Improved livestock practices for highland communities

RIU

Validated RNRRS Output.

In Bolivia, work has been underway to find better ways of managing draught animals in the Andes. As part of this, the project has addressed the need to treat animals well and keep them healthy so that they can work for longer. But, importantly, it has also tackled the fact that inappropriate tillage practices are causing the delicate soils of the area to degrade, reducing productivity and forcing people to leave land on which they can no longer make a living. The project's outputs include the development of better ways of allocating feed, housing animals and caring for their health. It has also developed new equipment specifically for working the delicate soils found in hillside environments, and identified better ways to manage soil and conserve water.

Project Ref: **LPP12:**
Topic: **2. Better Lives for Livestock Keepers: Improved Livestock & Fodder**
Lead Organisation: **Simms, B. (Independent), UK**
Source: **Livestock Production Programme**

Document Contents:

Description

LPP12

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Bolivia, India, Mexico,

Target Audiences for this content:

Livestock farmers,

A. Description of the research outputs

1. Improved management and use of draught animals in the Andean hill farming systems of Bolivia (Prometa-CIFEMA).

2. RNRRS Programme: Livestock Production Programme (LPP).

3. Project code R6970. Lead institution in the UK: Silsoe Research Institute (Project leader: Brian Sims). Partner institution in Bolivia: San Simon University (UMSS), Centre for Research, Training and Extension in Agricultural Mechanization (CIFEMA), Cochabamba, Bolivia (contact: Leonardo Zambrana).

4. Project R6970 was initiated in FY 1997/98 (April 1997) and, with a one-year extension, ran for four years to October 2001. The Project was preceded by a preparatory study in 1996 (R6605) which described and analysed the priority factors affecting draught animal use within Latin American hillside farming systems. This was a complement to existing R&D experiences which had principally emanated from sub-Saharan Africa and Southeast Asia. The principal **problems** that the Project addressed were:

- The **falling productivity** of hillside farming systems due, in part, to land degradation caused by inappropriate tillage practices on sloping land;
- **Poor animal husbandry techniques** and the **lack of appropriate implements**.

The consequent erosion of rural livelihoods coupled with population growth had given rise to rural-urban migration with its resulting increasingly damaging consequences for the rural poor.

The **outputs** resulting from the Project's activities and available from 2001 can be grouped as follows:

- Recommendations for improved management of working animals (feed resources, nutrition, use, health, housing) developed, validated and disseminated;
- Equipment for working animals in hillside environments developed, validated and disseminated;
- Recommendations for improved management for soil and water conservation developed, validated and disseminated.

Detailed outputs in each of the category areas are as follows:

- **Animal health**. Training and equipping rural paravets. Validation of local ethno-veterinary **vegetable products for parasite control**. Fodder availability and energy requirements throughout the year. **Fodder production** by diverse species of fodder crops and improved pasture / fallow.
- **Diversification of animal use**. High-lift harness and a range of **lightweight implements for equines** (conventional and reversible ploughs; ridgers, harrows; weeders; and carts. **Equipment for bovines** includes: single yokes; tined rake; scraper; reversible ploughs; seeders and carts.
- **Technologies for soil and water conservation** include: winged chisel plough; direct seeder; tied ridger; live contour barriers for fodder production.

5. Type of outputs.

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

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 and cereal crops also proving staple food requirements. The application of draught animal power (either with equids or bovines) is common throughout all the farming systems of the Andean region.

7. Production systems.

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

8. Farming systems

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

9. Value addition through clustering.

Draught animals for agricultural work naturally have to be associated with other agricultural inputs and assets to be productive and improve rural livelihoods. On their own draught animals will consume fodder but will not produce benefits unless judiciously employed in productive enterprises. Therefore the Project output (which is healthy, well fed animals equipped with a range of appropriate implements) offers potential benefits to clustering with many other agricultural improvement projects. One example of successful clustering is with hillsides soil and water conservation through the use of live barriers established on the contour. The naturally forming terraces between the barriers provide an ideal environment for the use of lightweight implements and reversible tillage implements. Projects R6621 (Hillside Soil and Water Conservation) and one of its immediate follow-up projects R7579 (Hillside Forage Production and Erosion Control) are good examples of local clustering potential. Similar synergisms could be expected if the Project model were to be transferred to other continents.

