Aquaculture and rural livelihoods in the Bolivian Amazon - Systems of Innovation and pro-poor technology development

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PhD Thesis

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Abstract

This thesis is about pro-poor agricultural innovations and smallholder development in Amazonia. The focus is on aquaculture in the Bolivian Amazon, with particular reference to indigenous territories. An Innovation Systems framework is used to analyse aquaculture Research and Development at a national level and its relevance to small farmers. The analysis of poverty-focused technology development at the project and farm levels is aided by a Knowledge Engineering Approach for agricultural research management and Livelihoods perspectives. The data comes from interviews with fish farmers and other actors, on-farm and on-station research and livelihoods surveys.

Indigenous-species aquaculture can help integrate conservation and development efforts in the region. Nevertheless, a weak innovation system, with limited participation of the public sector, and underdeveloped markets greatly limit poorer farmers' access to aquaculture technologies. Furthermore, low-external-input systems often promoted as 'pro-poor' have limited growth potential whilst requiring considerable skills and labour, both of which tend to be in short supply in Amazonia. Development and poverty reduction objectives might be best met by supporting small and medium-scale commercial aquaculture in areas with access to input/output markets, developing institutional innovations in the provision of inputs and credit and building producer associations for bulk marketing. Given limited resources, priority should be given to reinforce existing innovation networks, largely within the private sector.

Indigenous farmers with access to markets can also benefit from aquaculture with a commercial approach. There is considerable evidence of farmers in indigenous territories diversifying their production to include more market-oriented farming, as well as activities in the non-farm sector and wage labour. Here, interest in and access to aquaculture is influenced by location (access to markets and environmental settings), income portfolio and type of livelihoods diversification.

The research has important implications for rural aquaculture development in the Bolivian Amazon and provides relevant data about livelihoods and change in indigenous communities and their implications for Conservation and Development Projects in Amazonia.

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Acronyms and abbreviations

AA	*Action Aid*, international NGO
ADEPESCA	*Apoyo a la Pesca Artesanal y la Acuicultura,* European Union fishing and aquaculture Project.
AECI	*Agencia Española de Cooperación Internacional para el desarrollo* (Spanish International Development Agency)
BAAIS	Bolivia's Amazon Aquaculture Innovation System
BIDECA	*Bloque Integrado de Desarrollo Cantonal Caranavi* (The Caranavi Integrated Development Group) Bolivian NGO, La Paz
CAF	*Corporación Andina de Fomento. (*Andean Development Corporation)
CARITAS	CARITAS, international Roman Catholic NGO
CATIE	*Centro Agronómico Tropical de Investigación y Enseñanza* (Tropical Agricultural Research and Education) Costa Rica
CICA	*Centro de Investigación y Capacitación Agropecuaria* (Aquaculture Research and Development Centre) Bolivian NGO, Tarija.
CIDA	Canadian International Development Agency
CIDAB	*Centro de Investigación y Desarrollo Acuícola Boliviano* (Bolivian Aquaculture Research and Development Centre) Ministry of Agriculture
CIPCA-Beni	*Centro de Investigación y Promoción del Campesinado Bolivian* (Bolivian Centre for the Promotion of Rural Communities). Bolivian NGO.
CIRA - UAB	*Centro de Investigación de Recursos Acuáticos - Universidad Autónoma de Beni* (Aquatic Resources Research Centre - Universidad Autónoma de Beni)
CORDECRUZ	*Corporación Regional de Desarrollo de Santa Cruz* (Regional Development Corporation of Santa Cruz) Regional government, Bolivia
CORDEPAZ	*Corporación Regional de Desarrollo de la Paz* (Regional Development Corporation of La Paz) Regional government, Bolivia
DANIDA	Danish International Development Assistance, Ministry of Foreign Affairs, Denmark
DDS	*Dirección de Desarrollo Social* (Department for Social Development) Regional government, Bolivia.
DFID	Department for International Development, UK Government Department
DGCD	*Direction Général de la Coopération au* Développement (Development Cooperation Department) Ministry of Foreign Affairs, Belgium
DGIS	*Directoraat Generaal Internationale Samenwerking* (Directorate General for International Cooperation) Ministry of Foreign Affairs, The Netherlands
EED	*Evangelischer Entwicklungsdienst* (German Protestant Churches Development Service) NGO, Germany
EPARU	*Equipo Pastoral Rural* (Rural Pastoral Care Team) Catholic NGO, Bolivia
FAO	Food and Agriculture Organisation of the United Nations
FDTA-TH	*Fundación para el Desarrollo Tecnológico Agropecuario y Forestal del Trópico Húmedo* (Foundation for Agricultural and Forestry Technology Development in the Humid Subtropics), Bolivian NGO.
FIDA	*Fondo Internacional de Desarrollo Agrícola* (International Fund for Agricultural Development), United Nations Agency
FOCAS	*Fondo Común de Apoyo al Sistema Boliviano de Tecnología Agropecuaria.* Funding from Switzerland, Holland, UK and Denmark for (SIBTA), the Bolivian Agricultural Technology System.
FONAMA	*Fondo Nacional del Medio Ambiente* (National Fund for the Environment) Central government, Bolivia
FPS	*Fondo Nacional de Inversión Productiva y Social* (National Fund for Social and Productive Investment), Central government, Bolivia
HOYAM	*Centro de Estudios Hoya Amazónica*. Bolivian NGO
IDB	Inter-American Development Bank
INFOPESCA	*Centro para los servicios de información y asesoramiento sobre la comercialización de los productos pesqueros en América Latina y el Caribe* (Information about the commercialization of fish products in Latin America and the Caribean)
IRD	Institut de recherche pour le développement (Development Research Institute, formerly ORTSOM) French government.
ISTAIC	*Instituto Superior Técnico Agro Industrial de Caranavi, La Paz, Bolivia.* Technical school
JICA	Japanese International Cooperation Agency, Japanese government
MACA	*Ministerio de Asuntos Campesinos y Agropecuarios* (Ministry of Agriculture) Central government, Bolivia

MAN-B	*Misión Alianza Noruega in Bolivia* (Norwegian Mission Alliance in Bolivia), Norwegian Evangelical NGO
MDSP	*Ministerio de Desarrollo Sostenible y Planificación*, Ministry of Sustainable Development and Planning, Central government, Bolivia
MIRNA	*Manejos Integrado de los Recursos Naturales y la Agricultura,* (Integrated Management of Natural Resources) Caranavi, La Paz
MLE	Medium Large Entrepreneurs
NOVIB	*Nederlandse Organisatie voor Internationale Bijstand* (Netherlands Organization for International Development) Dutch NGO
PATAGC	*Proyecto de Asistencia Técnica Agrícola Ganadera Comunal* (Communal farming technical assistance project) Martín Cárdenas Boarding School, Coroico, La Paz
PDA	*Plan de Desarrollo Alternativo* (Alternative Development Plan) Project to cut coca production, Central government, Bolivia
PDAR	*Programa de Desarrollo Alternativo Regional* (Alternative Regional Development Plan) Project to cut coca production, Regional government, Bolivia
PLANE	*Programa Nacional de Empleo* (National Employment Programme), Central government, Bolivia
PRAEDAC	*Programa de Apoyo a la Estrategia de Desarrollo Alternativo en el Chapare* (Programme to support Alternative Development Strategies in Chapare) Bilateral European Union - Bolivia cooperation programme N° BOL/B7-310/96-41
PRODESIB	*Proyecto de Desarrollo Sostenible de los Pueblos Indígenas del Beni* (Sustainable Development Project for the Indigenous People of Beni) Ministry of Sustainable Development, Bolivia
PUMA	Foundation for the sustainable use and protection of the environment, Bolivian NGO
QHANA	'Sunrise' in Aymará, Caranavi, La Paz, Evangelical NGO.
RPF	Resource Poor Farmers
SDC	Swiss Agency for Development and Cooperation, Swiss government
SIBTA	*Sistema Boliviano de Tecnología Agropecuaria.* The Bolivian System for Agricultural Technology
TCA	*Tratado de Cooperación Amazónica* (Amazon Cooperation Treaty*)*. International organization aimed to promote the sustainable development of the Amazon
TCO	*Territorio Comunitario de Origen.* Indigenous Territory.
TIM	*TCO Territorio Indígena Multiétnic.* Multiethnic Indigenous Territory
TIMI	*TCO Territorio Indígena Mojeño Ignaciano.* Mojeño Ignaciano Indigenous Territory
TIPNIS	*TCO Territorio Indígena Parque Nacional Isiboro Sécure.* Isiboro Sécure Nacional Park Indigenous Territory
UAGRM	*Universidad Autónoma Gabriel René Moreno.* Autonomous University of Santa Cruz, Bolivia
UAPAC	*Unión de Asociaciones de Productores Agropecuarios Carrasco*. Carrasco Union of farmer associations, Cochabamba, Bolivia
UG TICH	*Unidad Gerencial Territorio Indígena Chimán* (Chimán Indigenous Territory Management Unit (part of PRODESIB)
ULRA-UMSS	*Unidad de Limnología y Recursos Acuáticos de la Universidad Mayor de San Simón.* Unit of Limnology and Aquatic Resources, Autonomous University of Cochabamba, Bolivia
UNDP	United Nations Development Programme
UNITAS	*Unión Nacional de Instituciones para el Trabajo de Acción Social.* National Union of Social Work Institutions, Bolivian NGO
UPA MACA	*Unidad de Pesca y Acuicultura, Ministerio de Asuntos Campesinos y Agropecuarios,.* Aquaculture and fisheries Unit, Ministry of Agricultura, Bolivia
USAID	U.S. Agency for International Development
VLIR	*Vlaamse Interuniversitaire Raad.* Flemish Interuniversity Council
VMDA	*Viceministerio de Desarrollo Alternativo*. Vice-Ministry of Alternative Development, Bolivia
VsF- France	*Vétérinaires sans Frontières.* Vetinarians Without Borders, French NGO
World Vision	Evangelical NGO, U.S.

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1 Introduction

This research aims to contribute to the debates about rural development in Amazonia and the role of agricultural innovations in poverty reduction by examining the case of pro-poor aquaculture development initiatives in the Bolivian lowlands.

In the last decade, and particularly since the sharp rise in cereal prices in 2007-2008, there has been growing consensus among donors and development agencies about the need to invest in agricultural and natural resource management innovations as a means to promote economic growth in developing countries (CGIAR, 2005; DFID, 2005; World Bank, 2007).

Aquaculture is the fastest growing form of food production in the world and has an important role in helping to meet the increasing demand for aquatic products worldwide and in contributing to food security and the growth of national economies (FAO, 2006, 2011). The bulk of aquaculture production comes from Asia, from small and medium family-based operations, often termed 'rural aquaculture'. Many governments and development agencies have targeted aquaculture as an instrument for poverty reduction and promoted the development of rural aquaculture among small farmers (Ahmed and Lorica, 2002; Demaine and Halwart, 2001; Edwards, 1999, 2000; FAO, 1997, 2000; Funge Smith, 1999; Haylor et al., 2003; Jahan et al., 2010; Luu et al., 2002). However, the results of these initiatives have been mixed and attempts to promote pro-poor aquaculture in regions where it has not been traditionally practiced, such as Sub-Saharan Africa or Latin America, have encountered important obstacles (Brummett et al., 2008; Brummett and Williams, 2000; Chapman and Abedin, 2002; FAO, 1997; Gupta et al., 2002; Martínez-Espinosa, 1999a; Thomas, 1994). Pro-poor aquaculture development efforts have been poorly documented and there is limited understanding of the socioeconomic and institutional contexts in which pro-poor aquaculture has flourished (or not). Problems have been associated with lack of knowledge and expertise, the promotion of 'inappropriate technologies', the poor sustainability of development interventions and macro-level factors such as an unfavourable policy environment, limited access to markets and credit or institutional weakness. These issues, combined with the emergence in recent years of more commercial and specialised aquaculture enterprises in several Asian and African countries (Beveridge et al., 2010), has raised questions about the direct benefits of aquaculture development for poorer farmers in less favoured areas (Allison, 2011;

Belton et al., 2012; Beveridge et al., 2010; Brummett et al., 2008; Moehl et al., 2006; Stevenson and Irz, 2009).

Questions about the effectiveness of targeting small farmers directly via the development and extension of pro-poor aquaculture technologies are also the focus of much debate on agriculture and innovations in natural resource management more widely. Although there has been renewed interest in the agricultural sector and its contribution to economic growth in developing countries, there is little consensus about the future of small farms (for example Byerlee et al., 2009; Hazell et al., 2010; Lipton, 2006; Sumberg, 2006; Wiggins et al., 2010). The prospects for small farms are deteriorating in many parts of the rural world, due to changes in local and global conditions such as increased liberalization of international trade, the retreat of state intervention in agricultural research and development, the rise of supermarkets and a trend towards the diversification of livelihoods away from farming (Byerlee et al., 2009; Collier, 2008; Dorward et al., 2004a; Dorward et al., 2004b; Ellis, 2005, 2006). In this context, efforts to develop useful innovations for small-scale producers are facing growing challenges.

The thesis explores these debates by examining the case of aquaculture and its role and potential as a pro-poor natural resource management innovation for Amazonia. Indigenous species aquaculture is seen by many as an environmentally-friendly development alternative that could contribute to rural livelihoods enhancement in the region (Alcántara, 1999; Araujo-Lima and Goulding, 1997; Gomes et al., 2006; Gram et al., 2001; Guerra et al., 2000; IIAP, 2006; Smith, 2000), along the lines of Integrated Conservation and Development Projects. The research focuses on aquaculture development in the Bolivian Amazon, with particular reference to aquaculture development initiatives in Indigenous Territories. In recent years, in Bolivia, as in many other Amazon countries, millions of hectares of land have been reconverted into Indigenous Territories (Urioste, 2010), as a result of mounting pressure from an ever more politically conscious indigenous movement. The design and implementation of management plans for these territories is currently at the centre of conservation and development efforts in the region (Camacho Nassar, 2008).

The research examines the case of aquaculture development in two Indigenous Territories in Moxos, Beni. But pro-poor aquaculture development in Moxos and other parts of lowland Bolivia cannot be understood in isolation. The development and adoption of innovations at the local and farm levels is influenced by processes in the wider sector and economy, and the role that is assigned to poverty reduction in aquaculture development. There is limited data on aquaculture production in the Amazon region of Bolivia and a poor understanding of its driving forces. Thus the thesis combines local level analysis in indigenous communities with an analysis of the aquaculture sector at the regional and national levels.

The following general research question is addressed: Can aquaculture contribute to the realisation of improving rural livelihoods for poor people in the Bolivian Amazon?

If so, which technologies should be favoured, how should they be promoted and who should be targeted?

The author of the thesis worked in the aquaculture sector in Bolivia for several years and was directly involved in the implementation of fish farming projects in indigenous communities in Moxos. I acknowledge that my involvement in these initiatives and in communities that are the focus of some of the research represents a challenge to objective analysis. Therefore, particular emphasis has been given to identifying possible biases. Nevertheless, I think that, on the whole, my experience in the field benefits the study by providing depth and a solid basis in first-hand observation and analysis.

The thesis is divided into five main chapters.

Chapter two reviews the debates surrounding conservation and development efforts in Amazonia and the role of natural resource management innovations in delivering poverty reduction objectives in less favoured areas. It then turns to examine the current debate about aquaculture's contribution to food security and rural incomes. The second section presents the study area and an overview of the aquaculture sector in Bolivia and pro-poor aquaculture development initiatives in indigenous communities in Moxos, and is intended to establish the background necessary to contextualise the research questions and strategy. The final section outlines the research questions.

Chapter three describes the conceptual framework and research strategy adopted in the thesis. The process of aquaculture technology development and extension in the Bolivian Amazon is examined using an Innovation Systems Framework (for examples of Innovation Systems approaches used in agricultural R&D in developing countries see

Biggs, 2007; Clark, 2002; Hall et al., 2003; Spielman et al., 2009; Spielman et al., 2008; Sumberg, 2005b). The framework recognises the role of different actors at the micro- and macro-level, and the contexts in which they operate, in shaping the production and delivery of innovations. Local level analysis is aided by a Knowledge Engineering Approach to technology development (Reece et al., 2003; Sumberg and Reece, 2004) and Livelihoods perspectives (Carney, 1999; Ellis, 2000; Norton and Foster, 2001; Scoones, 1998). They are used in tandem to inform the study of 'the adaptive end' of the research and development process, at the project and farm levels. The Knowledge Engineering Approach is particularly useful in helping define and characterise often poorly understood innovations and increase the effectiveness of poverty focused technology development. Livelihoods analysis provides a valuable entry point for understanding farmers' diverse 'rural worlds', including their possible interest in and access to proposed innovations, beyond a focus on Farming Systems.

Chapters four and five present the thesis' empirical research and results. Chapter four builds a picture of the nature and dynamics of the aquaculture sector in the Bolivian Amazon and its role in smallholder development, drawing from interviews with fish farmers and other actors from the public and private sectors that are involved in aquaculture development. It includes the first survey of fish farmers to be carried out in the region and a review of the short history of poverty-focused aquaculture development efforts. The recognition that innovation comes from diverse sources and that agendas in the research and development process are negotiated and contested requires that attention is given to actors, roles, context and interactions between actors. Interaction matrixes are used to map information networks, clusters of actors and isolated actors or mismatches that might be hindering the innovation process and blocking channels for the exchange of knowledge, and assess the system's overall cohesion and effectiveness (see Temel, 2006; 2007 for methodological approaches to linkage analysis in innovations systems).

Chapter five presents the results of the study of fish farming in Moxos, in Indigenous Territories that have been at the centre of pro-poor aquaculture development efforts. Local level analysis is based on interviews with fish farmers and non-fish farmers in the indigenous communities, on-farm and on-station research and a livelihoods survey. The chapter provides detailed information about the different types of technologies being promoted in the region, in terms of the inputs they require for adoption and the benefits they generate. Similarly, farmers in the indigenous communities are described in terms of key aspects of their livelihoods and the wider context that might influence their interest in and access to aquaculture technologies. Once 'potential users' and technologies have been described in the light of benefits/resources it is possible to begin to evaluate how the different types of aquaculture technologies fit in with the livelihoods, needs and expectations of indigenous people in the region and whether aquaculture is an effective pro-poor innovation for Indigenous Territories. The analysis of the innovation process at the farm and community levels reveals the existence of some patterns and trends that can help identify why some families decide to take up aquaculture and others do not, and to identify those people that tend to be excluded. The chapter also includes more qualitative data and brings in the voices from the communities, allowing farmers to evaluate their experience with aquaculture in their own words.

Chapter six discusses the thesis' main findings in light of the debates introduced in chapters two and three, and concludes with recommendations. The study has important implications for aquaculture development in the Bolivian Amazon and in Indigenous Territories in particular, and provides relevant data about livelihoods and change in indigenous communities and institutions and their implications for conservation and development efforts in Amazonia.

The full questionnaires used in interviews are included at the end of the thesis in the appendices.

I have published some of the data produced for the thesis as sole author, in Chapters 1 and 3 of 'Canal, E. ed. 2007. *Piscicultura rural: una experiencia de desarrollo en la Amazonia boliviana*: Bolivia, Editorial Imprenta El País SRL', a book for which I also acted as editor. In this publication it is specified that the data comes from the author's fieldwork as a part of her PhD in the School of International Development, University of East Anglia. The book was published in Spanish, financed by the Catalan Cooperation Agency (*Agencia Catalana de Cooperación al Desarrollo*) and distributed in Bolivia.

The full publication can be found online at http://www.ceam-ong.org/publicaciones-y-recursos/publicaciones

Chapter 1: Canal, E., 2007, La Piscicultura Amazónica en Bolivia, in Canal, E., ed., Piscicultura rural: una experiencia de desarrollo en la Amazonia boliviana: Bolivia, Editorial Imprenta El País SRL., p. 18-75.

Chapter 3: Canal, E., 2007, Piscicultura rural en comunidades indígenas de Moxos: evaluación de los resultados 2001-2006, in Canal, E., ed., Piscicultura rural: una experiencia de desarrollo en la Amazonia boliviana: Bolivia, Editorial Imprenta El País SRL., p. 167-245.

2 Debates, context and research aim

2.1 The debates

2.1.1 Amazonia: reconciling conservation and development, tradition and modernity

Over the last two decades, increasing interest in tropical forests as providers of environmental services, as well as sources of income for the rural poor, has brought development and conservation concerns closer together. The interconnectedness between 'the fate of the forests' and 'the fate of the poor' was already highlighted in the late 1980s by the UN-commissioned Brundtland report (WCED, 1987). The diagnosis of poverty-led natural resource degradation that became mainstream thinking in major international organisations, such as UNEP and the WWF, led to increasing emphasis on the promotion of Integrated Conservation and Development Projects (ICDPs). The premise behind these initiatives was that 'sustainable development' could yield an efficient 'win-win' strategy to satisfy the objectives of both poverty-alleviation and conservation. Critiques, however, claimed that the poverty-degradation causal link might reflect an incorrect diagnosis of the problem and that tropical forests do not lend themselves easily to 'win-win' solutions. Furthermore, it has been argued that natural forests may offer little comparative advantage in terms of poverty reduction compared to other land use alternatives.

The following section will review some of the debates surrounding development and conservation efforts in tropical forest, with particular emphasis on Amazonia.

Sustainable development in Amazonia: reconciling conservation and development

During the 1960s/70s and most of the 1980s, environmental policy in Amazonia was conceived independently of the development process (Hall, 2000b). Traditional approaches to conservation were based on the creation of 'conservation units', such as National Parks, and their regulation through command-and-control mechanisms.

Empty Forests/Busy Towns

The idea behind traditional approaches to conservation and development has been one of establishing strategic 'islands' of biodiversity to protect essential species and environmental services whilst stimulating development in areas of lower ecological importance. Supporters of this view stress how forests are being threatened by changes in traditional land-use practices in Amazonia and other tropical regions (Arnold and Pérez, 2001; Bennett and Robinson, 2000; Novotny, 2010; Redford and Padoch, 1992) and the precarious economic situation of most small and medium-scale farmers and ranchers (Browder, 1992a; Carvalho et al., 2001; Chomitz and Gray, 1995; Southgate, 1994, 1998), and suggest that pressures to clear further land in the forest might be reduced through stimulating regional development around existing settlements in frontier areas (Carvalho et al., 2001; Illukpitiya and Yanagida, 2010; Lovejoy, 2000). The argument is that economic and social development will reduce encroachment by farmers and ranchers on tropical forests and efforts should be made to strengthen the economy and institutional capacity of existing settlements by providing basic services, marketing facilities, technical assistance and improvements in local road networks. Although it is acknowledged that higher crop and livestock yields can be powerful incentives to clear further land (Müller et al., 2011; Reis and Guzmán, 1994), it is argued that this phenomenon might occur at a local or regional level, but at a national level the overall relationship between agricultural productivity increases and deforestation will be negative (Chomitz and Gray, 1995; Southgate, 1994).

Associated with traditional approaches to conservation and development, and as the result of increasing concerns about climate change, is the more recent idea of 'debt-for-nature' swaps and other forms of financial inducements to restrict the clearance of natural vegetation (Börner et al., 2010; Edwards et al., 2010; Hall, 2008; Wunder, 2005).

The conservationist approach recognises the role of activities with low environmental impact such as ecotourism, the exploitation of non-timber forest products or sustainable timber extraction, in contributing to conservation and livelihoods improvement in selected areas. However, it is argued that their contribution to livelihoods enhancement has been overstated and cannot serve as the corner stone for sustainable development in Amazonia (Byron and Arnold, 1999; Pokorny et al., In press; Wunder, 2001). It is stressed that much more could be accomplished if the conversion of natural ecosystems into marginal farmland were made less attractive by raising crop and livestock yields elsewhere and improving human capital. In other words, the aim is to empty the forests by making traditional land use practices redundant. This position views the process of urbanization, which in Latin American countries is amongst the fastest in the world (De-Janvry and Sadoulet, 2000), as playing a key role in furthering both conservation and development objectives.

