotion of the conservation of natural resources in Bolivia. These are:

- **Soil and water conservation platform**. This platform, which receives financial assistance from two NGOs (MISEREOR and AGRECOL) has prospered well and now has three regional branches (for Cochabamba, the Chaco and the *Altiplano*).
- **Natural resources conservation platform** which does not receive financial assistance for a secretariat and so has had less impact.

iv) Demand for SWC services from diverse sources

There is a constant demand for SWC services from municipalities, NGOs and other national programmes, for example the National Programme for Combating the Effects of Climate Change (PNCC). This demand, often articulated via the Platforms, maintains the Project in an active and progressive mode.

v) Training as a diffusion strategy

Training forms a strong base for future champions of SWC. SWC concepts are included (by the Project) in university-level courses, NGO technical training and in training workshops at all levels. Trained personnel are important ambassadors for disseminating the Project's products.

vi) Seed production

The leguminous cover crop species introduced by the Project have been promoted by two organizations, both of the UMSS. The Centre for Forage Crop Research (CIF) has tested and bulked seed (e.g. of *Vicia* spp. and tagasaste (*Chamaecytisus proliferus* ssp *palmensis*). Seed is now being produced by the forage seed company SEFO. CIF also supplies *Phalaris* plants for vegetative reproduction.

vii) The new focus of the Bolivian government

The redistributive polices of the current Bolivian administration, led by the MAS party, has had and will have a marked impact on the focus of policies and strategies to reduce poverty in the country. Although the administration is relatively new, it has already made provision for Bolivia's oil riches to be directed at poverty alleviation. One example of this is the hydrocarbon tax (IDH) which, amongst other activities is being used to fund poverty reducing activities which will include appropriate poverty alleviating R&D in the future. The government is also strongly promoting food security through sustainable agriculture and the conservation of natural resources. The Project will have an important role to play in the realisation of these progressive thrusts.

Current Promotion

D. Current promotion/uptake pathways

16. Where is promotion currently taking place?

Most of the promotion of the Project outputs is taking place in Bolivia. The Project follows a thorough promotional strategy within the country, but with an increasingly important international impact (e.g. in Chile and Cuba). Promotion is taking place through the following methods:

- Rural development contracts
- Extension bulletins
- Videos
- TV and radio
- Regional agricultural fairs
- Extension visits
- Field days
- National and International SWC seminars and workshops
- National and International Conferences
- Courses
- International courses (Chile and Cuba)
- Inter-institutional collaboration

At the local level, the incorporation of elements of the Project into R8182 (Innova) has meant better promotional coverage within Bolivia, especially in the *altiplano* and the mesothermic valleys of Santa Cruz.

17. What are the current barriers to greater adoption?

As the adoption rate in Los Pinos shows (Q14) there are few barriers to effective scaling out of the live barrier concept. Provided that an initial supply of *Phalaris* slips is available, the expansion process becomes self sustaining.

Phalaris plants are currently available (at the UMSS, for example but also in the private sector), and multiplication plots at community level have been easy to establish. It would always be possible for greater impetus to be given to the process by the Agricultural Development Secretariat (SEDAG) and in future projects this aspect of scaling up should be incorporated at the outset.

From the Project's perspective some barriers have been identified and include:

- Government policies. As indicated in Q15(vii) this situation has now changed and the challenge will be for the Project to assert itself as a major player in the execution of new government policies for sustainable agriculture.

- The initial stimulus needed in areas new to the concept that introducing SWC measures carries a cost which has to be covered. There are still many hundreds of thousands of farm families to reach and the Project is sometimes frustrated by the lack of interest in promoting SWC. The current focus on production chains is all very well, but if there is no production because of unsustainable agricultural practices, then there will be no production chain.
- Associated with the previous point is the seeming lack of appreciation of the problem in many farming communities. The steady decline of soil fertility and soil degradation is still seen as a natural process which is irreversible. Strong messages are required at the national level for recognition of the dangers to be universally appreciated.

Scaling–up and out requires a coherent series of linkages between actors at community level; municipal and Departmental government level; and national government policy makers. At the time of the Project this was not the situation in Bolivia and it remains to be seen whether stronger linkages can be forged with current policies. The indications are positive.

In the meantime the present situation of providing technical expertise to NGOs, international development projects and regional governments seems to be working very well.