The Project is probably one of the few examples, amongst the RNRRS projects, of a successful private-public partnership that has responded to the needs of the poor whilst still making commercial sense. The synergy between the R&D and instruction elements of Prometa and the commercial CIFEMA-S.A.M. factory has produced benefits for resource poor farmers in a sustainable way in a commercial environment.

Validation

B. Validation of the research outputs

10. How were the outputs validated and by whom?

The Project was based in the Agronomy Faculty of San Simon University and so the principal method of validation of research outputs, in the first instance, was by means of student degree theses closely supervised by project staff.

The research was carried out in three provinces of the Cochabamba Department (Ayopaya, Capinota, Tiraque), chosen because they represent the broad spectrum of agro-ecological zones, socio-economic circumstances and draught-animal usage within the region, and consisted mainly of participatory selection and evaluation of improved animal husbandry techniques, implements for the more efficient and diversified use of the available work animal resources and technologies for improved soil and water conservation.

In each of the 6 collaborating communities the research work was co-ordinated through a group of collaborators (3-5 farmers), elected by the communities and confirmed by the local grass-root organisations. The members of these groups were not only recognised experts on the research issues selected by the communities, but they were also, generally, known local innovators and researchers. The groups organised and co-ordinated the involvement of the wider community in the implementation of farmer-participatory trials and the continuous iterative process between the communities and the Project, that have formed the participative basis for the development of technologies and strategies.

In addition, the Project implemented its activities and organised the wider promotion of the outputs achieved through a range of different organisations and institutes. In each of the provinces, specific collaborators were carefully selected on the basis of an established presence within the area and a proven capacity for the development, and the dissemination and diffusion, of technologies and strategies.

The research activities conducted by the Project used the operational framework described above, all went through a first stage of participatory selection exercises, during which the communities chose the technological options or strategies to go forward to the participatory evaluation stage.

The participatory evaluation stage followed a novel ‘to and fro’ methodology whereby farmer-selected technologies were produced in prototype form in the Project’s workshop and delivered to farming communities for on-farm evaluation (after a period of training in the correct use of the equipment). Following field trials the performance of the prototype was discussed and modifications effected in the workshop before returning to the field. The process continued to the pre-production prototype stage.

11. Where and when were the outputs validated?

The validation process described in Q10 took place principally in the specific regions of Cochabamba Department covering the main agro-ecological regions as indicated. Further validation of no-till seeders took place in a range of wheat producing regions in many Departments of Bolivia (via the Protrigo project), and also in India and Mexico as part of CIMMYT's (International Maize and Wheat Improvement Center) world wide R&D activities.

Output validation took place throughout the Project life, that is from 1997 to 2001. Validation has continued after 2001 to the present through Prometa-CIFEMA's own efforts and via a series of agreements with local authorities, farmers' groups and NGOs and a subsequent DFID project, R8182 (Innova: Strengthening technological innovation systems in potato-based agriculture in Bolivia).

Current Situation

C. Current situation

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

The Project outputs are being used by many thousands of small and medium scale producers of basic food crops (potato, broad-bean, wheat and other grains), principally at the subsistence level or slightly above. Such family farms have typically 1-2 ha per family with an annual income of less than $US 500.

The majority of the animal traction implements are used for crop production, from soil preparation to harvest. Natural remedies for internal parasite control are being increasingly used as there employment is promoted by development programmes (e.g. UNDP). Improved nutritional outputs are also being increasingly disseminated by NGOs (e.g. PASAT diffusing clover for forage). In this sense NGOs are also users of the Project's outputs, other examples being the Quinoa producers association and the NGO CIAPROT.

13. Where are the outputs currently being used?

The outputs are in use in Bolivia in the Andean region which comprises the highlands (*altiplano*) the inter-Andean and lower (mesothermic) valleys. The Departments of highest demand are: Cochabamba, La Paz, Oruro, Potosí, Chuquisaca, Tarija and Santa Cruz. The technical and socio-economic characteristics of the region include: sloping terrain with a high risk of soil erosion; small plot sizes; and widespread use of animal traction as the principal farm power source.