The conservationist approach re-examined

The conservationist approach has been criticised by many, mainly for underestimating the incentives that intensification gives to farmers to clear further land (Fearnside, 2000) and for overlooking the irrationality of initiatives that aim at increasing returns to land when what is scarce in most of Amazonia is labour (Brown and Schreckenberg, 1998).

There is evidence that the adoption of more efficient agricultural technologies has actually accelerated the rate of deforestation; for example, highly intensive soybean plantations in many parts of Amazonia (see Fearnside, 2000; Pacheco, 2006). Some authors have stressed the role of large farmers and ranchers in accelerating habitat loss in Amazonia (Barona et al., 2010; Brown and Schreckenberg, 1998; Fearnside, 2000; Müller et al., 2011). They note that a closer look at deforestation processes in Amazonia demonstrates that large-scale agribusiness, combined with timber exploitation are the main drivers of habitat loss, not small-scale farmers and foragers (Fearnside, 2000). Finally, there seems to be a positive relation between deforestation rates and macroeconomic factors such as the inflation rate and money availability (to which small farmers tend to be less responsive) (Fearnside, 2000: 14-15). Governments' capacity to police conservation units effectively has been seriously constrained by economic forces that favour forest clearing.

On the other hand, critics of setting aside forested areas and promoting intensification in frontier areas suggest that farmers will not risk technological changes unless alternatives represent a more rational use of their labour. This view emphasises the rationale behind shifting cultivation and other labour extensive farming practices. In conditions of land surplus, innovations must focus on increasing labour productivity if farmers are to be interested in using them (Brown and Schreckenberg, 1998).

The limited impact of the 'conservationist' approach in reversing the deforestation process and generating alternatives to improve rural Amazonian livelihoods, combined with the fact that most of the forests in Amazonia are inhabited (Hall, 2000b), have triggered a move towards new approaches to tackle environmental problems and poverty in the region. The fact is that 'conservation units' in Amazonia cover limited areas. In Brazil only 9% of Amazonia is in the form of conservation units under direct or indirect use (Hall, 2000b: 101) whilst more than 20% is composed of Indian Reserves (Capobianco, 1996). Therefore, in opposition to the 'empty forests-busy towns' thesis, it is argued that strengthening agricultural and NR management forest systems in difficult production environments might represent one of the most effective ways of combating rural poverty and deforestation.

Busy Forests/Empty Towns

Since the 1980s there has been a progressive move from command-and-control 'protectionist' positions towards more flexible 'productive conservation' in which traditional and settler populations themselves are being incorporated into conservation strategies.

In radical opposition to the 'conservationist' approach discussed above, the 'integrated conservation and development approach' is grounded on the idea that the responsibility for conserving natural habitats in Amazonia should be handed over to those whose livelihoods depend on them. This position is often backed by proponents of Resource Mobilisation Theory and the idea that when faced with threats to survival, peoples come together and create forms of group identity and collective action[1] that unite them towards a common goal - in this case the defence of their natural resource base against encroachment motivated by the economic interests of external groups such as ranchers, loggers and land speculators (Hall, 2000b). Furthermore, it has been suggested that the very concept of sustainability is embodied in indigenous livelihood systems and that much can be gained by incorporating them into conservation and development strategies (Bierhorst, 1994; Callicott, 1989; Pascual, 2005b; Posey and Dutfield, 1997; Warren et al., 1995).

Integrated conservation and development projects (ICDPs) are thought to improve forest dwellers' standards of living whilst meeting conservation objectives. In practice, this translates into initiatives that will provide incentives for people to move away

[1] Collective action has been described as 'action taken by a group...in pursuit of members' perceived shared interests' (Marshall, 1998). It implies the involvement of a group of people and requires shared interests and some sort of common action. It may take various forms, including the development of institutions, the mobilisation of resources, information sharing and coordination of activities (Poteete and Ostrom, 2004).

from environmentally destructive practices in favour of more benign alternatives such as non-timber forest products (NTFP) extraction, agro-forestry, low-impact logging, genetic prospecting, ecotourism, enhanced fisheries etc. Fish farming projects in indigenous territories have often taken this approach. Indigenous-species aquaculture based on the fruit and seed eating characins, pacú (*Colossoma* sp.) and tambaquí (*Piaractus* sp.), has been seen as a low-impact technology that can be integrated with traditional agricultural and extractive economies (for example Romero et al., 2003), one reason being their variable diets. Several authors have highlighted the complementarities that can be attained by integrating pacú and tambaquí farming with fruit orchards (Araujo-Lima and Goulding, 1997; Gram et al., 2001; Moreira da Silva, 1997; Roubach and Saint-Paul, 1994; Smith, 2000).

For many, NTFP systems represent the interface between conservation and development in Amazonia (Allegretti, 1994; Azevedo-Ramos et al., 2006; Gockel and Gray, 2009; Gradwohl and Greenberg, 1988; Hoch et al., 2009; Panayotou and Ashton, 1992; Peters et al., 1989). The conservation through commercialisation of NTFPs position has been favoured by studies that reveal their high economic value (e.g. Peters, 1989) and other studies that seem to indicate that extractive economies do not alter natural habitats in a significant way (Schwartzman et al., 2000). On the other hand, productive conservation has been closely linked to efforts to secure land rights for forest dwellers and has been seen as a way of empowering indigenous peoples (Dove, 1993). Access to forests is particularly important to poorer households. Forest resources contribute to rural livelihoods through the provision of subsistence goods, farm inputs, income, medicines and serve as a buffer in times of crisis (Arnold and Pérez, 2001).

Underlying the productive conservation perspective is the belief in the potential value of drawing on the knowledge and experience of Amazonia indigenous peoples to build sustainable land use systems (Pascual, 2005b; Posey, 2000; Stiles, 1994). Those responsible for development interventions may be better advised to support innovative capabilities within constraints of existing land use systems rather than attempt to introduce alternative systems (Brown and Schreckenberg, 1998).

Productive conservation re-examined

Despite the hopes placed on productive conservation initiatives, the approach is not free of criticism, both from the conservationists and those concerned with poverty reduction.

Some authors suggest that the benign impact of harvesting NTFPs has been over-stated (Arnold and Pérez, 2001; Ezebilo and Mattsson, 2010; Homma, 1994; Pokorny et al., In press; Redford, 1992). The selective nature of market demand, and the fact that resources are unevenly distributed within forests, means that extractive economies can lead to the alteration, and ultimately the degradation, of tropical forests (Bennett and Robinson, 2000; Coomes, 2004; Manzi and Coomes, 2009; Ndangalasi et al., 2007). The long-term sustainability of extractive economies has also been questioned by many authors. The classical boom-and-bust cycles of extractive economies (once they are opened to the market) suggests that they are condemned to disappear sooner or later (Clough et al., 2009). The extraction of forest products typically undergoes three phases: expansion, stagnation and decline (see Homma, 1992).

Beyond the debate on the environmental sustainability of extractive economies, critics have argued that although productive conservation has been very important in ensuring local peoples' access to land and natural resources, its capacity to improve the economic wellbeing of forest dwellers is severely limited (Wunder, 2001). Many forest product activities are extremely time consuming and arduous, generate low returns, and are likely to be abandoned when more rewarding alternatives become available and household labour becomes scarce (Arnold et al., 1994; Arnold and Townson, 1998; Byron and Arnold, 1999; Novotny, 2010). Byron and Arnold (1999) argue that support for such activities, once higher return or less arduous alternatives emerge, could impede the development of better livelihood systems. It may be wiser to help people move into more rewarding fields of endeavour instead of attempting to raise productivity in their current activities (Arnold and Pérez, 2001; Byron and Arnold, 1999). It has been suggested that approaches to development that build on 'traditional' land use practices might be hindering the right of forest peoples to obtain better standards of living. 'To expect indigenous peoples to retain traditional, low-impact patterns of resource use is to deny them the right to grow and change in ways compatible with the rest of humanity' (Redford and Stearman 1993: 252).

Reconciling tradition and modernity

Underlying the discourse of productive conservation is the assumption that development and conservation interests in forests coincide. Some authors have argued that this position stems from unrealistic assumptions about the livelihoods and expectations of forest peoples (Redford and Stearman, 1993). Important questions are raised about whether the agendas of forest dwellers really are in keeping with the interests of those primarily concerned with biodiversity conservation as has often been suggested. The first problem in trying to tackle this issue is: Who are the forest peoples, and in what ways do they depend on the forest? It is worth emphasising that most 'forest-dependent-people' are also farmers, ranchers, artisans, etc. The extractor population defies precise definition as a discrete social category. Many different contexts exist in which different types of people depend on or relate to forests (Byron and Arnold, 1999; Coomes et al., 2004). Clearly, the motivations of people engaged in extractive activities for commercial purposes will differ from subsistence hunter-gatherers or slash-and-burn agriculturalists.

Although indigenous peoples in Amazonia have often been associated with different forms of 'land ethic' and sustainable land-use practices, many authors believe that traditional economies will not guarantee the conservation of forest biodiversity (Arnold and Pérez, 2001; Bennett and Robinson, 2000; Novotny, 2010; Redford and Padoch, 1992). Redford and Stearman point out that under growing pressures from outsiders, such as settlers, traders, loggers, ranchers, government officials etc. 'small ethnic groups may find it virtually impossible to hold on to traditional cultural values, including those that may have supported a conservation ethic' (1993: 251). They suggest that both Indian territories and extractive reserves are being created primarily in response to issues involving social equity and land rights (and not biodiversity conservation), and to expect that indigenous peoples will manage these reserves as natural conservationists is to place an unfair burden for forest dwellers. Furthermore, social capital[2] is an important prerequisite for productive conservation to work.

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[2] Social Capital has been defined as 'the shared knowledge, understanding, norms, rules and expectations about patterns of interaction that groups of individuals bring to a recurrent activity' (Ostrom, 1999) Social capital is associated with relations of reciprocity, exchanges and trust, common rules, norms and sanctions and connectedness between and within groups (Pretty and Ward, 2001)

Although there is considerable evidence of forest peoples with a strong tradition of collective action there is just as much evidence of the opposite. Some authors have argued that it might be possible to build stocks of capital within relatively short spans of time (Bebbington, 1999; Pretty and Ward, 2001; Sultana and Thompson, 2004). But others maintain that social capital cannot be promoted from the outside because it can only be accumulated over long periods of time (Putnam et al., 1993).

Indigenous communities are increasingly exposed to 'modern industrial societies' via market integration, demographic pressures, schooling, government policies, expanding road networks etc. 'The days of completely autonomous self-sufficient households that produce and consume outside of the cash economy are long gone' (Hentschel and Waters, 2002). In fact, some might be assimilated, other might hold on to traditional lifestyles and worldviews, and still others will absorb some aspects of modern society whilst retaining aspects of their culture and values. However, the pressures on indigenous populations for rapid change can be expected to keep increasing. Critics of productive conservation suggest that it is the socio-political and economic contexts within which extraction occurs that will determine land use practices, and not the innate character of rural inhabitants or their deep knowledge of the forests. Technological shifts have already been occurring in response to interactions between demographic, socioeconomic and political factors in the regional, national and international arenas (Schmink et al., 1992).

A starting point for those engaged in efforts to build a sustainable future for the peoples of Amazonia might be to acknowledge that indigenous knowledge and practices are not immutable but constructed through the history of particular regions and peoples, and are shaped by a wider policy context and political economy (Bebbington, 1994). Pressures on extractive and/or agriculture-based economies might undermine the relevance of some earlier practices (Salisbury and Schmink, 2007; Steward, 2007). The integration of rural economies into a far wider economy entails a whole range of changes in livelihoods and aspirations. As Bebbington notes, with market integration come 'new aspirations, access to many of which requires increased income. Farmers look for technologies that serve this end. The provenance of the technology (old or new, traditional or modern) matters far less than its effectiveness' (Bebbington, 1994: 92).

The next section starts by examining the debates surrounding the role of agricultural and natural resource management innovations in building sustainable rural livelihoods in less favoured areas. This is followed by a review of the case of pro-poor aquaculture development, with particular emphasis on Amazonia, where it is gaining increasing attention as a means to integrate conservation and rural development efforts.

2.1.2 Targeting the agricultural sector in less favoured areas: does it pay?

Investment in agricultural and NRM research and development (from now on agricultural R&D) has played a critical role in efforts to reduce rural poverty around the globe. A substantial body of literature supports theoretical and historical arguments that growth in the agricultural sector has been an important driving force in poverty reduction in agrarian dominated economies around the world (Byerlee, 2000; Irz et al., 2001; Otsuka, 2000; Peacock et al., 2004). Although the links between agricultural growth and poverty reduction are far from straightforward, a number of ways have been identified in which increasing productivity of farm activities can benefit the rural poor: a) directly, by increasing producer incomes, b) indirectly through changes in consumer prices, c) by providing new employment opportunities in the farm sector, and d) through growth linkage effects.

a) Pro-poor agricultural R&D is a vehicle for maximising direct poverty alleviation effects by focusing on smallholder producers. Efforts in this direction might emphasise agricultural development in marginal production environments, focus on commodities that are particularly relevant to smallholders or technologies suited to their needs and resources (Bebbington, 1996; Chambers et al., 1989). However, the effectiveness of targeting poor farmers is largely an empirical issue and will vary according to local conditions, such as the importance of farm activities in overall income portfolios, agro-climatic variables and the agrarian structure (Peacock et al., 2004; Sumberg, 2006; Wiggins et al., 2010).

b) Increased productivity of non-tradable staples is likely to benefit poor consumers, particularly in areas that are not effectively integrated with wider markets and where average budget shares for food are high. Many authors support targeting basic food staples as an effective way to contribute to poverty reduction, although we are warned that in some cases market-price effects of technological change can also have unforeseen effects and actually disadvantage the poor (Byerlee, 2000; Dorward et al., 2004a; Dorward et al., 2004b).

c) Increased demand for labour as the result of growth in the agricultural sector may also have major implications for poverty reduction, because wage labour constitutes an important source of income for many of the rural poor (Ellis, 2000; Reardon et al., 2001). For some authors, promoting broad-based technical improvements and labour-intensive commodities may, in some cases, be more effective in reducing poverty than efforts to target poor smallholder producers directly (Byerlee, 2000; David and Otsuka, 1994). In other words, positive spill-over effects from agricultural growth in more favoured areas may benefit less favoured areas through migration.

d) Indirect growth linkages generated by agricultural intensification in better endowed areas is also considered as having positive 'trickle down' effects for the rural poor. Opportunities for development in the non-farm sector are generated and general growth and income effects are induced through consumption, input and output linkages (Byerlee, 2000; De-Janvry and Sadoulet, 2000).

Despite the strong arguments presented above, the fact is that the impact of the 20th century Green Revolution on the world's rural poor has been markedly uneven (Pender and Haz, 2000; Ruben and Pender, 2004). Technological change in the post-war period permitted rapid growth in land and labour productivity, based primarily on the adoption of new varieties, inputs and machinery. However, agricultural growth in better endowed areas often failed to generate growth linkages for the poor (see Von Braun, 2003 for an analysis of the distributional effects of agricultural intensification) and, similarly, the direct benefits of agricultural R&D to rural producers in marginal areas have been disappointing (Freebairn, 1995).

The inability to provide useful innovations for poor and small-scale producers has been attributed to a number of factors: agricultural R&D has focused on areas with high potential; it has centred on the production of commodities without paying enough attention to the overall agricultural system; it has focused on outputs and not processes; it has overlooked local realities and been top-down; it has emphasised efficiency over poverty alleviation objectives, etc. A recurring theme in the literature has been the inability of formal research to deal with the agro-ecological, social and infrastructural diversity characteristic of less favoured areas (from now on LFAs).

LFAs can be described as having a fragile resource base and/or limited access to markets and infrastructure (Pender and Haz, 2000), and are characterised by having a wide diversity of production systems and livelihood strategies, in terms of assets, activity choice and involvement in market exchange. Ruben and Pender (2004) highlight three different dimensions of diversity and heterogeneity in LFAs: a) biophysical conditions at a plot or field level, b) economic diversity between and within farm households and c) social heterogeneity in community organisation at a village and regional level. One-size-fits-all policies, which have predominated in agricultural R&D, are doomed to fall short in the provision of adequate solutions to poverty and environmental problems (Sumberg, 2006).

Beyond the critique of formal research's failure to promote technical change in small-farm agriculture in LFAs (which will be discussed in detail later), some authors have questioned the effectiveness of targeting poverty alleviation in LFAs through promoting growth in the farming sector (Byerlee et al., 2009; Dorward et al., 2004a; Dorward et al., 2004b; Ellis, 2005, 2006; Ellis and Harris, 2004). Some of the earliest studies showed how local conditions (agro-climatic characteristics, human capital, communication infrastructure etc.) inhibit the intensification of farming systems due to lack of both push factors (population pressure, increased food demand) and pull factors (service provisions and trade) (Boserup, 1965). This is particularly the case in areas with low population density where unit costs in infrastructural development are high. Added to these constraints, new factors appear to be challenging the agriculture-centred argument. Some authors have argued that changes in local and global conditions and the policy environment might be undermining the positive links between smallholder development and poverty reduction:

At a local level, rural livelihoods research highlights growing trends towards diversification away from the farm sector (Barrett et al., 2001; Ellis, 2000; Reardon, 1997; Reardon et al., 2001; Steward, 2007). This process of 'deagrarianization' (Bryceson, 1996, 2002; Lanjouw and Lanjouw, 2001) seems to suggest that the future of rural dwellers might lie increasingly in labour force participation outside farming. Against conventional wisdom, it has been argued that it might in fact be growth in non-farm employment and earnings which explain rising farm yields, and not vice versa (Ellis and Harris, 2004). Changes on a global scale also affect the future of small farms (Byerlee et al., 2009; Collier, 2008; Echeverría, 1998; Pingali and Traxlera, 2002). New challenges to small-holder agricultural intensification include: the downward trend in real prices of primary agricultural commodities and policy modifications associated with the liberalization agenda; the rise of supermarkets in many developing countries, leading to the concentration of buying power and increasing use of demanding standards; a retreat of state intervention in agricultural R&D; and new environmental constraints such as climate change (see Byerlee et al., 2009; Hazell et al., 2010; Lipton, 2006; Sumberg, 2006; Wiggins et al., 2010 for reviews of the debates surrounding the role of agriculture in development and the future of small farms).

While these challenges and the haziness around the links between agricultural intensification and equitable economic growth are acknowledged, it seems likely that smallholder agricultural development in LFAs will still have a fundamental role to play in livelihoods enhancement for the foreseeable future (Wiggins et al., 2010). It is possible that with time and improved markets the non-farm sector may increasingly gain importance over smallholder agriculture in ensuring food security and wages, but meanwhile, and as long as farming contributes to the livelihoods of rural dwellers, securing and improving farm productivity is likely to remain of critical importance to poverty alleviation efforts (Dorward et al., 2004a; Dorward et al., 2004b; World Bank, 2007). In recent years agriculture for development and poverty reduction has received renewed interest from donors and international development agencies (CGIAR, 2005; DFID, 2005; World Bank, 2007). As suggested by Reardon et al. (2001: 395), the impact of rural non-farm employment on poverty alleviation has been particularly important in areas with dynamic economies (mainly, but not exclusively, in the agricultural sector). However, in stagnant rural economies the impact has been much smaller. It has also been argued that raising agricultural productivity has been a prerequisite for all countries that have been able to sustain a rapid transition out of poverty (Lipton, 2005). Therefore, it is thought that whilst developing rural non-farm jobs should be part of the agenda, this should not be at the expense of programmes promoting developments in agriculture and NRM. Dorward and his colleagues (2004a, 2004b) argue that both sectors should be developed in tandem. Renkow (2000) suggests that although the poor in LFAs might benefit more from investments in infrastructure or institutional reform, targeting agriculture and NRM systems in difficult production environments would appear to represent one of the most effective pro-poor investments. The challenge will be to find effective ways to incorporate poverty alleviation in priority setting for agricultural R&D in the light of changing rural livelihoods, decreasing prices of primary agricultural commodities and the diminishing budgets of national research institutes and government extension agencies.

2.1.3 Rural livelihoods diversification and agricultural innovations

It has already been noted that agricultural and NRM R&D can affect the lives of poor rural dwellers directly, by providing valuable innovations, and indirectly, by influencing market and consumer prices and through broader growth-induced effects (Byerlee, 2000). This thesis is particularly interested in the direct effects on the farming sector via the provision of innovations for the rural poor.

Farmers' interests in obtaining the benefits of a particular innovation can respond to a myriad of factors, including interest in increased labour or land productivity, increased disposable income, reduced risk and increased livelihood security, etc. However, these interests might be satisfied by a number of different options, such as other innovations within the agricultural system or engagement in off-farm activities. Rural peoples' 'interest' in a particular agricultural innovation will be influenced by the degree and nature of livelihoods diversification (Sumberg et al., 2004). Hence it might be as important to understand the underlying interests of farmers and their potential sources for fulfilment (livelihood strategies) as to understand their preferences with regards to particular agricultural innovations.

Understanding the sources and nature of farm household diversity is essential for effective targeting: diversification may differ with respect to the motivations and reasons behind changes in livelihoods and the form or pattern it might follow. Ellis (2000) identifies two 'sources of changes' in livelihoods: *diversifications by choice* (as a risk management strategy) and *diversification by necessity* (in response to shocks). The former is associated with diversification at the household level i.e. the specialisation of household members in different activities, whilst diversification that results from response to shocks is likely to take place at the individual level, via generalisation. This is an important distinction because what might appear at the household level as 'part-time farming' might in fact represent a full-time activity at the individual level. Another distinction can be made between diversification within the agricultural sector (intra-sectoral) and diversification away from farming (inter-sectoral) (Reardon, 1997). Intra-sectoral diversification may involve more or new crops, livestock, trade or food processing, etc. For Reardon inter-sectoral diversification may include employment in the rural non-farm and farm labour markets, self-employment in the local non-farm labour market and the migration labour market. In many parts of the rural world there is evidence of increasing diversification of income streams away from farming (Barrett et al., 2001; Bryceson, 1996, 2000; Ellis, 2005, 2006; Lanjouw, 2001; Ruben and Van Den Berg, 2001; Steward, 2007).

What are the implications of income diversification for technical change in agriculture and NRM activities? How does deagrarianization affect the adoption of innovations? There is a general consensus that a positive relationship exists between non-farm income and household welfare (Ellis, 2000), though there is less consensus about what triggers what. Do higher incomes from non-farm employment make it easier to invest in agricultural innovations and raise productivity levels? Or is it that only the relatively rich are able to access the more lucrative non-farm activities in the first place (Barrett et al., 2001; Reardon, 1997)? It has been argued that income diversification amongst poor households is likely to limit the direct poverty reduction impact of agricultural R&D, due to the 'dilution effect' of income diversification and the disproportionately large transaction costs associated with information acquisition[3] to inform decisions on technology choice (Sumberg et al., 2004). The 'dilution effect' of income diversification implies that as the percentage of non-farm income increases the expected gains from adopting a new agricultural technology will have to be higher (ibid). Non-farm sources of income could increase available cash but compete with agricultural activities for labour. Diversified rural dwellers are likely to incur higher information costs when implementing technology choice decisions than non-diversified farmers, hence the

[3] Investments in acquiring information about a potential innovation is the first of five stages associated with the technology adoption process: (i) potential users must learn about the innovation, must have 'knowledge' that it exists, (ii) they must be convinced that the benefits associated with its adoption are worth the investment (iii) they must decide to adopt the innovation (iv) they must implement it and finally (v) evaluate its performance

level of diversification can be expected to extend the initial phase of adoption (Sumberg et al., 2004). Poor diversified households might also find it hard to adopt the low-input technologies often promoted under 'sustainable agriculture' due to labour constraints (Tripp, 2001). Renkow (2000) arrives at similar conclusions in his study of the effects of spatial variability on the welfare effects of agricultural research. His study reveals a negative relationship between income diversification and the expected benefits and diffusion of new agricultural technology.

In light of the evidence about the increasingly diversified nature of rural peoples' livelihoods in LFAs, R&D might gain from moving away from notions of 'farmers' and 'smallholders' and begin to focus on rural livelihoods (Twomlow et al., 2002).