18. What changes are needed to remove these barriers?

Marshalling the developmental forces of the Ministry of Rural Development, Agriculture and Environment and SEDAG at national and regional level would be the first step in ensuring that policies favouring the environment, sustainable agriculture and poverty reduction are designed and implemented. Freeing the government from its neo-liberal market paradigm and replacing it with a genuine poverty-reducing sustainable production alternative would be the greatest step forward to scaling-out SWC technologies. Current signs are good and the government has recently passed legislature favouring ecological and sustainable agriculture.

One of the weakest links in the middle level actors is lack of human capacity to implement large scale projects aimed at achieving these goals. Departmental and municipal development authorities (the key actors following the Popular Participation legislature for decentralisation in the mid-90s) are notoriously divorced from agricultural communities and rarely address their needs; preferring instead high visibility infrastructure projects which are more likely to curry favour among voters[1]. Inserting competent technical people at this level with vision and the ability to empathise with community-level demands is a key factor in securing development investment for sustainable rural development.

Targeting promotional messages at the NGO community has, of course, taken place. It is difficult to fault the post-Project team on their efforts to inform this community, but of course more could always be done in the way of printed and broadcast material, field workshops and courses. These activities need to be financed and an insufficient (from the Project's perspective) flow of funds has been frustrating.

At the community level it is very likely that the adoption of the farmer field school (FFS) approach would have far-reaching community and district level impacts. The FFS approach has proved to be remarkably effective in promoting similar technologies in diverse developing countries.

19. What lessons have been learnt on the best methods to achieve adoption?

Declining productivity, land degradation and poverty remain a matter for concern in much of the mid-Andes. Different communities have different perceptions of the causes and may not be willing or able to consider suitable SWC technologies. This may be because productivity has not fallen below a critical level, households may be unwilling to risk new technologies when their farms are very small or alternative income sources have been identified. However there is a need to confirm which factors affect the adoption of SWC and to target appropriate interventions towards individuals and communities who are in a position to adopt them. There is a clear need to identify which factors promote greater awareness of SWC and to target appropriate interventions towards individuals and communities who are in a position to adopt them.

Although there is no simple recipe for promoting uptake and achieving adoption, the process needs to give attention to both institutional and community issues. This includes the involvement of all stakeholders in a participatory process, where farmers identify and prioritise the problems with which they were faced. At the same time potential solutions jointly agreed by farmers, extension and research personnel, require implementation by farmers followed by joint evaluation by all stakeholders. This process required commitment from both research and extension organisations involving greater emphasis on facilitation and less on teaching as well as recognition of the key role that farmers must play in the research and development process. Other facilitating factors included:

- Building institutional and community capacity in participatory approaches.
- Ensuring that institutional roles were well defined.
- Ensuring close integration of research and development activities.
- Ensuring feed back to local communities after researcher analysis of results.
- Ensuring farmers participating in the process were representative and had the capacity, after training, to lead and communicate with other farmers and promote farmer-to-farmer extension.
- Ensuring the ready availability of training and extension material that could be used as an integral part of a communication process.
- Ongoing access to planting material.

Cooperation agreements with other rural development institutions and local municipalities have been a particularly synergistic method of scaling-out. The exchange of experiences and horizontal training activities has been mutually beneficial for programmes actively involved in SWC activities at farming community level. Although the promotion pathways to the target institutions and the farming community are in place, there remains a need to strengthen these to ensure that new knowledge is effectively disseminated.

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[1]

Having said that, one of the obstacles faced by the Project in its scaling-out activities is that poor rural infrastructure (especially roads) has made access to remote areas particularly difficult. The steady improvement in the rural road network will help to alleviate this constraint.

Impacts On Poverty

E. Impacts on poverty to date.

20. Impact studies on poverty in relation to the outputs

The Project undertook one partial study of the impact on poverty in 2004. The study took place in Los Pinos, Caballero Province, Santa Cruz Department, Bolivia:

Graciela Tejada Pinell, 2004. Evaluación participativa de la adopción de barreras vivas de falaris en la comunidad de Los Pinos en Santa Cruz – Bolivia. (Participatory evaluation of the adoption of *Phalaris* live barriers in the community of Los Pinos, Santa Cruz – Bolivia). BSc (Environmental Engineering) Thesis. Universidad Católica Boliviana San Pablo. Unidad Académica Cochabamba. 90p.