14. What is the scale of current use?

The most readily measurable indicator of current usage of the Project's outputs are the sales figures for agricultural equipment produced and sold by the associated commercial factory (CIFEMA-S.A.M.). The following two Tables give production and sales figures for the FYs following the end of the Project:

Production of tools and equipment by the CIFEMA factory

	Production Year 2002/03	2003/04	2004/05	2005/06	TOTAL
Arado montaña	52	48	100	0	**200**
Arado combinado	271	563	514	294	**1642**
Arado reversible bovino	699	456	458	400	**2013**
Arado Coutrier	0	0	0	0	**0**
Arado múltiple equino	45	55	11	50	**161**
Rastras de aletas	106	95	190	150	**541**
Carpidora bovino	50	85	72	0	**207**
Cavadora de papa	69	146	0	0	**215**
Enfardadora de heno	20	50	65	50	**185**
Peladora de maní	0	0	0	0	**0**
Picadora de forraje	12	10	0	20	**42**
Desgranadora de maíz	0	50	500	0	**550**
Trilladora de granos	5	33	34	38	**110**
Rastra de discos	11	3	10	0	**24**
Carreta	1	8	0	0	**9**
Arado reversible equino	40	15	11	30	**96**
Arado sencillo equino	20	17	100	0	**137**
Rastrillo	0	0	0	0	**0**
Cultivadora Prometa	0	0	0	0	**0**
Niveladora	40	0	23	25	**88**
Arado reversible Prometa	43	74	73	0	**190**
Sembradora Prometa	10	45	17	30	**102**
Carpidora equino	0	40	15	0	**55**
Sembradora siembra directa	6	0	0	2	**8**
Fumigadora con ruedas	2	7	0	0	**9**
TOTAL	**1502**	**1800**	**2193**	**1089**	**6584**

Sale of tools and equipment by the CIFEMA factory

	Production Year 2002/03	2003/04	2004/05	2005/06	TOTAL
Arado montaña	83	44	52	38	**217**
Arado combinado	569	520	574	366	**2029**
Arado reversible bovino	864	432	507	408	**2211**
Arado Coutrier	8	1	7	29	**45**
Arado múltiple equino	51	21	16	25	**113**
Rastras de aletas	131	101	148	108	**488**
Carpidora bovino	112	6	30	49	**197**
Cavadora de papa	73	78	16	37	**204**
Enfardadora de heno	17	24	90	39	**170**

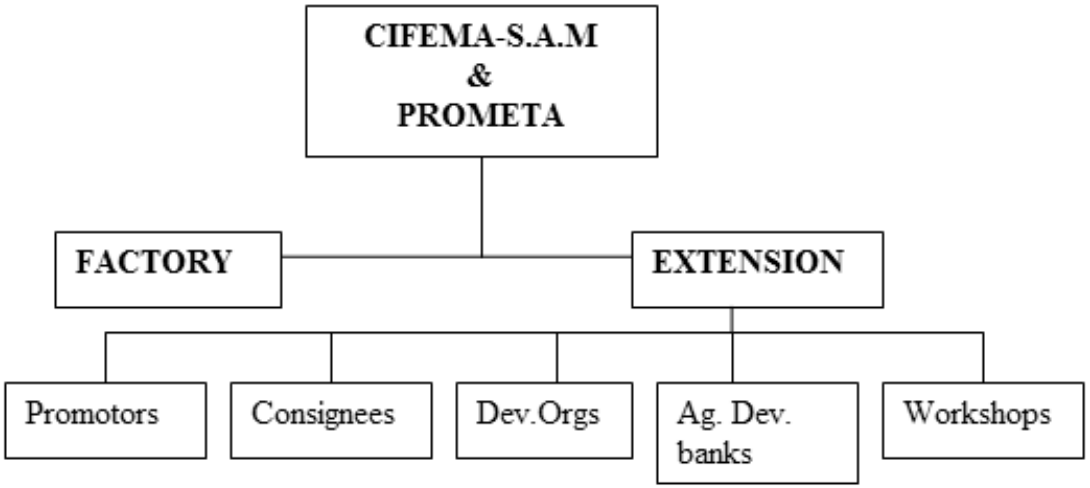
Peladora de maní	4	3	1	0	**8**
Picadora de forraje	11	2	1	22	**36**
Desgranadora de maíz	11	69	301	34	**415**
Trilladora de granos	15	31	35	23	**104**
Rastra de discos	12	2	10	2	**26**
Carreta	10	1	0	0	**11**
Arado reversible equino	35	16	12	29	**92**
Arado sencillo equino	88	38	34	36	**196**
Rastrillo	0	0	1	75	**76**
Cultivadora Prometa	5	0	4	0	**9**
Niveladora	20	23	17	41	**101**
Arado reversible Prometa	92	39	50	13	**194**
Sembradora Prometa	20	43	19	31	**113**
Carpidora equino	25	24	15	1	**65**
Sembradora siembra directa	0	0	1	1	**2**
Fumigadora con ruedas	4	4	1	0	**9**
TOTAL	**2260**	**1522**	**1942**	**1407**	**7131**