2.1.4 Aquaculture as a pro-poor natural resource management innovation

This section discusses the debates surrounding aquaculture's potential as a pro-poor natural resource management innovation. The discussion then turns to examine aquaculture development initiatives in Amazonia, with particular reference to Bolivia, which is the focus of our case study. It has been suggested that aquaculture might be an effective strategy for integrating conservation and development efforts in the Amazon region. Whereas many 'productive conservation' type initiatives have been criticised for not being able to compete with other land-use alternatives, such as cattle ranching and the intensification of agriculture, in helping forest-related peoples escape the poverty trap (Wunder, 2001), aquaculture has been presented as an option that can contribute significantly to both food security and income enhancement objectives. Furthermore, aquaculture's high returns per hectare make it a viable alternative to other land-use practices that require the clearing of vast areas of forest. Finally, although there is little tradition of aquaculture in Amazonia, historically fish has been one of the most important sources of animal protein for indigenous peoples and is much valued (Coomes et al., 2010).

The promise of a blue revolution

Aquaculture is a form of agriculture that involves the propagation, cultivation and marketing of aquatic animals and plants, such as fish, shellfish and algae. Aquaculture can be land based, involving rice fields or ponds, or water based, involving enclosed water bodies through the installation of cages or pens. FAO also includes enhanced fisheries or culture based fisheries in its definition of aquaculture as long as stocks are managed by a single group, such as a community (FAO, 1997).

Aquaculture has become the fastest growing form of food production in the world and currently accounts for almost 50% of the world's food fish (FAO, 2011). The motor of aquaculture development is Asia. Aquaculture in the Asian continent is responsible for 90% of global production (FAO, 2006). There is wide consensus that aquaculture has an important role to play in helping meet the growing demand for aquatic products worldwide and contribute to food security and the growth of national economies (FAO, 2006, 2011). According to its promoters, it promises to offset declining catches in marine environments, provide a source of income and high quality food for the poor, generate employment opportunities and fatten up foreign exchange earnings for Third World governments. Contrary to what many might think, the bulk of aquaculture production comes from small to medium family-based operations and not from large-scale industrial enterprises (Lazard et al., 2010; Song, 1999). Its long history[4] and continuing growth in some Asian countries seems to favour the thesis that aquaculture is an effective instrument for poverty reduction strategies (Ahmed and Lorica, 2002; Demaine and Halwart, 2001; Edwards, 1999, 2000; FAO, 2000; Funge Smith, 1999; Haylor et al., 2003; Jahan et al., 2010; Luu et al., 2002; Roos et al., 2002; Singh and Dey, 2010).

Critics, however, have identified environmental, economic and social 'side-effects' arising from the gradual intensification of aquaculture practices (D'Abramo et al., 2002; Deb, 1998; Kelly, 1996; Martinez-Cordova et al., 2009; Nguyen and deVires, 2009; Souza et al., 2000; Tacon et al., 2010). Meanwhile, many attempts to promote pro-poor aquaculture in regions where it has not been traditionally practised, particularly in Sub-Saharan Africa and Latin America, have encountered significant obstacles (Brummett et al., 2008; Brummett and Williams, 2000; FAO, 1997; Martínez-Espinosa, 1999a; Thomas, 1994). The failure of donor-funded aquaculture development projects in regions where the activity is relatively new has been associated with the promotion of 'inappropriate technologies', lack of tradition and human resources in the sector, poor sustainability of development projects and

[4] Aquaculture in Asia is thought to have developed over 2,500 years ago. For a historical review of aquaculture development see (Costa Pierce, 2002)

unfavourable macro-level conditions such as policy, credit availability and institutional weakness. The precise nature of unsuccessful attempts to introduce aquaculture, however, is complex and poorly documented. Extensive literature has covered engineering aspects of pond construction and biochemical requirements for successful cultivation of commercial fish species, but much less is known about the socioeconomic, cultural and political contexts in which pro-poor aquaculture has flourished (or not) and the most appropriate ways to promote its development (Edwards, 2000; FAO, 1997; Lewis et al., 1993).

Whilst it is acknowledged that artisanal aquaculture has benefited resource poor farmers in Asia, in regions with little aquaculture tradition it is large-scale commercial farms that are taking the lead. In South America, aquaculture development is very much tied in with commercial shrimp and salmon farming (FAO, 2006, 2011). Furthermore, the last decade has seen the emergence of more commercial and specialised small and medium-scale aquaculture enterprises in several countries in Asia and Africa; leading many to believe that perhaps development and poverty reduction objectives might be best met by favouring more commercially-oriented aquaculture in those areas with access to markets, technologies and expertise (Allison, 2011; Belton et al., 2012; Beveridge et al., 2010; Brummett et al., 2008; Moehl et al., 2006). Whilst it is recognised that in some cases artisanal aquaculture can have important poverty prevention effects, it is thought that it is small and medium-scale commercial aquaculture that can better contribute to poverty reduction, by enabling capital accumulation and generating economic growth and employment in value chains. Still, there are few studies assessing the impact of this important increase in aquaculture production on poverty and food security, and insufficient data to properly inform investments for poverty reduction from aquaculture (Allison, 2011; Gordon and Kassam, 2011). Some authors have suggested that pro-poor aquaculture is actually a contradiction in terms, as the investments required to set up the infrastructure and services associated with the activity make it inaccessible to poor producers. Promoting aquaculture to alleviate poverty is thus promoting ‘a rich man’s technology for a poor man’s problem’ (Chapman and Abedin, 2002; Gupta et al., 2002).

Defining pro-poor aquaculture

All too often heated debates about the contribution of proposed innovations to rural development are fuelled by differing views about what the innovations actually involve. Debates about the potential contribution of aquaculture to equitable development are sterile if an agreement is not reached on what should be included under the heading aquaculture. Aquaculture may encompass large-scale, super-intensive industrial production responding to financial profit objectives or small-scale, low external-input systems that respond to a myriad of motivations, such as food security, livelihood strengthening, income generation etc. Between both extremes there is a continuum of farming practices associated to varying levels of 'intensification' (Lazard et al., 2010; Muir, 2005). Similarly, aquaculture may 'benefit' the poor in a number of ways and it is important to identify which of these 'benefits' are at the centre of interest. Which of the theoretical positive links between aquaculture and poverty reduction are being questioned? Aquaculture has been said to benefit poor producers *directly* by providing a source of income and high quality food and *indirectly* by making fish available to poor consumers, generating new employment opportunities and other growth linkage effects.

The focus of this study is on aquaculture's <u>direct</u> benefits to poor farmers. Although the indirect benefits are likely to be many and should not be overlooked (Barrett et al., 2002; Hishamunda et al., 2009; Muir, 2005), their analysis is beyond the scope of this study. The research is set within debates about efforts to develop and promote pro-poor aquaculture technologies, and the contribution of these technologies to food security and income generation. Pro-poor aquaculture technologies are those that are considered to fall within what some have called 'Rural Aquaculture' (Edwards and Demaine, 1997; Edwards et al., 2002b), 'Small-Scale Aquaculture' (ARPE[5] in its Spanish acronym) (FAO, 1997; Martínez-Espinosa, 1999b), or aquaculture 'for the poor' and the 'less poor' (Martínez-Espinosa, 1994). 'Rural aquaculture' or 'small-scale aquaculture' are terms generally used in contrast to 'industrial' and 'super-intensive' aquaculture, based on the monoculture of high market-value species at high stocking densities and open (i.e. high water exchange) pond, tank or cage-based systems. These are often

[5] Acuicultura Rural en Pequeña Escala (ARPE)

stand-alone systems that rely on the purchase of high-cost nutrient inputs in the form of high-protein foodstuffs; rural aquaculture, on the other hand, is generally integrated within a larger farming system and is less dependent on external inputs.

For Edwards et al. (2002b) rural aquaculture defies simple definitions as it is restricted to no single technology or set of practices. For these authors the unifying criteria is the 'beneficiaries' of these technologies, the rural poor, and the use of the term is a reaction to the tendency of aquaculture development in the past to by-pass the poor. However, this definition (aquaculture for the poor, or in the case of FAO's definition also for the *less poor*) seem to tell us more about the intention and ideology of those promoting aquaculture development than about pro-poor farming. Rural aquaculture has been described technically in relation to 'smallholders using low-cost extensive and semi-intensive husbandry for consumption and/or income' (FAO, 1997). These systems depend largely on natural food, such as plankton, which can be increased through the application of low-cost fertilizers, such as manures, and complemented nutritionally by supplementary feed, such as agricultural by-products. Edwards et al. (2002b) consider that the definition for rural aquaculture should include higher input and higher cost systems of production, as in some situations the poor might also benefit from operating more intensive systems.

Edwards (1999) identifies three major types of aquaculture systems that are directly relevant to the poor: rice/fish systems, pond culture and enhanced or culture-based fisheries. In terms of commodity groups, herbivorous and omnivorous fish species, such as carps and tilapias, molluscs, freshwater aquatic plants and seaweeds are generally considered to be most relevant for the poor, though this will clearly vary from country to country (Tacon et al., 2010).

The direct contribution of rural aquaculture to the livelihoods of the rural poor can be summarised as follows (see Edwards, 1999):

- Increased food security through the provision of aquatic produce of high nutritional value
- Income generation through the sale of aquatic produce with high market value
- Reduced risk through the diversification of farming
- Increased farm sustainability through ponds which serve as on-farm reservoirs for other activities

- Increased farm nutrient recycling and efficiency in resource use through synergies and complementarities between aquaculture, crops and livestock farming
- Integrated Pest Management through stocking fish in rice fields
- Benefits from common property resources through the use of water-based systems such as cage culture and culture based fisheries

Some authors have highlighted the particularly valuable contribution aquaculture can make to improving the situation of rural women, as ponds are often close to households allowing women, who are often less mobile, to play a central role in husbandry (Boll and Garádi, 1995; Bouis, 2000; Setboonsarng, 2002; Wetengere, 2009).

However, there is a wide consensus that poor households are unlikely to be early adopters of aquaculture (Nhan et al., 2007) unless specifically targeted and assisted in the initial stages (FAO, 1997). Challenges to pro-poor aquaculture development in regions where there has been little tradition are many, both at the micro- and macro-levels. According to Martínez Espinosa (1999a) the most common problems are thought to include:

- Limited indigenous technical knowledge of aquaculture
- High costs of pond construction and dependence on hatcheries for seed
- Weakness of producer organisations
- Lack of awareness of smallholders' needs and priorities
- Focus on strategic research at the expense of adaptive research
- Lack of credit to 'kick start' enterprises
- Limited capacity of national institutions to function as service providers
- Limited access to seed or fingerlings and the centralisation of large government hatcheries in and around urban centres
- Limited involvement of the private sector (in the provision of associated services)

2.1.5 Indigenous-species aquaculture in Amazonia

Aquaculture in Latin America is principally known for the salmon industry in Chile and intensive shrimp farming in Ecuador. Enthusiasm for the benefits of export-oriented, large-scale industrial production as a means to increase foreign exchange earnings and generate employment has eclipsed interest in rural aquaculture (Martínez-Espinosa, 1999a). Rural aquaculture in the region accounts for less than 2% of the world's production and revolves round the culture of exotic freshwater species such as the common carp (*Cyprinus carpio*), Nile tilapia (*Oreochromis niloticus*) and trout (*Onchorhinchus mykiss*) in the Andean countries (Martínez-Espinosa and Pedini, 1998). Increasing concern over the impact of exotic species on native fish populations and aquatic habitats (CBD, 1992; Gozlan et al., 2010; Loebmann et al., 2010; Zambrano et al., 2007), and recognition that the Neotropical Region has the most diverse freshwater fish fauna in the world (Goulding, 1980), is gradually leading national and international research institutes to pay more attention to the development of indigenous-species aquaculture (Núñez, 2007, 2009).

At the centre of the Neotropical Region's freshwater aquatic diversity is Amazonia (Junk et al., 2007). In the last two decades, growing attention has been given to the potential role of indigenous species aquaculture in paving a sustainable path for the region (Alcántara, 1999; Araujo-Lima and Goulding, 1997; Gomes et al., 2006; Gram et al., 2001; Guerra et al., 2000; IIAP, 2006; Smith, 2000). Fishing has traditionally been the most important source of animal protein for the peoples of the Amazon and still plays an important role in sustaining rural livelihoods today (Coomes et al., 2010), although worrying signs of declines in fisheries are increasing (Anderson et al., 2011; Petrere et al., 2004; Reinert and Winter, 2002; Ruffino, 2004, 2005; Smith, 1981). It is argued that indigenous species aquaculture could contribute to the double goal of food security and income generation whilst conserving fisheries resources. The Amazonian basin, with one of the worlds' richest hydrological and fish resources and, some have argued, also some of the best tasting fish (Araujo-Lima and Goulding, 1997), could potentially become a major player in world aquaculture.

Most of the Amazon fish fauna described belong to characin and catfish species. Amongst the native characins, the larger fruit and seed eaters are at the centre of indigenous species aquaculture development in Amazonia. *Colossoma* and *Piaractus* include some of the most important food species exploited in the Amazon, both for subsistence and commercial purposes (Araujo-Lima and Goulding, 1997). Their varied diets, which have earned them the name of *chanchos del agua* (water pigs), make them particularly suitable for rural aquaculture. *Colossoma* and *Piaractus* feed on fruits and seeds found in flooded forests. After the floods they migrate down the nutrient-poor tributaries and enter the main white water rivers where they spend the dry season. From the start to the middle of the annual floods they move upstream to spawn and eventually return to the flooded forests to feed. These species are important seed-dispersal vectors in the Amazon. The interdependence between the fruit eating characins and inundation forests has been well documented (Anderson et al., 2011; Anderson et al., 2009; Araujo-Lima and Goulding, 1997; Goulding, 1980; Goulding et al., 1996; Lucas, 2008; Moreira da Silva, 1997; Roubach and Saint-Paul, 1994).

For *Colossoma* and *Piaractus* to be farmed they must first be induced to spawn in captivity. The first successful induced reproduction was achieved in Brazil in 1977 (Silva et al., 1977). During the 1980s and 1990s national governments in many Amazonian countries invested in the establishment of hatcheries to favour the development of *Colossoma* and *Piaractus* farming in the region (Araujo-Lima and Goulding, 1997). Farmed[6] *Colossoma* and *Piaractus* are usually fed with pellets, either purchased commercially or homemade, and zooplankton. More intensive operations use commercial pellets. These can represent about 50% of the costs of production, their price being directly related to their protein content. The recommended protein concentration of pellets to feed *Colossoma* is 18-25% (Chellappa et al., 1995; Gutiérrez, 1996), though this will vary with the age of fish and style of farming being practiced, as fish stocked at low densities in fertilised ponds can obtain much of their protein from zooplankton. Common ingredients of commercial pellets include soybean meal, fish meal, meat meal, blood meal, maize, wheat, and rice bran. Under good water conditions the average apparent feed conversion efficiency (AFC[7]) for commercial feed

[6] *Colossoma* and *Piaractus* are grown in tanks, dams and cages, but the most common practice in rural aquaculture is to use earthen ponds. Unless otherwise stated, reference to aquaculture or fish farming from here on implies farming in earthen ponds.

[7] The AFC efficiency is the ratio of weight of pellets fed to the weight of fish produced. Producers aim to minimise the AFC rate as it relates directly to production costs.

is around 2:1 for individuals below 600 g and increases progressively the bigger the fish. Growth rates of pellet-fed *Colossoma* and *Piaractus* have been said to range from 600-1,500 g/yr and pond productivities between 6-9 tons/ha/yr (Canal, 2003; Ferrari et al., 1991). Mortality rates are influenced by stocking densities, quality and quantity of feed supplied and prior 'preparation' of ponds to eliminate predators. However, under normal conditions and assuming no anomalies in physicochemical parameters or fluctuations in temperature, mortality tends to be below 10% (Araujo-Lima and Goulding, 1997).

Small producers with limited access to commercial feeds complement or substitute pellets with fruits and vegetables such as mango, papaya, guava, cacao, pumpkin, banana, manioc, rice, corn, seeds and food leftovers and organic residuals (Ferraz de Lima et al., 1992; Tacon and De Silva, 1997). Some authors have highlighted the complementarities that can be achieved by integrating *Colossoma* and *Piaractus* farming with fruit orchards (Araujo-Lima and Goulding, 1997; Gram et al., 2001; Moreira da Silva, 1997; Roubach and Saint-Paul, 1994; Smith, 2000). Zooplankton produced naturally in ponds is particularly important in extensive farming operations where feed supplements are likely to be of poor quality, because it provides the fish with essential amino acids that might be otherwise lacking. Zooplankton production can be increased by fertilizing ponds with animal manure or other organic fertilizers. Although these systems might produce less-than-maximal growth rates, using alternative foods, such as those mentioned here, can be an important means to reduce the cost of production. Fish farming can also be integrated with mammals and birds such as pigs, cows, ducks and chickens. Integrated agriculture-aquaculture systems (IAAS) that involve crop, livestock and fish farming subsystems, allow for better farm-nutrient recycling. The idea is that outputs from one subsystem become inputs to another subsystem (Figure 2-1), resulting in a more efficient use of the farm's overall resources (Dey et al., 2010; Kipkemboi et al., 2010; Pant et al., 2005; Prein, 2002). IAAS differ significantly from stand-alone enterprises. The latter operate at high levels of energy, information and capital and are exposed to greater risks, such as diseases or price fluctuations, whilst it has been argued that integrated systems are theoretically likely to benefit from synergisms among enterprises and diversity of produce.

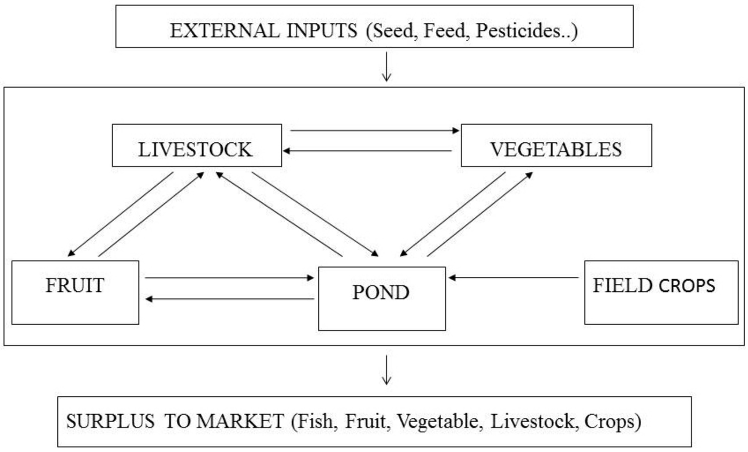

Figure 2-1 Resource flow diagram of an IAAS. Arrows represent flows in manures, residues, by-products and water (Adapted from Pant et. al. 2005).

Another type of association is that of rearing *Colossoma* or *Piaractus* (primary sp.) with other fish, generally detritus or leaf-eating species (secondary sp.). Polyculture can reduce the AFC ratio as resources get better used. The idea is that by increasing the system's biological complexity better energy transfer and use of resources are obtained. However, it is important not to stock species together that compete with each other for food. In polyculture, primary species production *per se* is lower than in monoculture, but total pond productivity is higher. Some of the most common native species cultured together with *Colossoma* sp. and *Piaractus* sp. include *Prochilodus* sp. and *Brycon* sp. (Alcántara, 1999)

2.2 Context

The thesis aims to contribute to the debates surrounding rural development and livelihoods in Amazonia and the role of agricultural and natural resource management innovations in poverty reduction efforts. It examines the case of aquaculture development in the Bolivian Amazon and its potential as a pro-poor natural resource management innovation for the region, with particular reference to aquaculture development initiatives in indigenous territories.

2.2.1 Bolivia

Bolivia is one of the poorest countries in Latin America. Social indicators are much closer to those of African countries than to the rest of Latin America. In 2009, under-five mortality rate was the highest in America after Haiti (WHO, 2011). The estimated population in Bolivia in 2009 was 9.9 million, 60% of which was living below the national poverty line (World Bank, 2011). Extreme poverty is above all a rural phenomenon, affecting 23.7% of the urban population and 63.9% of the rural population in 2007 (UDAPE, 2011). The precariousness of rural livelihoods is reflected in the high rates of migration from rural areas to cities (O'Hare and Rivas, 2007). Bolivia has a very unequal distribution of income. Together with Haiti, Bolivia has the highest Gini coefficient of Latin America (Tornarolli et al., 2011). Among the most disfavoured are the indigenous populations. Seventy percent of Bolivia's population is considered indigenous and in rural areas indigenous peoples make up for 90% of the population (Albó, 1994). Both in the Andes and Amazon regions we find highly stratified dual societies of Spaniards/Mestizos and Indians, which are the result of 500 years of ethnic exclusion (ibid). The five largest indigenous ethnic groups include the Quechua and Aymara in the highlands and the Guaraní, Chiquitanos and Mojeño in the lowlands. In rural areas, between 1997 and 2002, extreme poverty increased from 65% to 72% among the indigenous population, while it remained constant around 53% among the non-indigenous population (Hall and Patrinos, 2005: Chapter 3, tables 2 and 3). Seventy percent of Bolivia is less than 500 m above sea level, covering 75 million hectares (MDSMA, 1995). The distribution of land in the lowlands is highly skewed. According to the agrarian census of 1984 for the department of Santa Cruz, 74.7% of farm units were smaller than 50 hectares and accounted for 6.64% of the total land available; while farms larger than 1000 hectares represented 2.7% of the total number of farms but encompassed 72% of the total land available (Sandoval, 2003 cited in Valdivia, 2010: 70). In the last decade, 16 million hectares have been declared Indigenous Territories, mostly protected areas and land previously owned by the state (Urioste, 2010). Although deforestation rates in the past have been low in comparison to other Amazon countries, this trend has been reversed in the last couples of decades. Structural adjustment policies have led to a process of agrarian change in which the agricultural frontier is being increasingly connected to the international markets for commodities, mainly soybean (Pacheco, 2006). The industrial production of soybean has grown significantly in the north and east of the department of Santa Cruz and has recently reached the department of Beni, bringing about an important increase in deforestation rates in both regions (Müller et al., 2011; Redo et al., 2011). In the period 2007-2010 about a million hectares were deforested and converted to soybean fields (Urioste, 2010).

2.2.2 Aquaculture development in the Bolivian Amazon

Bolivia is divided between three water systems: the Amazon basin, the Plate basin and the Altiplano basin. The Amazon water system covers up to 66% of the country's surface (Arteaga and Coutts, 1996). Despite the highly diverse and rich aquatic environments in Bolivia (Navarro and Maldonado, 2004), the fisheries sector is relatively small compared to forestry, mining, livestock and agriculture. Aquaculture in the Amazon region of Bolivia (or Amazon aquaculture) is a comparatively new activity and there is very limited data available on the nature and size of the sector. At the time of the fieldwork carried out for this research in 2005/2006, the National Aquaculture Sector Overview Fact Sheet for Bolivia put together by FAO's Inland Water Resources and Aquaculture Services, estimated aquaculture production in the country's Amazon region to be in the order of 140 t/yr (Salas, 2005). According to FAO's Fact Sheet the bulk of Amazon aquaculture is based upon the farming of exotic species, mainly tilapia (*Oreochromis sp*.) and carp (*Cyprinus sp.*). FAO was involved in promoting Amazon aquaculture development in the 1980s and 1990s through the introduction of carp and tilapia generic technologies. Nevertheless, in the last decade there has been increasing interest in indigenous species aquaculture, based on the farming of *Colossoma* sp. and *Piaractus* sp., mostly among medium and large farmers and entrepreneurs (Canal, 2007; Hartwich et al., 2007).