An analysis of costs and benefits of live barrier SWC technology revealed the following information from the farmers' perspective:

IMPACT OF CONSERVATION	BENEFITS AND COSTS
Farmers perceptions of advantages	**Quantification of benefits**
Direct benefits Increase in crop yields Reduced soil erosion Sediment trapped in field Other fields protected from storm damage Less work in repairing storm damage Material available for mulching or incorporation Increased soil moisture Increased soil organic matter Intensification of farming system Reduced incidence of pests and weeds Reduced labour for weeding	*Productivity increase* Increase in yields and their value less any increase or decrease in costs of production.
Indirect benefits Increased livestock fodder Firewood and building materials Fruit Shade in the fields	Value of additional fodder, wood, sticks, fruit etc.
Farmers' perceptions of disadvantages	**Quantification of costs**

Time taken for establishment and maintenance Limited effectiveness in first year Reduction in area for cropping Competition with crops for nutrients, soil moisture, and sunlight Increases incidence of pests and weeds	*Establishment and maintenance* Materials (Seed, plants, fertiliser, transport, fencing) Labour (skilled and unskilled) *Loss of productivity on lost land* Loss of gross margin with no conservation on area occupied by conservation

It was shown that farming system intensification as a result of live-barriers greatly enhances viability. In particular the biomass produced by *Phalaris* makes it particularly attractive as fodder for livestock and this is an important reason for its expanding use.

21. How have the poor benefited?

Livelihood Impact

In areas where there has been widespread adoption, as for instance in Los Pinos, the incorporation of contour barriers into the farming system has brought a consequential series of benefits which have had a positive impact on local livelihoods, through an increase in incomes. This has been achieved as a result of greatly reduced erosion allowing the processes of soil fertility improvement to become effective. This in turn encouraged the use of additional fertiliser, either organic manure or inorganic fertiliser as the risk of losing such amendments via runoff was reduced. The resulting increases in production and productivity ensured increases in family income in the early years after adoption of the technology.

Stabilising hillside agricultural plots not only means that fertility declines can be halted and investments become more worthwhile, but it also means that more rainwater can infiltrate into the soil rather than being lost as runoff. This not only reduces the risk of cop failure in drought prone regions, but can actually enable an additional catch crop to be produced to make use of residual soil moisture after harvesting the main crop.

One of the advantages of *Phalaris* grass barriers has been confirmed since 2001. This is that the grass can adapt to regions at high altitude (>3000 masl) which other grass species cannot do. This is a region inhabited by the most extremely resource-poor farm families and so increasing dry-season fodder provides direct benefit to this underprivileged group.

Live barriers of suitable species are a valuable source of materials which can have a direct impact on livelihoods. The most important product is fodder for livestock, especially during the dry months of the year. Fodder can be used for large stock such as bovines and equids, and also for smaller stock such as guinea pigs, an important protein source for the farm family in the Andean hill farming systems.

Environmental Impact

H. Environmental impact.

24. Direct and indirect environmental benefits

The environmental impact of live barriers and leguminous cover crops is very positive and very quickly realised. Reduction of soil erosion from hillside agricultural areas not only reduces the loss of valuable topsoil and so the increasing decline in crop yields, but it also has important downstream effects. Steams run free of their traditional sediment load; reservoirs do not silt up requiring expensive dredging; and drinking water becomes more abundant and less contaminated.

An additional environmental advantage is that the availability of forage in the dry season (from the contour barriers and leguminous cover crops) reduces the pressure on forests to provide this necessity. Forest resources can therefore be left intact as agricultural and livestock production become more sustainable and less dependent on outside resources.

25. Adverse environmental impacts.

There are no adverse environmental impacts.

26. Increased capacity to cope with the effects of climate change.

The resilience to hurricane Mitch of barrier-protected hillside plots in Honduras has been mentioned (Q22). Climate change is likely to make such extreme weather events more frequent in the future. Increasing desertification – a real threat in the areas of the Project and a major concern of the Bolivian government – will be combated by the increased rainwater infiltration and reduced loss of water through runoff in hillside regions.

In summary, the Project's technologies will greatly improve the capacity of poor people to cope with the effects of climate change.