The point to note from the information presented in the production and sales tables is that there is a healthy turnover of a wide range of products. Sales may exceed production in any given period as stocks are used up. The Project has helped to maintain this buoyant trend by adding diversity to the production line.

15. Programmes that have assisted promotion

There are five important elements to the successful promotion of the Project's outputs. These are:

i) The diffusion strategy of the Project starts with the multiplication of technologies by means of a coordination with the CIFEMA-S.A.M. factory where the implements are batch produced. CIFEMA-S.A.M. together with Prometa-CIFEMA has developed a promotional platform with the following structure:



Training forms an additional part of the CIFEMA family, with a strong potential for increasing diffusion. Products are used in university training courses, NGO technical training and in training workshops at all levels. Trained personnel are important ambassadors for disseminating the Project's products.

Potential areas for expansion of product diffusion have been carried out for example by Javier Rocha (Identification of potential areas for the diffusion of animal traction products, 2005) and by Rodrigo Paz and his team in the post-Prometa technology diffusion study funded by LPP.

ii) The synergistic links between associated DFID-funded R&D projects. Links between R6970, R6621 (Soil and water conservation on Bolivian hillsides) and R7579 (Forage production and erosion control) have led to synergy in the development of vegetative conservation measures, which also serve as work animal forage banks in the dry season. The establishment of vegetative contour barriers has resulted in modifications of animal use and the Project has developed equipment (reversible ploughs, vertical tillage implements) for single animals (equines and bovines) to aid the formation of terraces. The subsequent DFID project R8182 (Strengthening technical innovations) has also had some impact on dissemination of Prometa-CIFEMA'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 reorganisation of the Bolivian national agricultural research strategy (into SIBTA – the Bolivian Agricultural Research System) has had some impact on the Project's promotional success. Prometa-CIFEMA has participated in a range of SIBTA-funded activities which are characterised by emanating from demand from farming communities. Activities in this category focus on supply chains and the interconnectivity of the value chain links. Examples are the development of equipment for the groundnut, potato, quinoa, milk and fruit supply chains.

iv) NGO and development thrust demand for the Project's outputs has been a constant stimulus to Prometa-CIFEMA. Not only have NGOs been an important client base for CIFEMA's products and services, but collaborative R&D projects between Prometa-CIFEMA and NGOs has been a fertile source of innovative ideas,

designs and, eventually, products on the market. Examples are: the promotion of ethno-veterinary products by UNDP; and development of equipment for oregano processing with CIAPROT.

v) 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. Prometa-CIFEMA is participating in this process through the receipt of R&D funding from the Science and Technology Research Programme (DICYT) of UMSS. Actual projects include: *in situ* water harvesting on sloping land in low rainfall environments; and forage processing equipment (choppers and balers) for the milk supply chain.

Current Promotion

D. Current promotion/uptake pathways

16. Where is promotion currently taking place?

The vast majority of promotion of the Project outputs is taking place in Bolivia. Additional promotion is taking place in Central America (Honduras and Nicaragua) as a result of technology transfer via the Latin American Animal Traction Network (RELATA). Promotion of draught animal weeding technology has also taken pace in **Uganda** via cross fertilisation with project R7401 (Draught animal weeding).