Interest in indigenous species Amazon aquaculture as a pro-poor natural resource management strategy has also been increasing. The farming of pacú (*Colossoma* sp.) and tambaquí (*Piaractus* sp.) has received increasing attention as an effective strategy for integrating conservation and development efforts in the country's Amazon region (Agropeces, 2004; Brun and Camacho, 2003; Canal, 2003, 2007; Corcuy, 2005; Egüez et al., 2006; FDTA-JICA, 2003; Hartwich et al., 2007; IAS, 2003; Pascual, 2005a; PRODISA-Belga, 2005; Romero et al., 2003; Sakamoto and Suárez, 2005; SIBTA, 2006; UTB, 2004, 2005; Viruez, 2005; Viruez and Lacoa, 2005). Those who favour pro-poor aquaculture development maintain that fishing has traditionally been an important source of animal protein for Amazon peoples, today significantly reduced due to declining fisheries resources and the system of land tenancy, which limits access to water bodies (Romero and Pastó, 2003). Furthermore, fishing is a highly seasonal activity, restricted mostly to those months when the floods have retreated. There is an unsatisfied demand for fish, which has a high market value (Wiefels, 2006), and the region's environmental and climate characteristics are favourable for fish farming (Araujo-Lima and Goulding, 1997; Goulding et al., 1996). On the other hand, aquaculture's high returns per hectare could make it a viable alternative to other land-use practices that require the clearing of vast areas of forest, such as cattle ranching.

Nevertheless, aquaculture development projects in the region have had mixed results and there is no comprehensive study or evaluation that documents the impact of these initiatives on the rural poor or the effectiveness of aquaculture as a 'pro-poor' innovation for the Amazon region of Bolivia.

2.2.3 Pro-poor aquaculture development in Indigenous Territories

Local level analysis of the innovation process in Amazon aquaculture focuses on a pro-poor aquaculture development programme set up by the Bolivian NGO HOYAM (Centro de Estudios Hoya Amazónica) in two Indigenous Territories in Moxos, Beni: the *Territorio Indígena Mojeño Ignaciano* (TIMI) and the *Territorio Indígena Multiétnico* (TIM). The aquaculture project in Moxos was set up in 2001 and in 2002 managed to induce the spawning in captivity of pacú (*Colossoma macropomum)* for the first time in Bolivia (Hurtado, 2003). Project activities included poverty-focused technology development, training fish farmers, providing economic support for the capital investment needed to build ponds or adapt existing ones, building up a local market of input supplies and opening up commercial channels for farmed fish. The author of the thesis was involved in the aquaculture project in Moxos from 2001 to 2004 and returned for six months at the end of 2005 to complete the fieldwork for the present study. In line with the productive conservation approach, in its initial stages the project focused on the development of low-external-input integrated aquaculture-agriculture systems. The underlying rationale was that aquaculture could be effectively integrated within indigenous production activities and contribute to food security by providing a much needed source of animal protein which is increasingly scarce in light of diminishing returns to fishing and hunting. In practice this meant developing fish feed based on food stuffs produced or extracted by farmers, promoting initiatives to increase the size or productivity of *chacos* to respond to the new demand on agricultural products, identifying potential new high-protein crops to be grown in order to improve the quality of home-made feeds, etc. With time and in response to farmers' demands, technologies with a more commercial approach were also promoted in communities with greater access to roads and urban markets. In practice this meant putting greater efforts into ensuring these communities' access to the range of services and commodities associated with a more commercially-oriented aquaculture: quality feed, output markets, transport and cold chain facilities, credit schemes etc.

2.2.4 TIM and TIMI

TIM and TIMI are set in the Llanos de Moxos, a massive floodplain about the size of the UK that sits between the Andes, the river Beni, the river Iténez and the Santa Cruz and Cochabamba lowlands. The main river running through Moxos is the Mamoré, which joins the river Beni further north to form the river Madera, one of the principal tributaries to the Amazon River. Three broad ecological zones can be identified within the territory: forest, savannah and wetlands. The annual rainfall ranges from 1200 mm to 3500 mm, with precipitation generally increasing from the eastern plains towards the western mountains. Most of the rain is concentrated between November and April causing seasonal inundations. The size of the flooded area varies greatly from one year to another, ranging from a minimum of 2000 km^2 to a maximum of 80,000 km^2 (Hamilton et al., 2004). The indigenous territories TIM and TIMI at the centre of the aquaculture project cover approximately 450,000 ha and are inhabited by families mostly from the Mojeño-ignaciano and Mojeño-trinitario ethnic groups, although there are also families of Yuracaré and Movima origin. Their main sources of income include slash-and-burn agriculture (chacos[8]), livestock, hunting, fishing, harvesting of timber and NTFP, non-farm activities, employment in cattle ranches and the rural non-farm labour markets and remittances (Arias, 2002; Cuentas, 2000; Roper, 1999). Indigenous communities are organised around a variety of institutions that have evolved since pre-colonial times and the era of the *Reducciones* and have, more

[8] A *Chaco* is the area of land being cultivated by a family at a given time.

recently, incorporated many aspects of modern day ‘union type organisations’ (*sindicatos campesinos)* typical of the Andean region (Guzmán Torrico, 2004). Community-level governance institutions, such as the *Cabildos*[9]*,* are represented at the regional level, through the *Central de Pueblos Étnicos Mojeños del Beni* (CPEM-B) and, at the national level, through the *Confederación de Indígenas del Oriente Boliviano* (CIDOB).

Several studies suggest that some parts of the Llanos de Moxos, which host an impressive amount of archaeological remains, were densely inhabited and transformed in pre-Columbian times (Erickson, 2008; Lombardo et al., 2011b; Lombardo and Prümers, 2010; Mann, 2008). Water management was a major adaptive strategy pursued by pre-Columbian inhabitants of the Llanos de Moxos. Agriculture was made possible in areas subjected to seasonal flooding through the construction of raised fields (Lombardo et al., 2011a) and drainage canals (Lombardo and Prümers, 2010). Causeways were built to connect settlements but also to divert floods (CEAM, 2003; Erickson and Walker, 2009). Erickson has reported the existence of pre-Columbian fish weirs that served to trap fish at the end of the rainy season, when the floodwaters recede, and store them alive in artificial ponds during the dry season (Erickson, 2000). However, by 1675 when the Jesuits first arrived in the Llanos de Moxos, the once rich population that occupied the region known as El Gran Paititi o Tierra Rica (Rich Land) was only a fraction of what it had been. New illnesses brought by the Europeans had decimated it and the productive infrastructure fell in disuse (Barba, 2003).

The Jesuits established twenty organised townships, commonly known as *Reducciones,* which brought together dozens of different Arawak tribes that inhabited the region. San Ignacio de Moxos, the capital of what is today the province of Moxos, was founded in 1689 and brought together 16 different nationalities that spoke 10 different languages (Jordà, 2003). Cattle were introduced in 1688 by the Jesuits and became an important source of animal protein for the *Reducciones.* A century later the Jesuits were forced to leave Moxos and the *Reducciones* were largely abandoned by the indigenous population trying to escape from the raids of Spanish and Portuguese slave

[9] The *Cabildo* is a form of local government that was introduced by the Jesuits in 1701. Members of the Cabildos are elected by community consensus.

traders. Bolivia's independence in 1825 did not improve the situation of the indigenous population, which soon became the main source of slave labour for the growing rubber industry in the North of the Llanos.

Throughout the 20th century, descendants of Spanish and *mestizo* families from Santa Cruz took possession of millions of hectares in the Llanos and established country estates. The indigenous population was forced to work on these estates under a regime of slavery until the 1950s when Universal Suffrage was enforced. In this same period the government drew up an agrarian reform to deal with the highly unequal distribution of land, but this reform was hardly felt in Beni. Throughout the second half of the 20th century there were several pilgrimages in search of what the indigenous populations refer to as *La Loma Santa* (Sacred Land). La *Loma Santa* is thought to be a place that never floods, rich in game and pastures and 'free of evil' (Jordà, 2003). The most important pilgrimages occurred in 1959, 1960 and 1984, the first and last parting from San Ignacio de Moxos, and led to the foundation of many of the existing indigenous communities (ibid).

In the Llanos today the indigenous populations cohabit with white and *mestizo* cattle ranchers, the majority descendants of the Spaniards (*Carayanas*), who own most of the pampas, and an increasing number of *campesinos* who have emigrated from the highlands. The region has been subject to government policies centred on the development of cattle ranching and the transformation of the natural ecosystem into grazing lands (Romero and Pastó, 2003). Cattle ranching is practiced under highly extensive systems, productivities ranging around 25 kg/ha/yr (SENASAG[10] San Ignacio, 2003, pers. com.), and its expansion competes for land with the indigenous population. Logging companies and industrial soybean agriculture (Müller et al., 2011; Redo et al., 2011) also compete for land with the indigenous population, whose rights over the Territory have still not been fully recognised (Ávila-Montaño, 2003; Vargas, 2003).

[10] *Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria*

2.3 Aim of Research

The research is intended to contribute to debates on rural development and livelihoods in Lowland Amazonia. Of particular interest is understanding diversity and change in livelihoods and implication of and for the promotion of pro-poor innovations in agriculture and natural resource management. The study focuses on rural aquaculture development initiatives in the Bolivian Amazon, with particular reference to the farming of *Colossoma* sp. and *Piaractus* sp. in two Indigenous Territories in the province of Moxos, Beni. The analysis looks at the whole hierarchy of factors influencing the process of aquaculture development and diffusion at micro and macro levels, from the technologies being generated and promoted and their compatibility with indigenous livelihoods and institutions to elements at the community, regional, national and international levels that affect aquaculture R&D outcomes and their relevance to poverty reduction.

The thesis addresses the following general research question:

Can aquaculture contribute to the realisation of improving rural livelihoods for poor people in the Bolivian Amazon?

This research question is explored in the thesis by pursuing three main critical dimensions of the introduction of a new activity into rural livelihoods in the Bolivian Amazon and Indigenous Territories. These are phrased here as subsidiary questions to the overall research question:

A. In encouraging the uptake of aquaculture as a new livelihood activity, have institutional conditions in the Bolivian Amazon worked effectively to support its adoption by poor rural dwellers? What is the nature of Amazon aquaculture R&D and what are the poverty effects of the innovation process?

B. Does aquaculture represent a positive net addition to the livelihood portfolio of rural families and communities, and does its livelihood contribution vary according to the initial livelihood circumstances of its adopters? If so, what type of aquaculture technologies should be favoured and who should be targeted?

C. Does the organisation of production, broadly distinguished between individual, kinship-based, and communal alternatives affect the uptake, livelihood contribution and sustainability of aquaculture in the Bolivian Amazon setting?

3 Conceptual framework

3.1 Introduction: linking theory and practice

The study builds on the belief that the representation we make about the material world is neither an objective reflection of reality 'as it is' nor completely arbitrary, and it makes a fundamental distinction between the physical world and the metaphysical realm of morals and judgement in terms of positivist science's success in producing 'useful' knowledge. In dealing with the cultural dimension of human existence the study takes an actor-oriented stance that acknowledges the role of both structure and human agency in shaping social change and introduces an interpretative perspective to account for multiple realities. The process of pro-poor aquaculture technology development and extension in the Bolivian Amazon is examined using an Innovation Systems Framework (Andersen et al., 2002; Carlsson et al., 2002; Hall et al., 2003), that acknowledges the role of different actors at the micro- and macro-level and the contexts in which they operate, in shaping the production and delivery of innovations. Local level analysis is aided by a Knowledge Engineering Approach to agricultural research management (Reece et al., 2003; Sumberg and Reece, 2004) and Livelihoods perspectives (Carney, 1999; Ellis, 2000; Norton and Foster, 2001; Scoones, 1998). These approaches are used in tandem to inform the study of 'the adaptive end' of the R&D process. Knowledge Engineering is particularly useful in providing conceptual ground for the analysis of fish farming technology development alternatives. The other side of the 'technology transfer' equation requires the understanding of resource poor farmers' needs and expectations. The study moves beyond Farming Systems and draws on the notion of Livelihoods to inform the process of technology development and diffusion.

The following section describes in further detail the conceptual framework and research strategy adopted. It begins by setting the epistemological foundation of the study and the methodological approaches adopted. The different methods used for data collection and analysis are described in detail in the chapters that present the results of the study of aquaculture development in the Bolivian Amazon (Chapter 4) and of pro-poor aquaculture technology development initiatives in the indigenous territories TIM and TIMI in Moxos, Beni (Chapter 5).

3.1.1 Setting the foundations

Why bother with theory? The empiricist school of thought would argue that, in fact, we should not. Grounded on the 'correspondence theory of reality', empiricism is characterized by the belief that 'facts speak for themselves' (Bulmer, 1982). The researcher's task, therefore, is limited to the selection and/or development of the most useful techniques and tools for data collection. This is often what occurs in research practice (May, 2001). Critics of empiricism argue that 'facts' do not exist out there independently of the medium through which they are collected, analysed and interpreted, in other words, data are not collected, data are *produced*. *What* is produced and *how* it is produced are inseparable in the research process (Layder, 1998). Social theory must be made explicit in order that the assumptions and presuppositions we make are open to scrutiny. Furthermore, social theory provides an orientation and background to the issues being studied and it is useful for the interpretation of research results, to 'make sense' of the empirical data. However, it is equally problematic to try and explain reality by producing data without theory as to try to produce theory without empirical data (Bourdieu, 2000). To deal with the inevitable dependence between theory and data requires a *reflexive* practice. 'Reflexivity' on the part of the researcher implies an overt 'consideration of the practice of research, our place within it and the construction of our fields of inquiry...assisted by the constant interaction...between different interpretations of social life and the data which we produce about it' (May 2001: 44).

3.1.2 A working framework / A framework that works

The differing positions with regards to methods and approaches to rural development and extension science that have developed, and often coexisted, mirror differing views about how the social world is perceived and what counts as knowledge. In other words, they reflect differing epistemological positions.

The objectives of this research will lead us to explore both physical phenomena and the realm of values and judgement, working with a diverse and multidisciplinary set of research methods that do not seem to fit easily within one single epistemology. The analysis of technical aquaculture issues through the assessment of geo- and biophysical indicators could fit comfortably within a hypothetical-deductiveexperimental epistemology typical of modern science. We need not abandon the realm of the physical world to investigate these matters where modern science can produce theories that are empirically adequate. We could say we are dealing with ontologically 'objective' entities and processes that exist independently of any mental state of the perceiver (Searle, 1995). However, if the empirically adequate knowledge acquired is to be of any use, we need to engage with those who are going to build the ponds, breed the fish and reap the benefits (if there are any). Furthermore, we will have to trespass into the realm of morals and judgement to gain some sort of 'consensus' before we even agree on the relevance of developing aquaculture in the first place, let alone the most effective way of developing and delivering 'appropriate technologies'. Once the human dimension comes into the picture we enter a realm of knowledge which has always been less accessible for modernist epistemologies, because we must necessarily deal with entities which are ontologically 'subjective'. A rigorous modernist framework for research within the realm of metaphysics cannot work, because to function it must turn ontologically subjective entities into ontologically objective ones. However, if the criteria of success for scientific theory is not truth or falsity but 'empirical adequacy' (at a given time and place), we might find ourselves disagreeing with regards to what is 'adequate'. Development becomes a subjectively defined process whose aims and priorities are being continually negotiated over space and time. The emergence of an epistemology of development agency is providing new space for researchers and practitioners in the field to understand the role of these 'negotiations' in shaping social change.

3.1.3 The actor oriented paradigm: reconciling structure and agency

Structural models of development, such as modernization and neo-Marxist models, share a view of social change as emanating primarily from centres of power, in the form of state intervention or international interests. Despite ideological and theoretical differences, both positions understand development as following a broadly determined path. Social change is understood as being determinist, linear and promoted by external forces.

The actor-oriented paradigm has been a counterpoint to structural analysis (Long and Long, 1992). Although it acknowledges the role of outside forces (such as the market or the state) in influencing social change, it rejects the idea that development can be explained by external determination alone. Whilst external interventions influence the lives of social groups and individuals, in doing so they are also mediated and transformed by these same actors. The notion of 'human agency' is at the heart of actor oriented approaches and attributes to individual actors 'the capacity to process social experience and to devise ways of coping with life, even under the most extreme forms of coercion...social actors are *knowledgeable* and *capable*' (ibid: 22-23). Peoples' embeddedness within institutional structures and processes does not imply the total obliteration of behavioural choice, 'all forms of dependence offer some resource whereby those who are subordinate can influence the activities of their superiors' (Giddens, 1984: 16). Human agency manifests itself through social relations and requires organizing capacities to become effective. 'Social actors' that have the means of reaching decisions and acting upon them to a greater or lesser extent may include individuals but also civic organisations, political parties, enterprises, state agencies etc. Strategic agency depends upon the materialization of a network of actors who become committed to the same 'project', and requires the strategic channelling of claims, goods, information and other specific items to win the struggles that take place over the attribution of social meanings given to ideas and actions (Long, 1992). Social actors are not passive recipients of interventions, but active participants in social change who process information and build upon 'discursive means[11]' in their dealings and interactions with other actors. The focus of analysis is on understanding differential responses to similar structural conditions. Such differential responses reflect, in part, variations in how actors deal with the situations they face.

In the fields of rural development and extension science, the actor-oriented paradigm offers a different approach to technology development and delivery than that developed by the classical Diffusion of Innovations Theory (Rogers, 1983) and Farming Systems Research. Actor-oriented approaches concentrate on knowledge generation and transformation in rural development interfaces. 'Knowledge' is understood as a social process that emerges as a product of the interaction between different sets of actors often with competing interests. 'Knowledge systems' are understood in terms of

[11] Discourse refers to 'the assemble of ideas, concepts, and categories through which meaning is given to phenomena' (Gasper and Apthorpe, 1996: 2).

different *actors* and *networks* of actors through which technical and social information is communicated and negotiated (Scoones and Thompson, 1994: 3). 'Social interfaces' are points of intersection or encounters between different social systems or life-worlds[12], where discrepancies in social interests, normative values, knowledge and power are most likely to occur i.e. structural discontinuities (Arce and Long, 1992; Long and Villareal, 1994). A typical example of interface situations is when a new technology is introduced into existing farming systems and livelihoods. External agents' conception of the problem at hand and the innovation proposed to deal with it will most likely differ from that of farmers. There will be an encounter (and mutual transformation) of life-worlds and modes of knowledge. Farmers, under this perspective, are seen as active 'strategizers' involved in constructing his/her own 'farming world', based on varying environmental, cultural and socioeconomic conditions and differential use and transformation of knowledge. Adopted technologies undergo a continuous process of readaptation to fit livelihood strategies, resource imperatives and priorities.

The analysis of 'interface situations' requires an interpretative perspective to help uncover the 'hidden' agendas of different social actors. This is central to understanding the intended and unintended outcomes of planned intervention. If it is recognised that there are 'multiple realities' at play, then it is important to examine whose interpretations prevail and the relationships between power and knowledge processes. Interface situations bring individuals or groups with different life-worlds face-to-face, but these social actors also differ in the resources and power they bring to the game. Under this perspective, the analysis of knowledge generation and dissemination highlights the need to account for the social *context* in which it takes place, beyond 'formal institutions' or 'ideal type conceptions' (Smith and Stacey, 1997).

The epistemological stance adopted in this research entails a choice of methodological approaches that allow for the analysis of micro-processes whilst also accounting for larger scale economic, political and socio-cultural systems. The combination of Innovation Systems, Knowledge Engineering and Livelihoods Approaches provides a

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[12] A life-world can be understood as a lived-in and largely 'taken for granted' world (Schutz and Luckmann, 1973)

valuable framework through which to address both how particular groups or individuals deal with new elements in their life-worlds and attempt to create space for themselves, and how these processes can influence and be influenced by the broader environment in which they are set.

3.2 Innovation Systems: understanding technology change

Many theories have been devised to explain the process of innovation and technology development. Niosi et al. (1993) take us through the history of Technological Innovation Theory, from Schumpeter's initial writings on the role of 'heroic entrepreneurs' as major sources of innovative activity, through to the importance of demand and market determinants, the state, large firms and inter-firm interaction and collaborative agreements.

Technology is defined by Niosi and colleagues as 'technical knowledge about the production of goods and services' (Niosi et al., 1993). This knowledge many be in many forms, 'codified' as blueprints in manuals and handbooks or implicit in the experience and know-how of people. Technology development can be understood as the process of transforming knowledge into new ways of operating in the production of goods or services. Innovation is used to refer to improved 'products and processes'; although these may include new technical knowledge, i.e. technology, they are not solely dependent on it. Based on the classical definition by Schumpeter (1934), Niosi et al. refer to innovations as 'new improved products and processes, new organisational forms, the application of existing technology to new fields, the discovery of new resources and the opening of new markets' (Niosi et al., 1993). In this study the definition is taken further to include 'social' and 'political' innovations, as these are seen as having an important role in influencing trends in technical innovation, such as government subsidies, tax credits, standards policies etc. Some authors distinguish between product and process innovation, the former referring to change in the outcomes of the process and the latter to changes in the way products are created or delivered (Tidd, 2001).

In general terms, the innovation process has been classified as being *linear* or *systems-oriented* and *demand-side* or *supply-side oriented*. Linear views have supported a supply-side orientation in innovation policies aided by Economic Impact Assessment methods for targeting poverty alleviation at both the micro and macro levels. On the other hand, systems perspectives have been associated with demand-side approaches and participatory methods (Dalrymple, 2004; Edquist and Hommen, 1999).

3.2.1 The Central Source of Innovation Model

Historically, agricultural R&D has been dominated by linear and supply-led approaches grounded in what Biggs (1990) has termed the 'Central Source of Innovation Model'. The Central Source Model, greatly influenced by Diffusion of Innovation Theory (Rogers, 1983), is based on the idea that agricultural research and technology diffusion follow an unambiguous, one-way progression from research centres to extension agencies and finally to farmers. Knowledge is created by research and the challenge is to get it through: to 'Transfer the Technology' from 'Lab-to-Land'. However, after many decades and colossal investments, R&D's limited success in addressing the specific needs of the poor (Chambers, 1997; Chambers et al., 1989; Okali et al., 1994; Sumberg et al., 2003) has highlighted the severe limitations of the Central Source model. Conventional methods to evaluate R&D performance, such as adoption studies or economic surplus models, have been critiqued on conceptual grounds for providing little insights into how the R&D process takes place and having poor diagnostic power (Rajeswari, 1995). It has been argued that one of the main weaknesses of the Central Source Model has been the tendency to marginalise the potential contribution of resource-poor farmers and other (non-research) actors to the innovation process.

3.2.2 The Multiple Source of Innovation Model

The Multiple Source of Innovation Model is based on the idea that innovation and technology development come from diverse sources that include international research centres, national research systems, NGOs, extension staff, private corporations, and, to a great extent, farmers themselves (Bebbington, 1996; Biggs, 1990). Far from being a one-way, unambiguous process, agricultural research and technology development systems are seen as being in constant disequilibrium while different interest groups compete for the benefits of research and technological innovation. The Multiple Source Model highlights the fact that technology development and promotion activities are never neutral and that the political, economic, agro-climatic and institutional context in which they occur will influence priorities and outcomes. The Multiple Source Model calls for greater attention to the *process* of technology change, the *context* in which it takes place and the role of different *actors* in shaping it. Farmers are no longer seen as passive recipients of innovations triggered from above but as protagonists in the process of technology change. The Multiple Source Model provides a conceptual basis for the growing interest in 'systems' approaches in R&D and the larger 'participatory development' agenda.

In recent years there has been increasing interest in the use of the Systems of Innovation Theory both to understand and reform agricultural research systems (Sumberg, 2005b). The strength of the approach, it is argued, is the emphasis it gives to institutional learning and context. It emphasises the need to incorporate the 'evaluation as learning' principle and the need to move beyond technology development towards a more inclusive approach that will capture how the research community operates (Hall et al., 2003). The framework draws from earlier work focusing on the multiple sources of innovation and agriculture technology development (Biggs, 1990) and shares important similarities with the Modes of Knowledge Production perspective (Gibbons et al., 1994) and interactive learning and evolutionary theories (Edquist and Hommen, 1999). The shift towards a more pluralistic system coincides with a swing towards privatization and decentralisation processes and the emergence of new actors in R&D (Echeverría, 1998). Whilst most of the work on innovation systems has focused on industrial economies in developed countries (Andersen et al., 2002; Carlsson et al., 2002), a growing body of literature attempts to use systems of innovation theory to inform the processes of agricultural R&D in developing countries (Biggs, 2007; Clark, 2002; Ekboir, 2003; Furtado et al., 2011; Hall et al., 2001; Hall et al., 2003; Hartwich et al., 2007; Spielman et al., 2009; Spielman et al., 2008; Sumberg, 2005b; World Bank, 2006).

3.2.3 Systems Approaches: technology development as process

Carlsson et al. define a system as 'a set of interrelated components working toward a common objective' (2002: 234). Systems of Innovation have been described as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies' (Freeman, 1988 cited in Niosi et al., 1993: 208). Institutions include the physical organisations involved in R&D activities and the rules and norms under which they function, i.e. role-oriented and rule-oriented institutions (Brinkerhoff and Goldsmith, 1992). The function of an innovation system is to 'generate, diffuse and utilise technologies...that have an economic value' (Carlsson et al., 2002).

At its simplest, the framework acknowledges that innovations emerge from systems of actors. The concept of systems implies an 'environment' that lies outside (Niosi et al., 1993) and recognises that the way systems interact and behave is shaped by the environment in which they are embedded. This idea has been emphasised by a growing body of literature that stresses the need to account for the social, political and institutional contexts when planning and evaluating R&D (Biggs, 1994; Hall et al., 2001; Hall et al., 2003). Systems of Innovation Theory helps us understand the wider contextual issues that affect the research and innovation process. The framework highlights the importance of: a) institutional learning, b) institutional context, c) actors' roles and interactions and d) the fact that innovation is the outcome of the above.

The debate on the institutional context of R&D has shown how different arrangements might exclude different players whilst favouring the agendas of others. No technology can be detached from the context in which it is to be used (Clark et al., 2003; Gass et al., 1997). Analysis must account for the rules and norms that govern the R&D process: how priorities emerge, the role of different players and interactions between them, how R&D is evaluated and made accountable, how organisations learn and build up their knowledge, etc. The recognition that agendas in the R&D process are negotiated and contested implies that particular attention must to be given to actor interaction and system dynamics.

Hall and his colleagues (2003: 222-223) summarise some of the principles that are required to relate R&D to institutional context and suggest practical ways to address them. A suggested starting point is to build an 'inventory of innovation actors', i.e., to identify the full range of actors relevant to a particular innovation system, including those that are normally excluded from conventional policy representation. But as was mentioned earlier, these are not isolated units but rather they influence and are influenced by other actors and elements of the system. Hence, the focus is on linkages and interactions among actors and the nature of these relationships. Three areas are identified as being particularly worth studying: ‘system competency’, the extent to which relationships exist among actors; ‘actor roles’, including multiple roles by some actors and those excluded from existing arrangements; and finally, ‘relationship dynamics’, the nature and dynamics of existing linkages and interactions. The types of relationships existing within an innovation system will reflect organisational cultures and the broader national context. Hall et al. suggest that the analysis should integrate the cultural, political and institutional context in which the innovation system is embedded. Finally, the framework emphasises the role of ‘institutional learning’ as a key element of successful innovation systems (Horton and Mackay, 2003). Indicators of institutional learning might include the closeness between policy rhetoric and research practice and the degree of self-evaluation within organisations (Smith and Stacey, 1997).

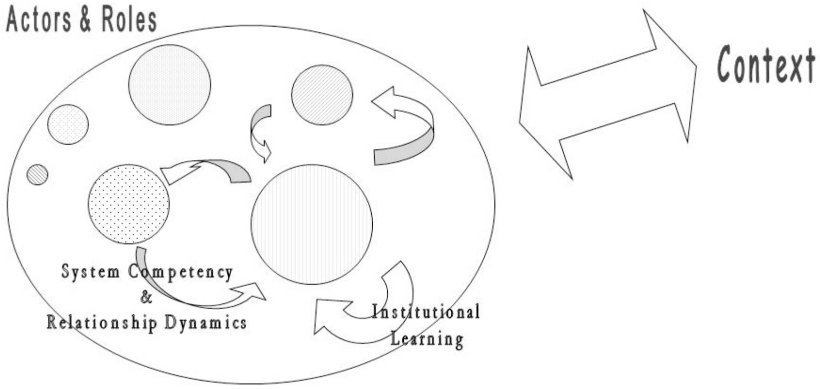

Figure 3-1 A Systems Approach to the analysis of R&D (based on Hall et al., 2003)

The process of innovation and technology development is shaped by Systems of Actors that interact with each other and the wider context in which they are set (Figure 3-1).

Innovation Systems imply that some degree of synergy and coherence among institutions forming the system must exist, such that the output of one must be reinforced by the output of the other related institutions. It has been suggested that the extent and nature of interaction among the components can be used to distinguish between effective and ineffective systems, as the development of personal and professional networks is an important component (Biggs and Smith, 1998; Clark, 2002; Clark et al., 2003; Edquist and Hommen, 1999; Ekboir, 2003; Lundy and Gottret, 2006). In light of the growth of private investment in agricultural R&D in developing countries

(Pray, 2002), increasing attention has been given to the role of public-private partnerships in the development of agricultural innovations (Hall, 2006; Hartwich et al., 2005; Hartwich and Tola, 2007; Spielman et al., 2007)

3.2.4 Bolivia's Amazon Aquaculture Innovation System, BAAIS

What is the appropriate level of analysis for the purposes of this thesis? Where should the 'boundaries' of the system be set? Systems of innovation can be viewed in several dimensions and can be defined according to the focus of attention in a variety of ways: they can be national, regional, sectoral or technological. The purpose of this research is to uncover the process of generation and diffusion of technologies in a specific knowledge field: aquaculture. The focus on a specific field of knowledge is known as a 'knowledge-based approach' (Carlsson et al., 2002). This approach centres on 'the network of agents interacting in a specific technology under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology' (ibid: 237). Therefore, this study includes all those actors, from both the public and private sectors, with competence in aquaculture. The identification of relevant actors can be aided by the 'snowball method' i.e. each actor is asked to point to further participants. In this study, geographical boundaries have also been established; the system is limited to aquaculture development in the Bolivian Amazon, in the thesis often referred to as 'Amazon aquaculture'.

There is very little data on the nature of the aquaculture sector in the Bolivian Amazon. This study could not build on government publications or censuses of fish farmers so the characterisation and analysis of Bolivia's Amazon Aquaculture Innovation System (BAAIS) is based almost entirely on primary data collected and analysed by the author. Approximately 400 fish farmers were interviewed to build up a picture of Amazon aquaculture production, technologies being used, opportunities and challenges faced by both entrepreneurs and resource-poor farmers. In order to help characterise BAAIS (actors, their roles, and context in which they operate), a second set of interviews were carried out with 90 actors representing the whole array of different organisations involved in the aquaculture sector. For the purpose of the study, actors were organised within 'components' or groups of organisations that theoretically share objectives and roles in the system: policy, research, education, extension, provision of associated inputs and services (national and international firms), credit, medium/large fish farmers, resource-poor fish farmers and external assistance organizations. The analysis of BAAIS' relationship dynamics, information networks and system competency is aided by graph-theoretic concepts (Richardson, 1999). Following the approach developed by Temel *et al*. in their ISNAR study of Azerbaijan's agricultural innovation system, the analysis of BAAIS uses interaction matrixes and their graphical representation to systematize the qualitative information gathered in the interviews and map information networks, clusters of actors or subsystems, isolated actors or mismatches that might be hindering the innovation process and blocking channels for the exchange of knowledge (Temel, 2004a, 2004b, 2006, 2007; Temel et al., 2003).

There is nothing inherently 'pro-poor' in the use of graph theory techniques to analyse BAAIS, nor, more generally, in the use of innovation systems approaches to understanding the development and spread of innovations (Biggs, 2007). But these approaches can be effective tools for pro-poor innovation analysis if used for this purpose. In this study, the innovation system approach and graph theory techniques are used to carry out a distributional or poverty analysis of BAAIS and explore the changes experienced in the system's structure and dynamics when targeting resource-poor farmers: situations where pro-poor innovations are already taking place, key actors and groups of actors involved, favourable and unfavourable institutional arrangements for the development of a pro-poor BAAIS, etc.

Methods for data collection and analysis used in the study of BAAIS are described in greater depth in Chapter 4.

3.3 Knowledge engineering: matching technologies with end-users

The next section turns to review the conceptual framework and methodologies used for local-level analysis of rural aquaculture R&D in the Indigenous Territories *Mojeño Ignaciano* (TIMI) and *Multiétnico* (TIM). Here the focus is on 'the adaptive end' of the spectrum of research and the experience of an NGO initiated aquaculture project. The analysis draws from key concepts of the Knowledge Engineering Approach to research management (Reece et al., 2003; Sumberg and Reece, 2004) and Livelihoods perspectives to inform the analysis of pro-poor aquaculture technology development and diffusion. Whilst the knowledge engineering framework provides a conceptual ground for the characterization of innovations and technology development alternatives, livelihoods analysis provides a valuable entry point to further our understanding of farmers' interest in and access to proposed innovations and how the adoption of innovations might affect rural peoples' assets beyond a narrow focus on agricultural systems.

Priority setting in agricultural/NRM R&D is carried out at national, programme and project levels, through the allocation of human and financial resources. Amazon aquaculture development at the national level is examined in Chapter 4. Chapter 5 turns to examine decisions and processes that take place at the lower levels of this hierarchy, as it is believed that the greatest potential to increase the chances of the adoption and diffusion of agricultural/NRM innovations often lies at the project level. To a great extent, nascent technologies are specified within extension organisations, hence these organisations play an important role in determining which research results are adopted by groups of farmers (Byerlee, 2000).

3.3.1 Targeting the poor in agricultural development & extension

Model-Ts

As noted earlier, the Central Source of Innovation Model has been predominant in much agricultural R&D to date. Approaches to agricultural extension that have developed within the Central Source paradigm have often been associated with what has come to be known as Transfer of Technology (TOT). TOT approaches to agricultural extension offer significant advantages in tightly regulated and predictable environments or where a robust physical technology can be effective in many different environments. However, these approaches have not been as successful in less-favoured areas (LFAs) where environments tend to be highly diverse, complex and risk-prone. Technologies developed in labs or on research stations have repeatedly failed to 'fit' local conditions, to the point that some authors consider 'misfits' to be *endemic* to TOT approaches (Chambers, 1997: 68).

TOT approaches to pro-poor agricultural development have been criticised on numerous grounds and by numerous authors (Altieri and Masera, 1993; Bernet et al., 2001; Byerlee, 1994, 2000; Chambers, 1997; Chambers et al., 1989; Collinson, 2001; Cox et al., 1998; Das, 2002; Okali et al., 1994; Ruben and Pender, 2004; Thompson and

Scoones, 2009). TOT 'misfits' have been associated with research that focused on high potential areas at the expense of LFAs, the production of commodities at the expense of the overall agricultural system, outputs and not processes, efficiency over poverty alleviation objectives and research that paid insufficient attention to local realities. While many of these criticisms have been answered (Renkow, 2000), on the whole they cannot be disregarded. In a time where agriculture is gaining renewed importance in the development agenda (CGIAR, 2005; DFID, 2005; World Bank, 2007), there is increasing consensus about the need to ensure further consultation, participation and demand-driven approaches in research and extension.

Farming Systems Research (FSR)

FSR received a lot of attention as a means of getting formal research and extension systems to respond to the needs of resource-poor farmers'. FSR provided new methods and techniques to close the gap between the lab and the field, the most important of which was on-farm trials. A shift from crops to ecosystems was triggered by the recognition that to tackle problems of poverty and environmental degradation presented by low-resource agriculture, additional research needed to be undertaken at a system level rather than focus on discrete commodities. Low resource agriculture is often characterised by complex farming initiatives that pursue multiple but complementary objectives. FSR accepted that innovations in particular areas or subsystems that detract from overall system performance can be counter-productive (Reece and Sumberg, 2003). Hence researchers required a detailed understanding of farmers' strategies. In trying to bridge the gap between formal research and the potential end-users of research outputs, it could be said that FSR began to give a 'market' orientation to the innovation process.

However, FSR was criticised for not dealing with the larger policy context and focusing solely on agricultural systems at the expense of other livelihood elements (Biggs, 1994; Drinkwater and McEwan, 1992). It has been suggested that greater awareness of the diverse ways people make a living will raise important questions about the links between on-farm and off-farm activities (Ellis, 2004, 2005). Furthermore, this approach has been criticised for requiring heavy investments of time and resources for gaining information on farming systems through elaborate surveys whilst providing limited applicability to other areas or groups (Gilbert et al., 1990).

Farmer Participatory Research (FPR)

At its simplest, FPR, also known as Farmer-First approaches (Chambers et al., 1989), and its variants, such as Participatory Technology Development, refer to approaches to agricultural research and extension that actively involve farmers in the process. At its core is the idea that potential end-user participation in the innovation process will ensure its relevance and increase the rates of adoption and diffusion. It is a response to the recognition that researchers have great difficulties in understanding the agricultural systems in which innovations are supposed to be used. It is argued that, in fact, nobody could possibly understand these systems better than those who work within them. Farmers are no longer passive recipients but important actors that will influence and shape the innovation process (Chambers, 1994, 1997; Chambers et al., 1989; Okali et al., 1994; Pretty, 1995; Scoones and Thompson, 1994). Like many other 'participatory' approaches to development, FPR is invariably contrasted with modernization and technocratic approaches to development. As Okali *et al.* (1994: 27) state, 'perhaps one of the weakest aspects of modernization theory is the implied stagnation of traditional society and culture'. Much to the contrary, researchers have documented the dynamic and innovative nature of rural peoples around the world (Sumberg and Okali, 1997). FPR highlights the importance and potential of farmers' own research. Ultimately, underlying FPR is the idea that agricultural research should always be carried out with specific end-users in view. In the case of LFAs, which are often the focus of FPR, farmers are more diverse and complex than many would think.

FPR has been used to refer to an approach to the design, testing and dissemination of technologies, but also as a means to promote community-based research capacity and empowerment at a number of levels. As both locations and peoples targeted by FPR are frequently marginalized and excluded from national political life, many believe that agricultural research and extension cannot function without engaging with problems of local empowerment. The argument goes that the development and adoption of innovations cannot take place unless farmers first develop the capability to take them on board. The very nature of FPR has been seen by many as an 'empowering' process in itself as it creates new space for farmers' voices to be heard and these are seen to be able to influence the priorities and decisions of the R&D process (Chambers, 1997; Chambers et al., 1989).

FPR has also been associated with the increasing interest in low-input, sustainable production systems that stress resilience and sustainability of production under different environmental conditions, most specially marginal ones, rather than boosting yields under optimum conditions as Green Revolution technologies do (Conway, 2007). The new generation of sustainable practices that focus on the optimization of locally available resources and the maintenance and/or enhancement of the resource base can contribute to increase farm productivity by 'working with nature' (Pretty et al., 2006). These approaches have often favoured building upon 'traditional' production systems (Bierhorst, 1994; Callicott, 1989; Posey and Dutfield, 1997; Warren et al., 1995). This has brought increased awareness about the importance of indigenous and local knowledge in contributing to the R&D process (Blaikie et al., 1997) and a growing emphasis on the nature of 'knowledge systems' and the dynamics and interaction between indigenous/local and formal/non-local knowledge systems i.e. knowledge 'interfaces' (Arce and Long, 1992; Eernstman and Wals, 2009; Fairhead and Scoones, 2005; Hassel, 2006).

To incorporate local peoples' own views of agricultural systems, livelihoods and the natural world they depend on, agricultural R&D shifted towards more 'sensitive' methods that are better able to capture 'the voices of the poor'. Farmer Participatory Research (FPR) is associated with Participatory Rural Appraisal (PRA) methods and techniques (Chambers, 1994a, 1994b).

How much participation?

Is participation always good? Is it a case of 'the more the better'? Is there a point in which the costs of participation might outweigh the benefits? What form of participation is best?

Whilst some authors argue that there can never be too much participation (Chambers, 1997; Chambers et al., 1989), others suggest that participation is not always useful nor desirable (Bebbington, 1994; Cleaver, 1999; Drinkwater and McEwan, 1992). In a review of Robert Chambers' writings, Cleaver highlights the dangers of attributing a ‘moral value’ to the knowledge, practices and attitudes of ‘the locals’. It is argued that by trying to escape from the untenable position of ‘we know best’ we might run into an equally untenable position of ‘they know best’ (Cleaver, 1998: 12). Bebbington (1994) points out that participatory approaches that emphasise ‘what farmers know’ about their environment or technology, has diverted attention from the myriad of things that they do not know about other aspects of the rapidly changing physical, socioeconomic and technological environments beyond the farm, which are shaping their present and future. Drinkwater & McEwan (1992) ask what the role of agricultural extension organisations should be when constraints on production are primarily institutional and not of a technical nature. How far should participation be taken?

Before entering into debates about the most desirable types and degrees of participation it might be important to establish the purpose of FPR initiatives and differentiate those that are directed towards improving the efficiency and success of agricultural R&D from those that are aimed primarily at the empowerment of local people through community development projects (Okali et al., 1994; Sumberg et al., 2003). It seems likely that there is no fixed level or form of participation which is appropriate in agricultural research, rather this will and should vary according to the *objectives* and particular *technologies* under study as well as the *context* in which the study is being carried out. Projects seeking primarily the empowerment of local peoples might indeed benefit from exalting local values as a means to strengthen the identity and self-esteem of marginalised groups in response to external pressures or impositions. However, if the aim of participation is primarily ‘functional’, i.e. a means to an end, local knowledge, practices and values will be incorporated into the project as long as they bring it closer to that end. In developing applied research, one might gain from other participants and perspectives, to provide a broader vision of what is possible given the knowledge and techniques available. Supply-driven approaches might have a particularly important role to play in initiatives aimed at capturing future possibilities, such as future market windows, or in the promotion of promising innovations that are completely novel to a region or group of potential users. It is likely that neither the Demand- or the Supply-Driven approach by itself will be able to effectively inform the priority setting process to get good applied research and meet broader long-term needs. The challenge might be to find an appropriate balance of both (Dalrymple, 2004).

When increased research 'efficiency' is the justification for farmer participation, it is important to consider how different research objectives and different kinds of technologies will influence the type and degree of 'useful' participation. The technology development process can be seen as undergoing several stages, from a broad initial idea or 'notional technology' to its full specification when the technology is ready to be used (Sumberg, 2005a). It has been argued that in the face of diversity and limited resources, the R&D process could benefit from handing over technologies to farmers before their full specification (Reece and Sumberg, 2003; Sumberg et al., 2003). If it is acknowledged that 'local' research and innovation takes place on a regular basis, it could be argued that there might be some degree of overlap between formal and farmers' research, especially in the final stages of the technology development process. This concept has been referred to as 'partial substitutability' of formal research for farmers' research (Sumberg et al., 2003). In studying farmers' experiments, Sumberg & Okali (1997) conclude that many farmers engage in planned and systematic activities directed at adapting techniques and production systems to suit local conditions. These results appear to support the idea that important similarities exist between formal research and that practiced by farmers, and thus the idea that the latter could play a significant role in tuning techniques to suit individual circumstances (see also Clark et al., 2003).

3.3.2 A Knowledge Engineering Approach: Focusing on both sides of the technology transfer equation

The task of promoting innovations and technical change in agriculture and natural resource management is often seen as the responsibility of 'extension' organisations, which transfer outputs from formal research to client groups in the form of 'recommendations' (management methods or material inputs or a combination of both). As discussed above, attempts to increase the impact and effectiveness of poverty-focused technology development have included farming systems research, participatory technology development, on-farm research etc. But the fact remains that agricultural and NRM R&D is under increasing pressure to better serve the goal of rural poverty alleviation (Byerlee, 2000; CGIAR, 2005; DFID, 2005; Dorward et al., 2004b; Hazell and Von Braun, 2006; World Bank, 2007). Certainly, attempts should be welcomed to further understanding of agricultural systems and rural livelihoods to inform the process of pro-poor technology development. However, it is equally important to pay attention to the characteristics of the technology itself and the context in which it should be implemented in order to increase the likelihood of its adoption. Efforts to match technologies with potential users need to make various assumptions about both the target users and the innovations. Further attention must be given to the development of approaches and methods with which to analyse agricultural technology development alternatives and identify critical performance targets. In other words, what aspects of the technology should be studied in order to evaluate the probability of this technology being adopted?

A Knowledge Engineering Approach to technology development (from now on KEA) (Reece et al., 2003), which focuses on both sides of the technology transfer equation, on the one hand, the realities of potential users and on the other, the characteristics of proposed innovations, is used in this study to analyse the development and adoption of aquaculture technologies in the indigenous territories TIM and TIMI (Chapter 5). Underlying this approach is the idea that agricultural and NRM R&D can gain from making better use of theory and experience in the field of industrial and commercial 'new product development' (Sumberg and Reece, 2004). 'Knowledge engineering' refers to the manner in which the approach builds a complex picture of the 'appropriateness' of innovations based upon combining information about simple relationships. At its simplest, KEA involves segmenting the market for new agricultural technology based upon interests in the benefits associated with a given innovation and the access to resources required for its adoption. Similarly, proposed innovations are defined in light of these same generic 'benefits' and 'resources'. Then, market segments and technologies are matched according to five different dimensions: benefits, resources, bio-physical requirements, solution space and agricultural logic, as elaborated below (Reece et al., 2003).

The KEA was originally developed to inform *ex-ante* assessment of the likely uptake of proposed innovations at a 'pre-development stage', that is, when the idea is first conceptualised to address a problem or opportunity and screened to decide whether resources should be committed to its development. However, in the case study at hand, the development of fish farming is already taking place and some farmers are actively involved in the adaptation and re-invention of partially finished technologies. In other words, the innovation is already in its early stages of development and diffusion.

The strength of this approach is the emphasis it gives to the description of innovations. All too often, heated debates about the contribution of proposed innovations to rural development are fuelled by differing views about what the innovations actually involve. Inherent to the KEA is the idea that farmers have an important role to play in technology development and the need to favour the greatest possible synergy between farmers' own innovation and formal research. An important advantage of the approach is the contribution it can make to informing and determining the design specification that would be necessary for a given innovation to be of use to a particular market segment. Reece et al. (2003) draw on three concepts to define key characteristics of technologies and the context in which they are used:

Environmental range: refers to the set of bio-physical conditions under which a given technology will yield satisfactory results in terms of end-users' expectations. For example, technologies with a wide environmental range will be desirable if yield stability is of major concern.

Solution space: focuses on the use and management of the technology. It can be defined as the flexibility of a technology to withstand sub-optimal management practices and still yield satisfactory results. Technologies with a wide solution space will be more forgiving of failure to attain 'best practice' than those with small solution space. Technologies with a small solution space require relatively precise management and hence their use makes most sense within a strong or intermediate intensification logic. Large solution space technologies are important for user groups with low management precision. Similarly, large solution space technologies might be relevant in situations where there is a high degree of livelihood diversification, as many competing demands on labour and resources will be incompatible with precision farm management.

Farming system precision: deals with the control that farmers have over their farming systems and the precision with which they can successfully execute their plans and decisions. High precision systems will be those over which farmers have considerable control whilst in low precision systems farmers might have limited access to key resources and their capacity to carry out initiatives could be truncated. System precision measures the gap between how people would like to farm under ideal settings vs. how they actually farm due to constraints in access to resources. Farming precision is useful in the differentiation of potential user groups or market segments. The notion of the precision of farming systems can be expanded to include the precision with which rural dwellers can successfully execute their plans and decisions with regards to livelihood options more generally, including non-farm activities.

It is probable that the more specialised a technology becomes, the more its environmental range and solution space will decrease. If the environmental range and solution space of a technology decrease, so too does the number of farmers that could potentially adopt it (as it becomes more demanding) (Reece and Sumberg, 2003; Reece et al., 2003; Sumberg and Reece, 2004).