The Project follows an aggressive promotional strategy within Bolivia, but with an increasingly important international impact. Promotion is taking place through the following methods:

Extension bulletins

Videos

TV and radio

Regional agricultural fairs

Extension visits

Field days and Technology days

- Commercial production of tools and implements and regional distributors

National and International draught animal power seminars and workshops

National and International Conferences

Courses

International courses (Honduras, Chile and Cuba)

Inter-institutional collaboration

At the local level, the incorporation of elements of Prometa-CIFEMA into R8182 has meant better promotional coverage within Bolivia, especially in the *altiplano* and the meso thermic valleys of Santa Cruz.

17. What are the current barriers to greater adoption?

Although the adoption rate for draught animal technologies in Bolivia can be considered to be satisfactory, as evidenced by the sales of equipment, the nutritional and animal health aspects of the Project have not resulted in widespread adoption to date. Nevertheless some barriers to greater scaling out have been identified:

- **Retail price of equipment seems high to potential users.** Prices are clearly a reflection, in part, of the costs of raw materials, especially of different steel sizes and sections. As CIFEMA-S.A.M. operates in an open, uncontrolled, market, there is little that can be done to reduce retail prices further. However, an increasingly important factor operating in the inter-Andean valley economy is the impact of migratory labour, both seasonally within Bolivia, and abroad. This labour injects cash into the economy and can have a marked impact on the purchasing power of farm families.

- **Development is identified with tractor use**. Although the present administration is actively pursuing a policy of poverty reduction and improved rural livelihoods, some of the thrusts in this direction are in the process of refinement as policies are developed. Access to farm power is a critical factor in achieving increased farm production and productivity. Currently the government is focussing on supplying tractors to improve the situation and is giving less weight to improvements in draught animal power technology. The increase in available farm power from tractors is to be applauded and there is a strong expectation that the emphasis on animal traction will increase as appropriate technologies for the different strata of producers are identified and sought. CIFEMA actually has animal traction development contracts signed with SEDAG (the Departmental entity of the Ministry of Agriculture) for this purpose.

- **Negative climatic conditions**. The problems caused by natural phenomena such as drought, severe frosts and flooding limit the potential for the purchase of agricultural equipment rather than the absolutely essential inputs of seeds and fertiliser.

18. What changes are needed to remove these barriers?

Perhaps the most important change that is needed is to redouble efforts to scale up the promotion of draught animal and other lower cost technology for resource poor farmers. The present government is very aware of the need for **practica**l measures to combat rural poverty, rather than the rhetoric more often associated with policies aimed at achieving this goal. This change would be brought about by exposing government decision makers to

the technical, social and economic realities of small farm power supply and mechanization. Rather than grand gestures (e.g. supplying tractors with little technical back up and few associated implements) a clear-headed analysis of the realities of the situation should result in a dramatic shift in policy towards promoting draught animals as a viable power source for the small and medium scale producers. This would, of course, be in addition to the supply of tractors which will play a key farm power role in the more developed agricultural sector.

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

Linkages and collaboration

Prometa-CIFEMA alone would not be capable of generating the massive marshalling of forces needed for the potential market for its products. The geographical area is too great and the numbers too large. As a result the Project has concentrated on training technical staff whose job it is to reach farming communities. One of the strengths of the Project is that it has facilitated the development of a broad network of interaction and iteration between diverse actors that not only combine a wide range of skills and competencies, but also change patterns of interaction, ways of working and support from local organisations and communities.

In the execution of its activities, the Project has constructed and established linkages between organizations and institutions, although all are interested in the broad objective of poverty alleviation through agricultural development, they had not previously been linked directly. It has, for example, effectively linked farmers with research organizations and universities, development projects with research projects, the private sector with research and the public sector, GOs with NGOs, and provided training and training materials to a large number of GOs, NGOs, and other educational bodies. Moreover, through its establishment of a Bolivian Animal Traction Network (RENTA) and its incorporation into the Latin American Network (RELATA) it has effectively connected these Bolivian organizations and institutes with similar organizations and processes in Latin America and beyond.

Mainstreaming of process and methodologies

Through its activities, based on the direct and decisive involvement of client-farmers during all stages of the research and decision making process, the Project has contributed significantly to the institutionalization of, and the institutional capacity for participatory research and wider participatory processes. Such developments have been most prominent in the UMSS, the main agricultural university in Bolivia, where prior to the Project, theses based on the results of farmer-participatory research were deemed inappropriate, but which have, during the life of the Project, become mainstreamed. The employment of participatory technology development techniques by the Project has enabled it to achieve an almost immediate impact as technologies have direct access to future users.