In matching technologies with potential users it is also useful to define a technology as a set of 'benefits' provided by its adoption and of 'resources' required for its effective use (Reece et al., 2003). Furthermore, innovations can be described in terms of the production context for which they would be appropriate. The economic characteristics of a particular production environment can be described by the notion of 'agricultural logic' with three logics being identified: strong, intermediate and weak intensification. The argument is that a strong logic of intensification is created by pressure on land resources (or in the case of aquaculture, water resources) and/or increased market access. Market access is considered to be dependent on the distance of the location in question to a road, the distance to a market and the size of the latter, which will determine the strength of the 'pull' exerted by the market. On the other hand, in the absence of pressure on resources and access to market, there will be little logic for intensification.

The other side of the technology development equations involves understanding how appealing and accessible innovations are to potential users, in other words, how they 'fit' with rural livelihoods and the wider context in which they are set. The KEA highlights three important aspects that will influence adoption: the interests of potential users in the benefits to be derived from the innovation, access to the resources required for the innovation, and location i.e. the physical characteristics of their production environment.

Interest in a particular technology can be seen in terms of utility and functionality. The "functionality threshold" is described as the minimum objective performance (independent of price) that a given product must deliver in order for the consumer to consider it. The "utility threshold" is "the highest price a consumer is willing to pay for a product that just satisfies his or her functionality threshold" (Levinthal, 2001: 615 quoted in Sumberg and Reece, 2004). In general terms, if the functionality threshold is too low and/or the utility threshold too high, then there will be no demand for the innovation[13]. In this case the innovation will either not be used or, alternatively, it may be 're-invented' by farmers during the evaluation process. The functionality and utility thresholds can be seen as responding to the relative attractiveness of expected benefits (yield potential and reliability, time till benefits can be obtained etc.), the magnitude of these and their relative importance with regards to the overall portfolio of activities that constitute a livelihood (How do expected benefits compare to existing practices and/or other potential innovations?).

Access to resources required to use the innovations successfully is often treated in debates about 'constraints' on the adoption of innovations in LFAs (Sumberg, 2005a). Sumberg highlights the need to distinguish between constraints and pre-requisite conditions. The former refers to those elements that are likely to influence the outcome of the matching process between potential end-users and a proposed innovation (limited information, unavailability of requisite inputs etc.); whilst prerequisite conditions are seen as those elements that cannot be influenced by the R&D process, such as inappropriate land tenure arrangements or inexistent output markets when the innovation's agricultural logic is precisely to increase the area of production that will generate a surplus for sale. The idea is that the discussion of constraints should focus on those that are inherent to the innovation process and can be specified, modified and verified during its design and development. Although other

[13] Although these are useful concepts they must be taken with caution as the diffusion of unsuccessful innovations do take place, particularly when adopters lack information or knowledge to evaluate innovations (Soule, 1999). In agricultural R&D, externally supported programmes in which critical feedback might be seen as having implications on funding might present a popular narrative of success without considering the details, and promote the diffusion of unsuccessful innovations (Ibid).

elements of the wider context in which the innovation process takes place will no doubt influence its outcomes, it is argued that if these are not potentially favourable there can be no expectation of adoption and diffusion in the first place. It is worth stressing that both functionality and utility thresholds and access to resources will be influenced by the socio-economic and institutional context in which rural peoples live and work and are likely to vary among and within communities and among and within households.

3.4 From farming systems to livelihoods approaches

Local level analysis of the aquaculture project in Moxos and efforts to increase the impact and effectiveness of poverty-focused fish farming technologies in the indigenous territories TIM and TIMI is aided by livelihoods analysis. Livelihoods household surveys are used to gather information about farmers' diverse 'rural worlds', with particular emphasis on those aspects most likely to influence their possible interest in and access to aquaculture technologies.

As discussed in sections 2.1.2 and 2.1.3, a growing body of literature emphasizes the fact that the rural poor do not normally specialise in a particular farming activity, such as livestock, crop or fish production, to the exclusion of income generation activities in other areas. On the contrary, rural populations tend to diversify their productive activities to include a range of activities in many sectors with both positive and negative outcomes (Barrett et al., 2001; Berdagué et al., 2001; Bryceson, 2002; De Janvry and Sadoulet, 2001; Ellis, 2000, 2004, 2005; Ferreira and Lanjouw, 2001; Lanjouw and Lanjouw, 2001; Steward, 2007). This recognition has led some authors to characterize rural livelihoods as being constructed from a portfolio of activities. Livelihoods perspectives represent a shift from emphasis on sectoral and natural resource issues to people-centred approaches in poverty reduction programmes in rural areas (Carney, 1999; Chambers and Conway, 1992; DFID, 1999; Scoones, 1998). It moves beyond a focus on seeking improvements in agricultural production to looking at the whole range of strategies by which the rural poor sustain a livelihood. The framework is concerned with the dynamic dimensions of poverty and establishes a typology of assets that poor people and communities install to maintain well-being under changing conditions (Norton and Foster, 2001).

A livelihood can be understood as comprising 'the capabilities, assets (including both material and social resources) and activities required for a means of living.' (Carney, 1998). Livelihoods analysis focuses on five different types of assets upon which people draw to build their livelihoods: natural, physical, human, financial and social. In brief, natural assets refer to the natural resource stocks, such as land, water and wildlife, used by populations for their survival. Physical assets include the basic infrastructure and production equipment which enable people to pursue their livelihoods (tools, irrigation, machines, shelter, etc.). Human assets refer to the skills, knowledge and health status of individuals. Financial assets refer to the stocks of cash available to people, including credits. Social capital comprises the social resources (networks, relations of trust, associations etc.) from which people can draw support in pursuit of livelihoods (Ellis, 2000). Access to the different types of assets is mediated by social norms and rules. The institutional settings and context in which people make a living have a differentiated impact upon individuals' capacity to achieve his/her consumption requirements (Scoones, 1998). The analysis of assets and activities also entails an analysis of change i.e. how asset status and livelihood strategies are changing over time. One of the purposes of the analysis is to understand the process of change in livelihoods and its root causes (Carney, 1998).

Finally, it is worth noting that the notion of livelihood cuts across what have been seen as two opposing conceptions of poverty: those approaches aiming to measure poverty 'objectively' (in terms of income and expenditure indicators), and those that understand poverty as a subjective experience and highlight the importance of capturing what people themselves perceive as poverty and wellbeing (Bebbington, 1999). Livelihoods approaches are interested in understanding both the 'objective' dimensions of rural livelihoods and the subjective dimensions of the conditions in which people live (Moser, 1998). Livelihood decisions may address certain dimensions of poverty at the expense of others, such as leaving familiar kin and a safe environment in order to meet monetary needs, or on the contrary, desisting from migration and increased monetary income in order to be in a calmer and familiar environment. How people make these choice will be influenced by what poverty, development and livelihood mean to them. In this sense capital assets can be understood as *meaning* (to different people at different times during life cycles), as well as instruments to secure livelihoods (Bebbington, 1999).

The following chapters, 4 and 5, present the thesis' results. Chapter 4 builds a picture of the size, nature and dynamics of Bolivia's Amazon Aquaculture Innovation System (BAAIS) and its role in smallholder development, drawing from interviews carried out by the author with fish farmers and other actors in BAAIS. Chapter 5 presents the results of the study of fish farming in indigenous territories in Moxos that have been at the centre of pro-poor aquaculture development efforts. Local level analysis is based on interviews with fish farmers and non-fish farmers in indigenous communities and on-farm and on-station research.

4 Bolivia's Amazon Aquaculture Innovation System

4.1 Introduction

Chapter 4 presents the main findings of the author's research into Bolivia's Amazon Aquaculture Innovation System, BAAIS. The analysis uses Innovations Systems theory and Graph Theory techniques to explore the process of Amazon aquaculture innovation and technology development within the Amazon region of Bolivia and its current and potential contribution to poverty reduction. The recognition that innovation comes from diverse sources, from both the public and private sectors, and that agendas in the R&D process are negotiated and contested implies that attention must be given to actors, roles, context and interactions between actors and system dynamics.

The analysis of BAAIS addresses some of the research questions introduced in Chapter 2: In encouraging the uptake of aquaculture as a new livelihood activity, have institutional conditions in the Bolivian Amazon worked effectively to support its adoption by poor rural dwellers? What is the nature of Amazon aquaculture R&D and what are the poverty effects of the innovation process?

The chapter is divided into 7 sections. Section 4.2 describes the methods used in the study of BAAIS for data collection and analysis and the limitations of the approach. Section 4.3 presents the results of a diagnostic survey of Amazon aquaculture producers, the first to be carried out in Bolivia. Section 4.4 provides a descriptive analysis of BAAIS: actors, roles and contexts, impediments to and opportunities for the flow of knowledge, and the development of fish farming as seen by different actors. Production requires the existence of networks through which information and research results may flow into areas where they can be applied. Therefore, it is important to identify information networks, as well as barriers to the flow of knowledge in BAAIS. Section 4.5 moves beyond the individual actors and uses Graph Theory techniques to explore the system's workings and dynamics as a whole and uncover information pathways and circuits: system competency, relationship dynamics and BAAIS' Cause-Effect structure. Section 4.6 goes beyond identifying access to information and maps producers' access to other inputs which are crucial to the adoption of aquaculture technologies, such as fry and fish feed. Section 4.7 presents the results of a distributional or poverty analysis of BAAIS and reviews the short history of pro-poor Amazon aquaculture innovation projects in Bolivia drawing from the interviews with the different actors involved.

4.2 Data collection & analysis

Bolivia is divided into three water systems: the Amazon basin, the Plate basin and the Altiplano basin. Aquaculture R&D has evolved in different ways in the three river basins, in response to different environmental and climatic characteristics and development priorities. The Amazon water system, where this research was carried out, covers up to 66% of Bolivia's total surface (Arteaga and Coutts, 1996) and comprises the Departments of Beni, Pando, and parts of Santa Cruz de la Sierra, Cochabamba and La Paz. However, due to time limitations, the Department of Pando and the northern part of Beni could not be included in the survey. The study area is shown in Figure 4-1.

All the data in this study of Bolivia's Amazon Aquaculture Innovation System (BAAIS) comes from field work conducted by the author between June 2005 and January 2006. No references are made here to earlier studies as there were no censuses of fish farmers or reliable data on the nature or size of the sector before this study was carried out. Two types of questionnaires were designed to collect the data. The first questionnaire was designed for fish farmers and was aimed at gathering basic background information about who is producing what and where, and the main problems faced by producers, including access to input/output markets. The second questionnaire was designed for all key actors, from both the public and private sectors, involved in the production, dissemination or use of aquaculture technologies. The aim was to gain insight into BAAIS' workings, or in the language of Hall et al. (2003): system competency, actor roles, relationship dynamics, degree of institutional learning and context in which the innovation process is taking place.

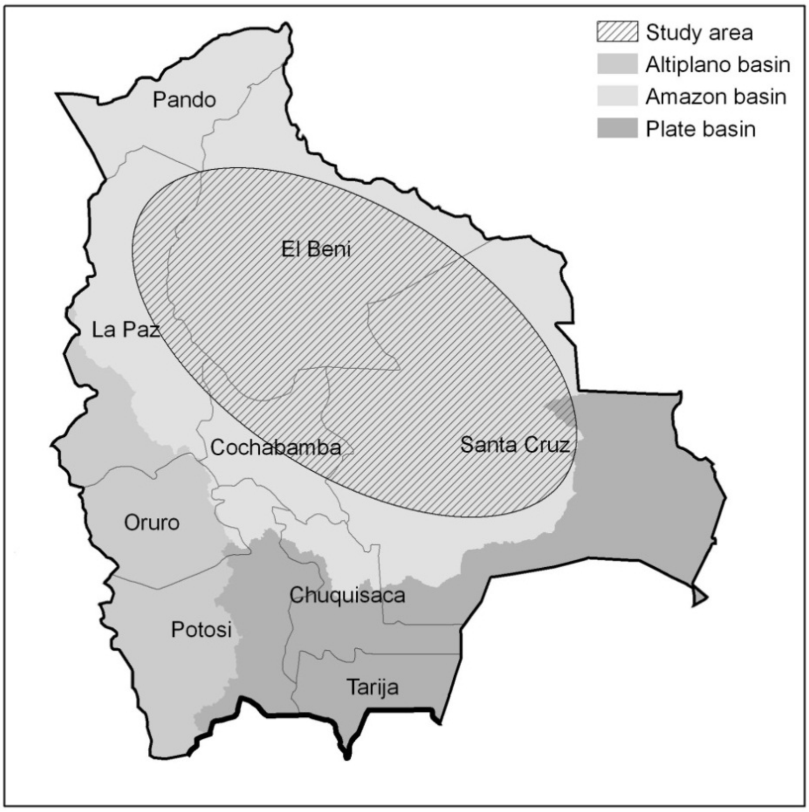

Figure 4-1 Bolivia's Amazon region and study area (striped oval)

4.2.1 Interviews with fish farmers in the Bolivian Amazon

384 producers from Beni, Santa Cruz and the tropical regions of La Paz and Cochabamba were interviewed[14]. One hundred and thirty five of these were medium/large entrepreneurs (from now on MLE) who had adopted aquaculture without any kind of external assistance, and 249 were resource-poor farmers (from now on RPF) who had initiated aquaculture activities as part of pro-poor aquaculture development projects funded by government or external aid agencies. Out of the 249 RPF interviewed, 141 were still benefiting from some kind of external assistance at the time of the interview, whilst the remaining 108 were ex-beneficiaries of projects already terminated, where external assistance had been withdrawn. Farmers were asked about the type of aquaculture being practiced, farm productivity, their main source of information, their access to input and output markets, credit, and main problems and opportunities faced.

14 The sample of fish farmers interviewed per region is presented in Appendix 1 Table A-2

The full questionnaire for producers is presented in Spanish in Appendix 3. The Box 4-1 highlights the main issues covered:

Box 4-1 Main themes covered in the questionnaire for producers

Part I. Role of aquaculture: producer's background, year aquaculture initiated, fingerlings purchased/year, motivation for fish farming and importance given to it as source of income

Part II. Type of aquaculture: Species farmed, size and type of pond, type of feed and fertilization, fish sold versus consumed, output/2004, potential output/yr, family labour invested, hired labour

Part III. Access to inputs: suppliers of fry, feed, pond construction services, subsidies and/or credits, information, equipment.

Part IV. Evaluation of fish farming: Degree of satisfaction with the farm, views on problems faced by the farmer and the sector, future plans with regards to fish farming, knowledge of anybody that lives from fish farming alone.

Some of the MLE had associates in their fish farming and most of the RPF beneficiaries and ex-beneficiaries of pro-poor aquaculture development projects were involved in some form of community or group based farming. Therefore, although only 384 producers were interviewed (second column in Table 4-1), the information provided on aquaculture production corresponds to 971 producers (third column in Table 4-1).

Table 4-1 Aquaculture producers interviewed in the Bolivian Amazon

CATEGORY	PRODUCERS INTERVIEWED	TOTAL PRODUCERS ACCOUNTED FOR
MLE Medium/Large entrepreneurs Non beneficiaries of aquaculture project	135	167
RPF Resource-poor farmers Beneficiaries of aquaculture project	141	804
RPF Resource-poor farmers Ex – beneficiaries of aquaculture project	108	
TOTAL	384	971

As no survey of fish farmers had ever been conducted in Bolivia, it was not easy to build up a sample of producers. Information provided by producer organizations, NGOs and the main suppliers of fry and feed helped spot individual farmers in the different regions of the Bolivian Amazon and the latter were asked to identify other fish farmers they knew in their area. The objective was to get a geographical representation of producers in the different regions in the study area and interview as many of them as time and resources allowed (The sample of fish farmers interviewed organised by regions in the Bolivian Amazon is shown in Appendix 1,Table A-2). Data analysis was carried out using the Statistical Package for the Social Sciences (SPSS version 11).

As this was a nonprobability sampling method it is tricky to extrapolate the findings to the whole population. Interviews with the main suppliers of associated inputs and services and with representatives of producer organisations and pro-poor aquaculture development projects have permitted some degree of triangulation of the information gathered from producers. It is estimated that the 971 fish farmers sampled for the study represent approximately half of the total population of fish farmers active in Bolivia's Amazon region in 2006[15]. Nevertheless, it is important to highlight that the figures given for total production of Amazon aquaculture are rough estimates.

4.2.2 Interviews with actors in BAAIS

The IS approach, described in Chapter 3, is built upon the idea that interactions between agents who produce, distribute and apply different kinds of knowledge are as vital to the innovation process as knowledge production itself. Hence, understanding the nature of the system's interactive structure and strengthening effective information networks might be as important to furthering and influencing production and economic growth as direct investment in aquaculture R&D.

For the purpose of the study, the different actors within BAAIS were categorized in relation to their objectives and the formal role they play within the system. The resulting categories or subsets of organizations are: (A) Policy formulation and enforcement; (B) Research; (C) Education; (D) Extension; (E_n) Provision of associated inputs and services (National firms); (E_a) Provision of associated inputs and services (Abroad); (F) Credit; (G_e) Producers (Medium/Large entrepreneurs); (G_f) Producers (Resource-poor farmers) and (H) External assistance. To allow for a poverty or distributional analysis of BAAIS, producers were classified as medium/large entrepreneurs who set up aquaculture on their own, or resource-poor farmers, mainly indigenous or campesino[16] farmers engaged in aquaculture with assistance from a rural development project.

The questionnaire used to interview the different actors within BAAIS was adapted from ISNAR's study on the agricultural innovation system of Azerbaijan (Temel et al.,

[15] This is a rough estimate made based on information from: 1) all existing seed providers; 2) all existing producer organisations; 3) NGOs and 4) statistics drawn from the sample about average farm size and fry mortality rates.

[16] The term 'campesino' is here used to refer to indigenous and mestizo farmers that are not originally from the Bolivian Amazon region and have migrated there from other parts of the country.

2002, 2003). The questionnaire is designed to identify the system's main actors, their roles and participation within the innovation process, the context in which they operate, the main obstacles they face and the interactive structure and dynamics of the system.

The full questionnaire for actors within BAAIS is presented in Spanish in Appendix 2.

The Box 4-2 highlights the main issues covered:

Box 4-2 Main themes covered in the questionnaire for BAAIS actors. Adapted from Temel et al., 2002; Temel et al., 2003

Part I. **Type of organisation and background:** interviewee's background and position in organisation, classification of organisation, mandate, main activities and areas of influence, schema of organisation's structure, schema of links with other actors in BAAIS.

Part II. **Involvement in the innovation process:** Types and aims of activities linked to innovation processes in which the organisation is involved, sources of information from other actors, sources of financing, US$ invested in innovation in aquaculture, organisation's main achievements in the innovation process, main challenges faced (within the organisation and in relation to the whole sector and national context).

Part III. **Relationship dynamics within BAAIS:** Types and strength of relationships with other actors within the same component and in other components, description of examples of collaboration, main obstacles to collaboration.

Part IV. Policy in force for science/technology in agriculture/aquaculture: Government's priorities for the agricultural and aquaculture sectors in the Amazon region, innovation policies in place and actors involved in their formulation and implementation, mechanisms to promote innovation in agriculture in general and in aquaculture in specific (if any).

The identification of relevant actors within BAAIS was facilitated by the author's knowledge of the aquaculture sector in Bolivia, having worked there from 2001 to 2004. Snow-ball methods (Heckathorn, 2002; Salganik, 2004) were used to check and further add to the sample. In total 90 people representing different organizations conforming BAAIS were interviewed (Table 4-2). The complete list of interviewees is presented in Appendix 1,Table A-1.

Table 4-2 Organizations interviewed for the characterization of BAAIS

COMPONENTS	PEOPLE INTERVIEWED	N
(A) POLICY	National government (Ministry) Regional government (Prefectura) Local government (Municipio)	3 9 3
(B) RESEARCH	National Research Centers & Universities	7
(C) EDUCATION	State and private Universities & Colleges	5
(D) INFORMATION & EXTENSION	Government extension services	5
PRIVATE INPUT SUPPLY, PROCESSING & MARKETING (E_n) National firms (E_a) Abroad, foreign firms	Seed Suppliers (producers, importers, traders) Feed Suppliers (producers, importers, traders) Information suppliers (consultancy firms) Processing/marketing enterprises	6 6 3 2
(F) CREDIT	Regional co-operative banks Micro credit specialist	1 1
(G_e) *PRODUCER ORGANISATIONS:* MEDIUM/LARGE ENTREPRENEURS	Aquaculture associations	3
(G_f) *PRODUCER ORGANISATIONS:* RESOURCE POOR FARMERS	Aquaculture associations Other producer organisations	7 4
(H) EXTERNAL ASSISTANCE	International research institutes Bilateral cooperation programmes NGOs	1 6 18
TOTAL		**90**

4.2.3 Graph-theory techniques

The analysis of system dynamics requires a range of analytical tools that are quite different from those generally used in agricultural economics. Methods such as stakeholder analysis (Alsop and Farrington, 1998; Gass et al., 1997; Grimble and Wellard, 1997), the contending coalitions framework (Biggs and Smith, 1998) and game theoretic modeling (Spielman, 2005) have been effective in aiding this type of analysis. However, it has been suggested that Innovation Systems research in developing countries has been of limited application in the design of strategies for strengthening the R&D process. This has been partly attributed to the absence of policy analysis (Clark, 2002) and the limited use that most IS research has made of the existing analytical tools and methods (Spielman, 2005, 2006). Spielman's review of the IS literature highlights how the majority of studies of developing-country agriculture to date have been limited to descriptive case studies of National Innovation Systems, limiting their diagnostic power and implications for policy.

This study of Bolivia's Amazon Aquaculture Innovation System (BAAIS) provides an in-depth description of the system's actors, roles, dynamics and the contexts in which they operate; but it also takes the analysis further and models the network of relations through which information and other important resources flow among agents, including government, the private sector and external aid organisations. Drawing from social network analysis (Freeman, 2000, 2005) and graph-theory concepts (Richardson, 1999), the study uses interaction matrixes and their graphical representation to systematize and present qualitative information about BAAIS. Graph-theory techniques help identify information sources and sinks, clusters of actors or subsystems, isolated actors or mismatches that might be hindering the innovation process and channels for knowledge transfer and diffusion (Temel, 2004a, 2004b, 2006, 2007; Temel et al., 2003).

Interaction matrix

One-to-one linkages or relationships between components or subsets of actors are mapped using a 10x10 interaction matrix. As can be seen in Figure 4-2, components are placed in the diagonal cells and their linkages in the off-diagonal cells (clock-wise).

A	ab	ac	ad	ae_n	ae_a	af	ag_e	ag_f	ah
ba	**B**	bc	bd	be_n	be_a	bf	bg_e	bg_f	bh
ca	cb	**C**	cd	ce_n	ce_a	cf	cg_e	cg_f	ch
da	db	dc	**D**	de_n	de_a	df	dg_e	dg_f	dh
e_na	e_nb	e_nc	e_nd	$\mathbf{E_n}$	e_ne_a	e_nf	e_ng_e	e_ng_f	e_nh
e_aa	e_ab	e_ac	e_ad	e_ae_n	$\mathbf{E_a}$	e_af	e_ag_e	e_ag_f	e_ah
fa	fb	fc	fd	fe_n	fe_a	**F**	fg_e	fg_f	fh
g_ea	g_eb	g_ec	g_ed	g_ee_n	g_ee_a	g_ef	$\mathbf{G_e}$	g_eg_f	g_eh
g_fa	g_fb	g_fc	g_fd	g_fe_n	g_fe_a	g_ff	g_fg_e	$\mathbf{G_f}$	g_fh
ha	hb	hc	hd	he_n	he_a	hf	hg_e	hg_f	**H**

Figure 4-2 Linkage or Interaction matrix

The linkage matrix captures the types of linkages (codes in Section III of Appendix 2) and strength of linkages (expressed in scales[17] from 0 to 3) between components. Values assigned to the actors interviewed in each component are reduced to an average vector. Thus, the first row of the linkage matrix presents the information gathered from interviews with actors within the policy component with regards to their links with other agents of the system. The first cell in the first row shows the strength and nature of interactions that exist within the policy component (A).

[17] No links (*nada*) = 0; Weak links (*poco*) = 1; Some links (*regular*) = 2; Strong links (*mucho*) = 3

Following clockwise convention, the second cell in the first row shows the links which exist between the policy component and the research component (B); the third cell in the first row shows the links that exist between the policy component and the education component (C) and so on. The second row of the linkage matrix provides information gathered from interviews with actors in the research component (B) with regards to their links with others; the third row provides information gathered from the education component (C) and so on. Similarly, the first column summarises the links that others in BAAIS have with the policy component; the second column summarises the links that others have with the research component etc. Blank off-diagonal cells reflect absence of linkages between components.

A well connected system would be represented by numbers in most cells and, a priori, would suggest that the system is potentially effective in developing and diffusing innovations. The density of a system, which gives us an idea of the degree of inter-component connectedness, can be calculated by dividing the total number of links that exist between components (number of off-diagonal cells that are not blank) by the total number of potential links (in the case of BAAIS, which has 10 components, the total number of potential links would be 90).

The System's Cause-Effect structure

The linkage or interaction matrix is then used to build a second matrix to trace networks of information and their direction (information sources and sinks) by crossing the data on *strength of linkages* between the systems' components with data on *sources of information* gathered in another section of the questionnaire (see section II.III in Appendix 2 and Appendix 3). In the literature, the resulting matrix is called the Cause-Effect structure of the IS (Temel, 2004a, 2006; Temel et al., 2003) and it can help identify the dominant components in BAAIS as well as the directionality of information flows. It should be pointed out that the system's C-E structure does not assume a linear relationship between the strength of an interaction and its importance as a source of information. Information exchange requires some degree of interaction to take place but interaction *per se* does not always bring about information exchange, particularly if one or both of the agents gain from not sharing what they know. An effective information network will require strong or medium links between components and willingness and ability to share functional information and skills.

The large sample of fish farmers interviewed for the BAAIS diagnostic survey has provided valuable information about the most important sources of knowledge and inputs for aquaculture. This has made it possible to go beyond 'claimed' linkages between the system's components and 'claimed' source of information and other inputs to inform the characterisation of the system's cause-effect structure and outline the 'true' interactive nature of BAAIS[18].

To sum up, the analysis of cross-component linkages and information sources-sinks in BAAIS can help to discover dominant components, information networks and constraints that hinder interactions; it can help to diagnose the 'health' of the system and identify possible interventions that might help steer the system towards specific goals. Furthermore, by distinguishing between resource poor farmers and medium/large entrepreneurs in the cross-component linkage analysis it has been possible to explore the distributional consequences of the innovation process and identify alternative ways of steering BAAIS towards more welfare-improving outcomes, which have often been overlooked in the IS literature (Spielman, 2005).

4.2.4 Accounting for the limitations of the approach

Despite the advantages of this approach, it does have some limitations: it overlooks the significance of intra-component dynamics and the versatility and multifunctional nature of many actors and organisations within small and emergent systems such as Amazon aquaculture in Bolivia. The use of cross-component interaction matrixes assumes that each component plays a specific function within BAAIS and that its performance is influenced by decisions and actions undertaken by other components. However, the system's performance is also influenced by intra-component dynamics and the type and strength of interactions that exist between actors and organisations

[18] The BAAIS Cause-Effect structure is based on the interviews with actors (what the 90 interviewees state about their organizations and the wider sector and what others state about them). This data is triangulated when possible with data from the survey of fish farmers (384) as they are also asked about sources of information, credit, markets etc. and main problems faced by them and by the sector in general. For example, if local government or a research centre state that they are promoting aquaculture among local farmers, but local farmers don't mention them at all and identify NGOs X and Y, and private firm Z as the main providers of inputs and extension services, it would seem that the local government and research centre in question are not really as vital providers of extension services to farmers in the region as they claim.

within the same subset. Furthermore, cross-component linkage analysis does not account for the fact that organisations or individual actors within the system might be pursuing, overtly or covertly, multiple and sometimes contradictory objectives and, hence, playing roles in more than one component. Although the study adopts cross-component linkage matrixes to help organize and analyse the data, the nature of intra-component dynamics and the behaviour of 'multifunctional actors' is also explored in the descriptive analysis of BAAIS and taken into account in the interpretation of the results. Finally, it should not be forgotten that the production and dissemination of information alone will not enable producers to adopt innovations in aquaculture if they do not have access to other inputs and associated services. Considering the short history of Amazon aquaculture in Bolivia and the emergent nature of the relevant input and output markets, this access is often limited. Therefore, it is an important aspect of the BAAIS study, which goes beyond the analysis of information networks and also looks at producers' access to seed (fry), fish feed and equipment.

Before turning to explore the components and dynamics of BAAIS and aquaculture's role as a pro-poor NRM innovation in Bolivia, the following section presents some basic figures about the aquaculture sector in the Amazon region: production, practices and trends. Given the absence of reliable data from previous studies, the figures are based on the author's 384 interviews with fish farmers in Beni, Santa Cruz and the Tropical regions of Cochabamba and La Paz, as well as interviews with input/service providers, NGOs and producer organisations.

4.3 Amazon aquaculture in Bolivia: production, practices & trends

In the late 1990s the EU assistance project for fishery and aquaculture in Bolivia (ADEPESCA) provided important insights into the state of the countries' fisheries resources in its three major hydrological basins (Allison, 1998; Hartmann, 1998; Palin, 1998), however, the project contributed only superficially to the characterisation of aquaculture production in the Amazon region. The survey carried out by the author as a part of this thesis is an attempt to fill this gap and is the first account of production, practices and trends in Amazon aquaculture in Bolivia.

4.3.1 Production

The results of this diagnostic survey suggest that previous official estimates of production were considerably underestimated. Interviews with producers and importers of fry revealed that approximately 1,600,000 fry were sold to fish farmers in the Bolivian Amazon between the end of 2004 and the beginning of 2005[19]. Household production statistics and fry mortality rates recorded by the fish farmers sampled for the thesis suggest that aquaculture production in the region was just under 500 tonnes at the end of 2005 (Table 4-3). In the National Aquaculture Sector Overview Fact Sheet for Bolivia for the same year, put together by FAO's Inland Water Resources and Aquaculture Services, Amazon aquaculture production was only estimated to be approximately 140 t/yr (Salas, 2005).

The present study also suggests that the type of aquaculture practiced in the country's Amazon region is significantly more extensive than is generally claimed, average yields per unit area being 3.18 t/ha/yr.

Table 4-3 Aquaculture production in the Bolivian Amazon (estimate for 2005)

	Source: PRESENT STUDY (2005)	Source: FIRI FAO (Salas, 2005)
Fish fry sold (unit/yr)	1,600,000	
Total production (T/yr)	**470**	**140**
Average yield per unit area (T/ha/yr)	3.18	4.50 – 5.00

Based on the present study's sample of fish farmers, about 70% of Amazon aquaculture production can be attributed to medium/large entrepreneurs (MLE) often engaged in agribusiness, rural tourism activities or the catering industry, including the Japanese and Mennonite communities in Santa Cruz. The rest of the sample can be associated with rural aquaculture promotion and extension projects targeted at resource-poor farmers (RPF), mainly indigenous and campesino communities. These projects tend to consist of subsidies and/or credits for pond construction, training in aquaculture and initiatives to increase resource-poor farmers' access to associated input and output markets.

In relation to the types of species farmed, neither do the data from the present study coincide with the official statistics for the same year (Salas, 2005) that states that the bulk of Amazon aquaculture was based upon the farming of exotic species, mainly

[19] The production and sale of fry is restricted to the rainy season, i.e. the natural spawning time for pacú and tambaquí. Fry are only sold from November to March approximately.

tilapia (*Oreochromis sp.*) and carp (*Cyprinus sp.*). The results of interviews with producers suggest that in recent years native species of the genera *Colossoma* (pacú) and *Piaractus* (tambaquí) have gained considerable importance and in 2005 represented 75% of all species farmed in the region. Based on the total number of fingerlings sold and the production statistics and fry mortality rates reported by the sample of 384 fish farmers interviewed, table 4-4 shows production estimates for 2005 by species and type of producer.

Table 4-4 Aquaculture production in the Bolivian Amazon by species and type of producer. Species of the genera Piaractus and their hybrids are frequently sold as Colossoma. It is likely that the numbers for pacú are exaggerated at the expense of tambaquí and hybrids. Other include giant freshwater prawn (Macrobrachium rosenbergii) and Ornamental spp.

Species	PRODUCTION 2005 (Tonnes)		
	MLE	**RPF**	**TOTAL**
Pacú *(Colossoma macropomum)*	221	88	309
Tambaquí *(Piaractus brachypomus)*	36	14	50
Carp *(Cyprinus carpio)*	45	26	71
Tilapia (*Oreochromis sp.)*	15	10	25
Other	12	3	15
TOTAL	329	141	470

4.3.2 Practices

Fish farming is usually practiced in earthen ponds, often existing water bodies such as cattle troughs or natural depressions that are modified for aquaculture. Fish ponds are in many cases multifunctional, serving also as water reservoirs for agriculture, cattle and domestic use. Pond fertilization is practiced by half of the fish farmers interviewed, mainly by periodically applying some type of animal manure. In most farms fish are given vegetable-based, low-protein feeds, often home-made, or a mixture of agricultural by-products and commercial feeds. However, as the market for fish feed in Bolivia grows and becomes more accessible producers tend to rely increasingly on commercial feeds so as to attain higher yields (see Table 4-9). Regional differences in the types of aquaculture being practiced are evident when examining producers' reliance on commercial feeds, 67% in Beni versus 14% in Santa Cruz (Table 4-5).

Table 4-5 Type of supplementary feed used in Amazon aquaculture

	MLE (%)	RPF (%)
Commercial	32	24*
Home-made	42	20
A combination	26	56

* Normally bought on credit and financed by a rural development project.

Fish farms vary considerably in size (Table 4-6). In 2005, three farms in Santa Cruz and one in Trinidad accounted for 15% of the region's total production area. If these four exceptionally large farms are excluded from the analysis, the average production per household for MLE is 1,406 kg/hh/yr.

Table 4-6 Amazon aquaculture production per household (hh) and unit area (ha) (2005)

	Farm size **fry/hh**	Farm size **m²/hh**	Production **kg/hh**	Yield **t/ha**
MLE	3,676 (SD 6,019)	7,920 (SD 21,191)	1,760 (SD 3,050)	3.54 (SD 2.59)
*MLE**	*2,917 (SD 3,725)*	*5,251 (SD 7,493)*	*1,406 (SD 1,922)*	*3.64 (SD 2.59)*
RPF	307 (SD 502)	420 (SD 445)	139 (SD 169)	3.14 (SD 1.52)

* Mean value excluding 4 outliers: farm size > 25,000 fry/hh

A regional analysis of the sample studied shows that Santa Cruz was the most important contributor to aquaculture production. There were more fish farms in Santa Cruz and these were, on average, larger than those in the rest of the country (over 1 hectare and 5,000 fry per household). However, aquaculture in Santa Cruz was fairly extensive, with an average yield per unit area of 2.3 t/ha/yr. Fish farming practiced in and around Trinidad was by far the most intensive, reaching 5 t/ha/yr. Trinidad was followed by San Ignacio de Moxos (3.6), Chapare (3.2), Santa Cruz and the area between San Borja and Rurrenabaque where yields were slightly over 1 t/ha/yr.

In the case of RPFs, individual family ponds ranged between 200 and 1,000 m^2; group ponds may reach up to 3,000 m^2. Yields per unit area were similar to those obtained by MLEs. However, average production per household/year was considerably lower for the RPF subsample because the area managed by each family was smaller.

In the interviews, producers were asked about the type of fish farming practiced and the dominant trend that emerged was aquaculture as a part-time family endeavour, complementary to other farm activities (such as agriculture, cattle or poultry farming), restaurants and rural tourism businesses. Less than 40% of producers in the study sample adopted aquaculture as a stand-alone business activity. However, important regional differences existed. In Santa Cruz less than 35% of the producers practiced aquaculture as a business activity (*como negocio*); in Trinidad, the capital of Beni, 65%

of producers were in this category and in Chapare, Cochabamba 80%. Nevertheless, these enterprises provided little direct employment. MLEs often hired seasonal workers for pond construction and maintenance and at harvest time, but only a few hired permanent workers to manage their fish farms throughout the whole year.

A third of the fish farmers in the study sample, including both MLEs and RPFs, produced mainly for the market (*principalmente para la venta*); 30% were engaged in aquaculture for their own consumption (*principalmente para consumo*) and 38% produced both for the market and self-consumption (*para consumo y venta*). MLEs tended to sell wholesale to fish markets in neighbouring cities (55%) and directly in their farms, restaurants or tourist resort as fresh or cooked fish. Pro-poor aquaculture development projects in the Bolivian Amazon are increasingly shifting from a focus on food security and subsistence farming, an approach widespread in the 1990s, towards greater market integration and the promotion of semi-intensive commercial aquaculture. RPFs usually accessed fish markets via networks established by NGOs and producer organisations. Approximately 25% sold their fish directly in their community or nearby ranches.

Partnerships were relatively frequent amongst MLEs setting up fish farms, particularly in Trinidad, where nearly half of the farms were run as joint-ventures. This practice brings together investors and people with some experience in Amazon aquaculture, often researchers linked to national universities and research institutes. In the case of RPF, the majority are engaged in fish production in association with neighbours, pooling resources together to cover the costs of pond construction and facilitate access to input and output markets.

4.3.3 Trends

Amazon aquaculture in Bolivia is growing. The development of the sector can be seen in the recent increase in numbers of regional aquaculture organisations and cooperatives[20] and the growth of the market for associated inputs and services. A striking example is that of the market for aquaculture seed. Whilst before the year 2000 the only suppliers of fry were the state Universities of Santa Cruz and

[20] Up until the year 2000 there were no legally established Amazon aquaculture producer associations in Bolivia. 2000-2005 saw the development of 8 regional organisations in the Departments of Santa Cruz, Beni, Cochabamba and La Paz (see section 4.4.8).

Cochabamba and the firm *Biofish-Bolivia SRL* with headquarters in Trinidad, by 2005 there were 11 national distributors and another half dozen who intended to engage in seed production and/or trading in the near future (see Table 4-8).

Most of the producers interviewed had initiated fish farming after the year 2000; nearly half had set up fish farming within the two years prior to the interview, between 2003 and 2005. About 14% had got involved in aquaculture activities before the year 2000. With regards to the future plans of the MLEs interviewed, 25% intended to expand their fish farms, whilst 17% intended to abandon the activity partially or totally. The rest planned to continue with the activity without changes, or to invest in improving existing infrastructures. Analysis of the RPF subsample showed that 67% of these producers became involved in aquaculture activities after the year 2000, and 30% between 2004 and 2005, reflecting a recent increase in pro-poor aquaculture development initiatives. RPFs that were still receiving some sort of support from aquaculture projects were optimistic with regards to the continuity and future enlargement of their fish farms. However, those families that were no longer beneficiaries of rural development schemes were less optimistic, 61% had abandoned aquaculture or planned to do so at the end of the harvest season; 39% planned to find ways to develop their farms further if possible. This statistic reflects the fragility of many fish farming initiatives in indigenous and campesino communities and the latter's dependence on external assistance from NGOs or local government to set up aquaculture ponds and access information and other important inputs.

Despite evidence of growth in the Amazon aquaculture sector in Bolivia in recent years and the increase in pro-poor aquaculture development initiatives, fish farming remains a relatively new and undeveloped activity in the region. To assess the current and potential role of aquaculture in rural development and poverty reduction in the country's Amazon region it is necessary to further our understanding of the nature and workings of Bolivia's Amazon Aquaculture Innovation System, BAAIS: how is R&D being conducted? Who are the main players in the production and dissemination of knowledge and other inputs? Who are the main receivers or 'sinks' of information on innovations? What are the main barriers to the flow of knowledge and the adoption of Amazon aquaculture at a national level? How could the system be strengthened and to what aim?

The following section describes the key players in BAAIS, their function and role within the innovation process, the context in which they operate and the constraints and opportunities they face. The analysis draws from the interviews with the different actors in the innovation system (questionnaire for actors in Appendix 2) and from information provided by the sample of fish farmers (questionnaire for producers in Appendix 3). Further on, the dynamics of the system as a whole are studied through interaction matrixes. In the final part of the chapter a poverty analysis of BAAIS is carried out and the short history of pro-poor Amazon aquaculture development projects is explored.

4.4 The ten components of BAAIS: actors, roles & context

As has already been discussed in the methods section of this chapter, the actors shaping BAAIS include: public sector organizations, such as government bodies responsible for aquaculture and fisheries policy design and implementation, government extension units, national research centers and state universities and technical colleges and private sector organizations, including input/supply firms, processors, marketing agents, consultancy firms, credit institutions, NGOs, international cooperation organizations and the fish farmers themselves.

For the purpose of this study the different actors have been organized in 10 categories or components in terms of their objectives and functions in BAAIS: (A) Policy; (B) Research; (C) Education; (D) Information and extension; (E_n) National input/output markets; (E_a) International Input/output markets (abroad); (F) Credit component; (G_e) Producers, medium/large entrepreneurs (MLE); (G_f) Producers, resource-poor farmers (RPF) and (H) External Assistance[21].

The descriptive analysis of BAAIS' 10 components focuses on intra-component dynamics and institutional settings, context and trends, as well as identifying key actors and their roles.

[21] For a complete list of interviewees see Appendix 1 Table A-1. The full questionnaire used is in Appendix 2

4.4.1 (A) Policy component

Units operating under the cabinet of ministers and regional government performing specific tasks to support the formulation and enforcement of fisheries and aquaculture policy

BAAIS' policy component comprises the Fisheries and Aquaculture Unit (UPA) and its operational branch, the Centre for Aquaculture Research & Development (CIDAB), under the Ministry of Agriculture (MACA), the Department for Biodiversity (DGB) under the Ministry of Sustainable Development (MDSP) and several operational units in charge of policy formulation and enforcement at the regional and local government levels (Figure 4-3).

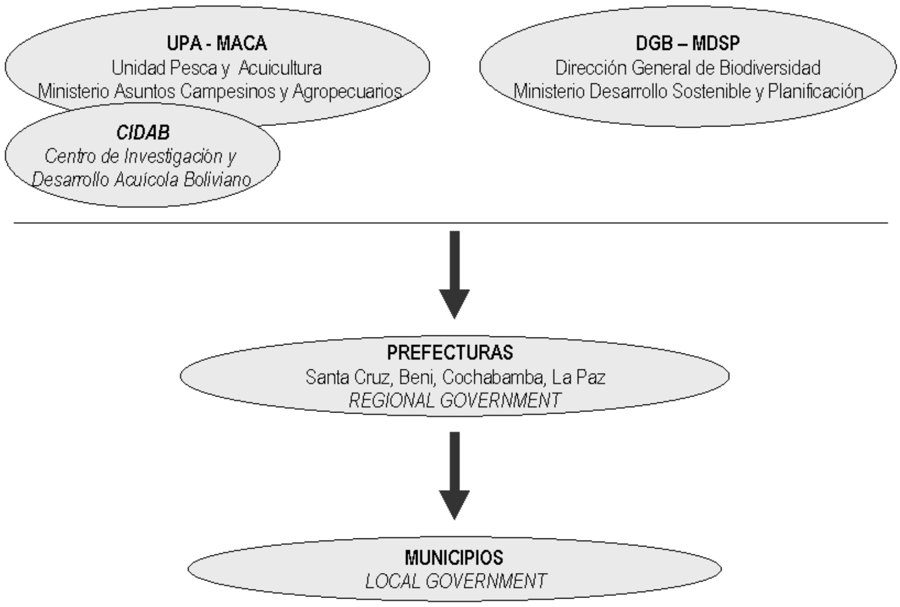

Figure 4-3 Formulation and enforcement of fisheries and aquaculture policy. Organisational structure (December 2005)

The fisheries sector in Bolivia has undergone important institutional changes in the last three decades. The Department of Fisheries Development, first created in 1975, was replaced in 1984 by the Fisheries Development Centre (CDP)[22], dependent on the Ministry of Agriculture. Under the 1990 Fisheries and Aquaculture Regulation[23],

22 Centro de Desarrollo Pesquero (CDP)
23 Reglamento de Pesca y Acuicultura de 1990, Decreto Supremo 22 581

Regional Councils were created to promote participation and build cooperative networks amongst public and private entities in the fisheries sector: local government, research institutes and universities, fishermen's organisations, fish farmers' organisations, private enterprises and NGOs (see Álvares, 2004). The passing of the 1994 Popular Participation Law[24] and the 1995 Law of Decentralised Administration[25] favoured the administrative decentralisation of the sector and responsibility for the CDP Councils was transferred to regional and municipal governments. However, in practice, regional governments have faced serious difficulties in taking on board the functions related to this transfer. Their present contribution to fisheries and aquaculture policy development and enforcement is at best weak. Interviews reveal that lack of qualified personnel, insufficient financial and physical resources, lack of continuity in interventions and high staff turnover due to political instability and interference are entrenched problems.

In 2005, nobody in the Ministry or *Prefecturas* had training in Amazon fisheries or aquaculture and access to information was limited due to insufficient financial and physical resources. Coordination was weak between the Fisheries and Aquaculture Unit at a national level and its corresponding regional and local operational units, in many cases governed by the political opposition. The national Fisheries and Aquaculture Unit with headquarters in La Paz admitted that their efforts were centred on the Altiplano basin, where highly organised fisherfolk constitute an important lobby. At the time of the interview the head of the Fisheries and Aquaculture Unit in La Paz was unfamiliar with the names of the technicians in charge of the regional units in Santa Cruz and Beni. Similarly, border disputes between Beni and Cochabamba over the National Park *Isiboro Sécure* hindered collaborative relations between regional governments. Lack of coordination within the BAAIS policy component was aggravated by unclear and overlapping mandates at all levels. With the 1997 Law of Organisation of the Executive Power[26] 'access to fisheries resources' became the responsibility of the Department for Biodiversity (DGB) under the Ministry of Sustainable Development (MDSP), whilst the Fisheries and Aquaculture Unit (UPA) under the Ministry of

[24] Ley de Participación Popular. Decreto Supremo 23813
[25] Ley de Descentralización Administrativa. Decreto Supremo 1654
[26] Ley de Organización del Poder Ejecutivo. Decreto Supremo 1788

Agriculture remained responsible for ‘fisheries production’. At the time of the interviews, both the DGB and the UPA were unilaterally engaged in the formulation of a new fisheries and aquaculture regulation. The same problem was evident at a regional level where fisheries and aquaculture units had been assigned to different Departments depending on the *Prefectura*[27], exacerbating organisational inefficiencies and slowing down the decision-making process.

4.4.2 (B) Research component

Research Centres and Universities engaged in Amazon fisheries & aquaculture R&D activities

In Bolivia, as in most other Latin American countries, the model favoured in the 1970s and 1980s was characterised by National Agricultural Research Institutes that integrated research and extension functions. This model was abandoned in the mid-1990s with the decentralisation laws. Currently there are two key public research centres that are directly involved in Amazon aquaculture R&D activities: The Pirahíba *Estación de Limnología y Acuicultura* and El Prado *Estación Piscícola* administered by the state universities of Cochabamba and Santa Cruz respectively. Both research stations are equipped with culture ponds, hatcheries and the necessary infrastructure for brood stock and post-larvae management. Other public organisations that are engaged in research and development activities relevant to Amazon fisheries and aquaculture include: The *Centro de Investigación de Recursos Acuáticos* of the Universidad Autónoma of Beni, the *Unidad de Ictiología* of the Natural History Museum in La Paz and the *Unidad Académica Campesina Carmen Pampa* of the Catholic University in Yungas.

During the 1980s and 1990s, strongly influenced by the FAO, these centres focused on developing carp and tilapia culture, which meant that native species R&D was neglected. ‘El Prado’ and ‘Pirahíba’ were the first centres to succeed in the reproduction of carp and tilapia and to develop and adapt generic fish farming technologies. It wasn’t until the late 1990s that the first artificial reproduction of native

[27] In Beni responsibilities are divided between the *Dirección de Recursos Naturales*, the *Dirección de Desarrollo Productivo* and the *Servicio Departamental Agropecuario*; Cochabamba is the only region that has established a Centre for Fisheries Development under the *Servicio Departamental Agropecurio*, as dictated by the 1995 *Ley de Descentralización Administrativa*; whilst in the *Prefectura* of Santa Cruz no regional fisheries or aquaculture unit exists under any form.

species of interest for aquaculture was achieved, and it wasn't until after the year 2000 that El Prado managed to consolidate the production of tambaquí fry. Other native species of interest for Amazon aquaculture that have been the target of recent research include pacú, sábalo (*Prochilodus sp.*), boga (*Schizodon sp.*), tucunaré (*Cichla sp.*) and surubí (*Pseudoplatystoma sp.*).