Similar processes can be observed in a number of other public and tertiary sector organizations, where the process of research and development for the identification of viable development and livelihood options is now firmly based on the participation of client communities and end-users.

Participatory methodologies permit the realization of a far greater demand for technologies which are relevant to the situation of farming communities. The methodologies facilitate stratification of users and potential users according to income and other livelihoods assets. It has been found that the demand of the poorest is, naturally, different to the initial estimates of demand. Identification of the real demand for this sector allows technology

development which has a far greater possibility of alleviating the situation of the poorest members of rural communities.

Impacts On Poverty

E. Impacts on poverty to date.

20. Impact studies on poverty in relation to the outputs

Throughout its four year history the Project has had a series of partial studies on the impact of its efforts and outputs on various stakeholders involved in the development of the small-holder farm sector. All of the studies have taken place in Bolivia:

Jeffrey BENTLEY (1998). Case study report: R6970. Improved management and use of draft animals in the Andean Hill-farming Systems of Bolivia. Report for Pat Norris, Reading University 26p

Vladimir PLATA (2001). Impacto socioeconómico de la tecnología PROMETA-CIFEMA en Morochata. Cochabamba. Proyecto Mejoramiento de Tracción Animal. 13 pp. (Socio-economic impact of Prometa-CIFEMA technologies in Morochata, Cochabamba).

Wilder QUINTEROS-TORRICO. (2001). Impacto agro-socio-económico de la tecnología CIFEMA-PROMETA de labores agrícolas (Estudio de caso en dos comunidades Andinas del Departamento de Cochabamba). Cochabamba, Bolivia. Universidad Mayor de San Simón, Facultad de Ciencias Agrícolas y Pecuarias “Martín Cárdenas”. Tesis de grado de Ingeniero Agrónomo. (Socio-economic impact of Prometa-CIFEMA agricultural technologies in two Andean communities of Cochabamba).

Marco ROMÁN (2000). Impacto socioeconómico del proyecto Mejoramiento Tracción Animal en el valle de Cochabamba. Cochabamba, Bolivia. *II Seminario - Taller de PROMETA, UMSS.* pp 134-159. (Socio-economic impact of Prometa technologies in Cochabamba).

Marco ROMAN (2001). Impacto socioeconómico del proyecto Mejoramiento Tracción Animal en el valle de Cochabamba. In: Vladimir Plata y Angela Rojas (Eds) Memorias II Taller Nacional de Planificación de PROMETA. Cochabamba, Bolivia. PROMETA-CIFEMA-UMSS. pp 31-54. (Socio-economic impact of Prometa technologies in Cochabamba).

Alexandra SHAW and SIBANDA, L. (2000). Evaluation of selected livestock research themes. Prepared for DFID by Landell-Mills Ltd. 3p.

Paul STARKEY (1998). Desarrollando tecnologías de tracción animal en Bolivia. Informe de revisión a mediano plazo del Proyecto de Mejoramiento de Tracción Animal (PROMETA) llevado a cabo en Cochabamba, Bolivia del 12 al 24 de octubre de 1998. (Trad. Joaquina Sánchez-Molero Fernández) Universidad de Reading, R.U. 45 p

Also in English: Developing animal traction technologies in Bolivia.

21. How have the poor benefited?

Livelihood Impact

Prometa-CIFEMA, through its participatory research activities has developed and adapted a wide range of work animal related technologies. Some of these, based on CIFEMA's sales statistics, have already found broad acceptance and adoption within the farming communities. Other technologies have been developed since 2001 and have reached the stage at which they can be commercialised and have found appreciable adoption. The success and adoption of Prometa-CIFEMA's outputs have been remarkable given the short time the Project has been operational and given the limited funds at its disposal. It has empowered farmers and farming communities with a choice of technologies and information that was thus far not available. In doing this the Project has contributed not only to a greater access and control that poor people have over their production assets, but also provided these households with the means to exploit such resources more effectively and sustainably.

The development of the range of equine-drawn implements, for example, for both primary and secondary cultivation tasks, has enabled farmers to improve the efficiency of use of a work animal resource that was previously used solely as a beast of burden. This development has also provided women with the option of using animals for the secondary cultivation tasks, for which they frequently carry the responsibility, potentially contributing significantly to a reduction of drudgery. According to Project data, more than 90% of farming households own one or more equids, and the developed technology thus not only provides the option of using work animals for cultivation purposes to a larger number of people, but it also provides potential access for the poorer segments of the Andean farming societies to such technologies.

The adoption of labour saving technologies, could, of course have significant negative effects on those in society who are dependent for their livelihoods on day labour. However, in the mid-Andean valleys of Bolivia, labour demands are high and supply scarce, especially in peak periods. The adopted technologies are thus not replacing income generation opportunities for the most vulnerable in society, but rather providing an option to improve the timeliness of operations, to reduce drudgery for family labour, and potentially liberating time that enables the pursuance of livelihood diversification activities.

The growth of the animal powered implement market also means that local artisans will benefit. Such rural artisans are needed to maintain and repair the equipment. And, possibly, to produce new lines of implements even better suited to local conditions.

In its final year the Project concentrated mainly on the scaling-up and dissemination of its outputs and activities, a task which it has carried out effectively and efficiently. It is proposed however that an impact assessment is commissioned to clearly quantify and qualify the extensive impact Prometa-CIFEMA has had on both institutional change and the improvement of livelihood options. Now would be an appropriate time for this study.

Sustainability of Project impact

Although predictions about the sustained impact of a project's outputs are generally difficult to make, it should be clear from the above discussion that the groundwork carried out by Prometa-CIFEMA provides a fertile basis for the durable and widespread adoption of the Project's outputs. Such assumptions are based on the adoption that

Project outputs have thus far found, following a period of commercialisation and dissemination activities. The establishment of effective farmer-research-private sector linkages is another factor that should ensure the further widespread dissemination of the technologies. Moreover, the institutionalisation of the Project's methodologies and processes, well beyond its core group of collaborators, through its extensive network activities has already catalysed the use and adoption of the Project's outputs well beyond the farming communities where the initial activities were concentrated.

Environmental Impact

H. Environmental impact.

24. Direct and indirect environmental benefits

Whereas agricultural mechanisation can have deleterious consequences for the environment if not carefully managed, the Project has had a clear bias towards environmentally friendly technologies. The management of soil cultivation between vegetative barriers is a combination which reduces soil erosion on hillsides. The use of inappropriate technology on hillsides (e.g. the '*arado de palo*' or wooden plough with a metal share introduced by the Spanish centuries ago and pulled by a pair of draught oxen) has caused untold damage to soil quantity and quality over the years. Replacing this by light weight implements pulled by equids working between protective vegetative barriers has a direct positive impact on the environment.

The Project has also made important progress (in association with CIMMYT) on direct seeding technology for small grains. Direct seeding not only does away with the need for the traditional practices of primary and secondary tillage (with ploughs and harrows) but also opens the way for practices (known as **conservation agriculture**) that provide a permanent protective vegetative cover for the soil. Conservation agriculture (a combination of direct planting, permanent soil cover with cover crops and residues, and crop rotations) has a remarkably positive impact on the environment. It reduces to zero any soil erosion and enhances soil biota as a means on improving soil structure and fertility.

25. Adverse environmental impacts.

As mentioned previously, soil manipulation will often lead to erosion with a consequent loss of soil fertility and land productivity. There will also be downstream impacts such silt loads in rivers used for water supply; road destruction; and reservoir silting. However the Project has not resulted in an increase in soil cultivation, rather the reverse. Replacement of inappropriate technology with smaller, more precise equipment will generally result in less environmental damage.

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

Increasing desertification as a result of climate change is already a major concern in Bolivia (as indeed it is in many other parts of the world). The Project has added to the range of technologies that will help to combat desertification by water harvesting *in situ*. Technologies that have proved to have a positive impact on soil

moisture content in marginal areas include the winged chisel plough, direct seeder, tied ridger and the mechanisation of the forming terraces between contour barriers. Further development into the full conservation agriculture technology (currently being proposed) will have an even greater impact on the possibilities for crop production on otherwise increasingly marginal land.