Amazon aquaculture R&D activities in Bolivia are severely limited by lack of financial support. Public research centres such as El Prado and Pirahíba receive funding from state universities to cover staff wages. Researchers have to find their own sources of funding to cover all other operating costs, from infrastructure creation and maintenance, such as ponds and incubators, to laboratory facilities, equipment and consumables. This problem is not restricted to fisheries and aquaculture R&D centres; however, this sector has been particularly neglected as the main lobbies in the Amazon region have traditionally favoured forestry, meat cattle and, more recently, soy agriculture.

Another serious weakness in the fisheries and aquaculture R&D component is the lack of qualified human resources. At the time of the interviews there were only 15 ichthyologists in the whole of Bolivia, 3 of which were non-nationals, and only a few were directly involved in applied Amazon aquaculture research. Even though the state universities of Santa Cruz, Cochabamba and Beni had been running aquaculture R&D programmes for over two decades, at the time of the interviews there were only half a dozen technicians trained in tropical aquaculture and artificial reproduction of fish farming species in Bolivia.

Two of the main obstacles for Amazon aquaculture development identified by fish farmers (N= 384) were: limited access to information, lack of qualified human resources and the degree of isolation and secretiveness of the different actors in the public and private sectors (see Table 4-12 and Table 4-13). The analysis of BAAIS detected a conflict of interest among some actors within the research component that has weakened the development of information networks and the diffusion of innovations. The need to ensure economic resources to cover operating costs has turned some 'research centres' into 'production centres', often limiting their activity to the production and marketing of inputs and services for aquaculture. This market-oriented focus has triggered the development of close ties between some research centres and private input providers, consultants and marketing/processing firms, and has contributed to the growth of associated markets for Amazon aquaculture. However, this *modus operandi* also acts as a disincentive to the flow of knowledge, as research centres are, *de facto*, competing with private firms in the market for aquaculture inputs and services.

4.4.3 (C) Education component

State and private Universities/Colleges that offer courses/degrees in Amazon fisheries and aquaculture

There are 53 higher education centres in Bolivia (10 public, 43 private), all dependent on the Ministry of Education. Despite the country's rich and diverse fisheries resources, at the time of the interviews, no institution for higher education offered degrees or postgraduate specialisations in fisheries management or aquaculture. Historically, the Amazon region in Bolivia has been portrayed as a region of meat cattle and ranchers, even though ranchers are a minority and fish is one of the region's most important sources of animal protein, particularly amongst the rural poor. In recent years, however, increasing demand has led some universities to offer optional courses in tropical aquaculture as part of agronomy or veterinary science undergraduate degrees (Table 4-7).

Table 4-7 Formal training in Amazon fisheries and aquaculture

Universities that offer courses in **Amazon fisheries and aquaculture**	Enrolled **Students/2005**
UMSS - Univ. Mayor San Simón, Cochabamba	30
UAGRM - Univ. Gabriel René Moreno, Santa Cruz	70
UEB - Univ. Evangélica de Bolivia, Santa Cruz	15
UCB - Univ. Católica de Bolivia, La Paz	10
UAB - Univ. Autónoma del Beni, Beni	30

The quality of education in the courses provided by the UEB, the UCB and the UAB is seriously affected by the lack of applied research facilities, which limits the universities' capacity to conduct field work and offer practical experience. The UMSS and the UAGRM have access to the Pirahiba and El Prado experimental stations, which are in fact run by these universities. However, there are few students who specialise in this field and acquire practical experience in artificial reproduction and farming of fish, despite the demand for aquaculture specialists and consultants among the growing number of entrepreneurs investing in the sector. National universities and technical schools are failing to supply the sector with qualified human resources and consequently most of the region's large aquaculture producers opt for hiring foreign experts, usually from Brazil, as consultants and farm administrators.

4.4.4 (D) Information & extension component

Government extension agencies promoting the dissemination of research results and transfer services

In Bolivia at the time of the interviews there were no national extension agency designed to promote the fisheries and aquaculture sector. Bolivia's Centre for Aquaculture Research & Development (CIDAB: *Centro de Investigación y Desarrollo Acuícola Boliviano*), created by the Ministry of Agriculture to coordinate and promote the flow of information and assistance for fish farmers at the national level, in practice limits its area of influence to the Altiplano basin. In some cases, such as the Prefectura of Beni or the Municipalities of San Andrés and Ivirgarzama, regional and local governments have participated in aquaculture extension initiatives in the Amazon region with a counterpart to external aid projects (see Appendix 6), but for the most part government extension services have been lacking altogether.

In the year 2000 a competitive funding system for agricultural technology development and extension was established: The Bolivian System for Agricultural Technology (SIBTA: *Sistema Boliviano de Tecnología Agropecuaria*)[28]. The Humid Tropics Foundation prioritised 15 agri-chains, of which aquaculture occupies the 10th position[29]. One short-term pro-poor aquaculture project was launched by SIBTA in the Municipality of San Andrés in Beni. It was carried out by the *Centro de Investigación de Recursos Acuáticos* of Beni's Universidad Autónoma during the period 2003-2005. The project's immediate results were positive, creating considerable expectations amongst local farmers; however, once external funds were withdrawn extension and transfer services were also interrupted.

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[28] SIBTA is based upon competitive funding managed by Foundations for Technology Development in the country's four agroecological regions: Altiplano, Valleys, Dry Chaco and Humid Tropics. For further information the reader is referred to SIBTA's webpage at: www.infoagro.gov.bo/sibta/sibta.htm

[29] Agri-chains prioritised by the SIBTA's Humid Tropics Foundation are, by order of importance, forestry, meat cattle, cacao, soya, rice, coffee, poultry and grains, nuts *(Bertholletia excelsa)*, sugar cane, aquaculture, manioc, milk cattle, camu camu (*Myrciaria dubia*), beekeeping and achachairú (*Rheedia sp.*)

In addition to these special funds for technical innovation channelled via SIBTA, the government has developed other mechanisms to promote innovation in agriculture that could benefit aquaculture producers indirectly. Some of these include: technical support services for small-scale agribusinesses[30], reduction of import duty (only for agrochemicals), export incentives (VAT refund) and low-cost loans or credits for enterprises[31]. However, few of the fish farmers interviewed fulfilled the conditions required to access any of these services and, in any case, none were aware of their existence. What is more, only 10% of the rest of the actors within the different components of BAAIS interviewed, including policy, information and extension and external assistance, were familiar with the country's agricultural innovation policy, and less than 5% were familiar with innovation policy specifically relevant to the aquaculture sector.

Despite this rather discouraging picture, some developments have taken place recently that might favour the establishment of extension units by the Prefecturas and Municipal governments, as dictated by the 1990s Popular Participation and Decentralised Administration laws. With increasing state intervention in the oil industry and the creation of a direct tax on hydrocarbons, regional governments' budgets have been significantly boosted, granting new resources for the provision of rural extension services. Furthermore, the development of new aquaculture producer organisations in the Bolivian Amazon is slowly enhancing the sector's political influence in the region. Still, the Prefecturas are confronted with serious problems associated with lack of qualified human resources, high staff turnover rates and lack of continuity of development programmes due to political instability and interference.

4.4.5 (En) Input/output supply, processing, marketing component (National)

National input & output markets for aquaculture: input and service providers, consultants, fish marketing and processing firms

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[30] Programme PROSAT. Proyecto de Servicios de Asistencia Técnica para Pequeños Productores Rurales (http://www.prosat.org.bo)

[31] Direct transfers for groups of farmers were established in Bolivia's 2005 National Strategy for Agricultural and Rural Development (ENDAR). Furthermore, the same year the world bank approved the Rural Alliances Project, a 28 million US$ credit 'to improve the access to markets for poor rural producers in selected rural regions of Bolivia by promoting productive alliances between different economic players at the local level' (http://go.worldbank.org/L8IL4H09L0)

In Bolivia, as in the other Amazon countries where aquaculture is not a traditional activity, state universities and research institutes, as well as international development organisations, have played an important role in the initial stages of the sector's development. However, the private sector in Bolivia is gaining increasing importance in the market for inputs and associated services: fish fry, feed, information, aquaculture infrastructure, farming equipment and fish marketing and processing services. There is little specialization in the private input supply and marketing sector; larger producers may sometimes engage in feed/fry production or trade and function as input suppliers to smaller producers and, at the same time, provide some technical advice.

Some actors within the private sector have established close ties with members of the research community, in several cases under the format of joint ventures to set up hatcheries, fish feed factories or import and marketing enterprises in partnership with researchers responsible for the administration of public aquaculture stations (such as in the case of Vallecito in Santa Cruz, (see Table 4-8). In fact, most researchers in public experimental aquaculture stations and hatcheries are also key actors in the private inputs/output supply, processing and marketing component of BAAIS. In turn, national suppliers of inputs for aquaculture have developed commercial links with public and private aquaculture stations in neighbouring countries.

Nonetheless, despite recent developments in the aquaculture input and service markets, access to key resources is still restricted, particularly in the tropical regions of Cochabamba and La Paz and most of Beni. The market for aquaculture is small and mainly centralised around the city of Santa Cruz (see Table 4-8 and Table 4-9). Those hatcheries and fish feed factory that were not based in Santa Cruz were run by NGOs or state universities. Farmers' limited access to aquaculture input markets is aggravated by poor road infrastructures and the relative isolation of some rural areas. Similarly, despite the unsatisfied demand for fish in Bolivia's major urban centres (Wiefels, 2006), access to output markets is problematic due to insufficient fish marketing and processing services in the Amazon region.

Seed

Secure access to quality fish fry at a reasonable price is a prerequisite for aquaculture development. According to the Fisheries and Aquaculture Unit of the Ministry of

Agriculture, in 2005 there were three aquaculture stations that produced seed for Amazon aquaculture (MACA, 2005): El Prado and Pirahiba, administered by the state universities of Santa Cruz and Cochabamba, and Mausa, run by the Bolivian NGO *Centro de Estudios Hoya Amazónica*, HOYAM, in Beni. However, the interviews with fish farmers and input suppliers carried out as a part of this research indicate that, in fact, there were 8 hatcheries producing and commercialising seed for Amazon aquaculture in 2006 and that another 9 were under construction (Table 4-8). Except for the hatcheries already mentioned and that of Piedras Blancas (between Rurrenabaque and Yucumo) and Tarija CICA[32], which were built with external aid funds, the rest were private initiatives. Furthermore, the introduction of fry from neighbouring countries, in particular Brazil, has attracted a number of traders responding to an increasing demand from the aquaculture sector.

Table 4-8 Seed suppliers for Amazon aquaculture in Bolivia (2005-2006). Native culture species (N); Exotic culture species or subspecies (E); Native and Exotic Ornamental species (O)

Region	Hatchery Location	Name & category	Hatchery operative	Hatchery being built	Importer	% market covered
BENI	Trinidad	*Biofish* - Private			√ (N,E,O)	21
		Poza Honda - Private		√		
		Villa Balper - Private		√		
	S. I. Moxos	*Mausa* – Bolivian NGO	√ (N)			9
	S. Andrés	*San Andrés* - Public		√		
	Pied. Blancas	*Pied. Blancas* - Private		√		0.5
SANTA CRUZ	Warnes	*El Prado* - Public*	√ (N, E)			19.5
	Okinawa I	*Tonoshiro* - Private	√ (N,E,O)			13
	Santa Cruz	*Vallecito* - Private	√ (N, E)		√ (N, E)	9
	S. J. Yapacaní	*Mitzushima* - Private	√ (E)			
	Portachuelo	*Espindola* - Private	√ (E)			
	Tres Cruces	*Los Lagos* - Private			√ (N, E)	12
	Okinawa III	*Antesana* - Private		√		
	Santa Cruz	*B. Gamarra* - Private		√		
	San Julián	*Moreno* - Private		√		
	Buena Vista	*C. Gallito* - Private		√		
	Santa Cruz	*Neptuno* - Private	√ (O)			
COCHA-BAMBA	Valle del Sacta	*Pirahiba* - Public	√ (E)			0.5
	Ivirgarzama	*Los Petos* - Private		√		
TARIJA	Tarija	*CICA*-Bolivian NGO**	√ (E)			0.5
BRASIL	*Imported directly by large fish farmers*				√ *(N, E)*	15
					TOTAL	100

* Note that the director of El Prado, the Aquaculture station that belongs to the Gabriel René Moreno Autonomous University of Santa Cruz, is also a key business partner in Vallecito, a private aquaculture enterprise.** CICA (Centro de Investigación y Capacitación Agropecuaria), located in the Department of Tarija, also supplies small quantities of carp fry to producers in Yungas, La Paz.

[32] Centro de Investigación y Capacitación Agropecuaria

There were 3 major importers of fry from Brazil who covered 38% of national demand, and another half dozen large fish farmers who imported fry to satisfy their own needs (15% of total demand). Just under half of the fry sold in 2005 were produced in national hatcheries.

Although reliance on external markets for aquaculture inputs, particularly fish fry, has contributed to the sector's growth by increasing producers' access to a key resource[33], it may also represent an obstacle to the development of national hatcheries which have difficulties competing with large stations in Brazil and Peru that produce millions of larvae per year at very low costs[34]. But perhaps the biggest problem with imported fry is the lack of a clear regulation on the importation of live fish and eggs (Ayala, 2004; DIREMA, 2004) and the potential impact that the introduction of non-native species and subspecies might have on the region's native fish populations (Fusiler, 2001; Pérez et al., 2004).

Feed

Until fairly recently Amazon aquaculture relied on imported feeds from Brazil or, more commonly, home-made foodstuff. However, the first national firm to produce and market fish feed, ProAni Industrias, was established in the year 2000, quickly becoming Santa Cruz's main supplier. By 2006 three feed factories had been established: the Fábrica de Alimentos de Soja (FAS S.A) and the Vallecito Aquaculture Station in Santa Cruz, and Mausa in Moxos, Beni. Between 2003 and 2004 the Brazilian subsidiary Biofish S.R.L. had become the most important feed supplier in Trinidad, the capital of Beni, but by 2006, national feeds had taken over the market, almost displacing imported feeds. Whilst imported feeds were sold at 0.45 – 0.7 US$/kg, national feeds could be bought at 0.25 – 0.5 US$/kg. Some producers, such as those affiliated to the cooperative in San Juan de Yapacaní, who practice aquaculture integrated with poultry farming, supplement fish diets with chicken feeds.

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[33] Peru and Brazil have developed the technology to manage the spawning season of *Colossoma* and *Piaractus* so that larvae and fry are available throughout the year. In Bolivia, however, fry production is restricted to the period from December/January to March/April, in accordance with the natural spawning season of the species.

[34] Whilst in 2002 pacú fry were being sold in Bolivia at 0.15 US$/u, the introduction of fry from neighboring countries brought prices down by half in three years. The price of pacú or tambaquí fry in 2005 ranged from 0.06 to 0.125 US$ for individuals between 5 to 10 grams, independently of their source.

Table 4-9 Feed suppliers for Amazon aquaculture in Bolivia (2005-2006)

Brand	Type	Maker	Origin
Nutrifish	Extruded	PRO-ANI	Santa Cruz
Fri-Ribe	Extruded	BIOFISH	Brazil
FAS S.A.	Extruded	FAS S.A.	Santa Cruz
Freeaqua	Extruded	VALLECITO	Santa Cruz
MAUSA	Pelletized	MAUSA	Beni

Information

The private sector is also gaining importance as disseminator of information and knowledge about aquaculture innovations via expert consultants and, more generally, via fry and feed providers, who indirectly act as 'extension agents' whilst marketing their products. This also applies to state funded research organizations competing in the market for aquaculture inputs and services. Nevertheless, fish farmers' access to information is still limited and lack of 'know-how' is an important constraint to the adoption and consolidation of the sector.

When MLEs were interviewed about their main sources of information on Amazon aquaculture technologies, approximately 35% indicated national input and service providers, private consultants, neighbours and friends. Another 20% claimed to rely primarily on input and service providers and private consultants from neighbouring countries, mostly Brazil. Only 25% of the MLEs mentioned national research organizations, such as El Prado, Pirahiba and CIRA (which are also important actors in the market for aquaculture inputs and other services) as their primary source of information. Other secondary sources of information identified by some MLEs included NGOs. Few references were made to the Policy, Education or Extension components. Up to 20% of those interviewed said they did not have any source of information to aid them on technical or managerial aspects of Amazon aquaculture.

In contrast, the vast majority of RPFs interviewed (68%) rely wholly and directly on NGOs as sources of information on Amazon aquaculture innovations. National research organizations participating in NGO run pro-poor aquaculture development projects as consultants and fry providers (primarily El Prado and CIRA) were also mentioned as sources of information by 24% of RPFs. Similarly, other input and service providers selling fry or feed to RPFs via NGO-run pro-poor aquaculture development projects were identified as important sources of information by 8% of those interviewed. However, RPFs tend to receive information from research organisations and other input/service providers indirectly, via the NGOs. There are hardly any references in the interviews to the Policy, Education or Extension components.

Infrastructures

The costs of pond construction were relatively high, particularly in Santa Cruz and Beni where the markets prioritise large fish, hence requiring longer production cycles and deeper pools (up to 2 m). Furthermore, lack of competitors in the provision of pond construction services and poor road infrastructures, which condition the movement of heavy machinery, increase excavation costs in rural areas. In the humid tropics of Cochabamba and La Paz excavation costs were considerably lower[35]: between 0.5 and 1 US$/$m^2$. In practice, most producers either recycled existing water bodies for aquaculture or they owned heavy machinery and could build ponds themselves, reducing considerably the costs of construction (Table 4-10).

Table 4-10 Strategies for pond construction and improvement. (N= 135 MLE; 249 RPF)

	Manual construction	Hiring of machinery	Ownership of machinery	Adaptation of existing pools
MLE (%)	2	34	23	41
RPF (%)	12	52*	0	36

* With NGO or government subsidies

Equipment

Only one out of every four fish farmers in the region owned fish nets and equipment for pond management and harvesting. In Trinidad, the capital of Beni, 43% of producers borrowed or hired the necessary equipment from friends and neighbours. The city of Santa Cruz is the main market for aquaculture gear, with relatively specialised stores such as Equipesca, Casa Cabral, Caza y Pesca, and VECTA. Fish nets, scales, coolers etc. can also be found in the popular markets of ‘Barriolindo’, ‘Mutualista’ and ‘Los Pozos’. However, more specialised equipment, such as automatic feeders, extruders or hormones used to induce spawning, have to be imported.

[35] The main advantage in these areas is that the markets for fish in Cochabamba and La Paz are more flexible and smaller fish can be sold, thus allowing fish farmers to shorten production cycles and work with shallower ponds. Furthermore, the unevenness of the terrain in Yungas and Chapare makes it possible to dam secondary rivers and streams without having to move large volumes of earth.

Marketing & processing services

Development in the fisheries sector is conditioned by Bolivia being landlocked, poor road infrastructures and insufficient fish marketing and processing services. The sector relies to a great extent on the importation of sábalo (*Prochilodus sp.*) from Argentina and trout (*Oncorhynchus sp.*) from Peru. Annual per capita consumption of fish is low, averaging 2.1 kg, although this figure does not show important regional variations (Wiefels, 2006). Fish is a luxury; in the city its market value is more than double that of beef. Prices range from 1.5 to 5.6 US$/kg, depending on the region, the species and the season. Amazon species represent 12% of fish consumed in the country's main cities, 9% of which comes from national fish farms (ibid). The vast majority is sold as fresh fish in local markets.

In recent years there has been an important decrease in Bolivia's capture fisheries (MACA, 2005). This decline has been compensated in part by more imports from neighbouring countries. According to the market study carried out by INFOPESCA[36] (2006) the decline in fishing represents an opportunity for aquaculture development in Bolivia, where an increase in the demand for fish could be expected if aquaculture were to succeed in ensuring a regular supply of fish, which at present is unreliable and mainly seasonal (Wiefels, 2006).

4.4.6 (E_a) Input/output supply, processing, marketing component (Abroad)

Foreign private enterprises that supply inputs and associated services to the Amazon aquaculture sector in Bolivia

Large farmers and input and service providers for Amazon aquaculture in Bolivia have established important ties with foreign organisations, particularly with Brazilian aquaculture firms, research centres and public extension agencies. Despite Bolivia's adherence to the Convention on Biological Diversity which should, in theory, entail restrictions on the trade of live aquatic organisms, in 2005 half of the fry purchased for aquaculture in the Bolivian Amazon were imported from Brazil. Although the consumption of fish feed is increasingly national, at the time of the interviews the Brazilian subsidiary Biofish S.R.L. was still supplying farmers in Trinidad. Large producers often hire Brazilian experts to administer their farms and national

[36] Centro para los servicios de información y asesoramiento sobre la comercialización de los productos pesqueros en América Latina y el Caribe (www.infopesca.org)

aquaculture organizations. Furthermore, specialised equipment such as extruders for fish feed production or hormones used in hatcheries to induce spawning are usually imported from Brazil[37].

4.4.7 (F) Credit component

The banking systems, government credit schemes for the agricultural sector

One of the main difficulties facing Bolivian farmers, and fish farmers in particular, is how to get credit, as there is no strategic plan to finance the agricultural sector. Credits granted by the regulated banking system, under the superintendence of banks and financial institutions, are secured by highly restrictive mortgages. Interest rates range between 8% and 14%. Few farmers fulfil the necessary conditions to access loans via the regulated banking system. For most farmers the only alternative are private non-regulated financial institutions that provide small collateral-free loans. However, interest rates on these loans can be as high as 30%.

In the sample of 384 fish farmers interviewed for this study, only 2% obtained a loan from non-regulated financial institutions to set up aquaculture, another 3% borrowed money from friends or family. No individual farmer had accessed credits via the regulated banking system. However, the experience of CABE, Beni's Aquaculture Association, is an interesting example. CABE was able to negotiate a loan for ten of its members with the Bank of Los Andes at the relatively low interest rate of 7.5%. This loan was designed to finance the last six months of the production cycle (to purchase fish feed primarily) and had to be paid back at the end of this period with part of the sales from the harvest. CABE's governing body was directly responsible for supervising the activity of each of the members who had been granted the loan. On behalf of its associates, CABE was also looking into other sources of finance at reasonable interest rates to cover all the stages of aquaculture production, from pond construction to fish processing and marketing.

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[37] Interviews show that some of the key Brazilian input and service providers for the aquaculture sector in the Bolivian Amazon include: Projeto Pacú Aqüicultura Ltda, a private firm in Campo Grande, Matto Grosso; the Asoc. Brasileira dos Criadores de Organismos Aquáticos; EMBRAPA, Empresa Brasileira de Pesquisas Agropecuária, an initiative of the Ministry of Agriculture; CEPTA, Centro de Pesquisa e Treinamento em Acuicultura, the state aquaculture R&D centre; and INPA, Instituto Nacional de Pesquisas da Amazônia, the national insitute for Amazon fisheries in Manaus. The main Peruvian provider is IIAP, Instituto de Investigaciones de la Amazonia Peruana, the state aquaculture R&D institute with headquarters in Iquitos.

4.4.8 (G) Private fish-farm component: producers

(G_e) MEDIUM/LARGE ENTREPRENEURS, MLE

(G_f) RESOURCE POOR FARMERS, RPF

As already noted, aquaculture in the Bolivian Amazon tends to be a part-time family endeavour aimed at diversifying farm or business activities. At the time of the interviews, there were no stand-alone, intensive aquaculture enterprises producing for export in Bolivia. The most intensive farming is practiced in Trinidad, but even there yields per unit area do not surpass 6 t/ha/yr and the fish are sold in local and regional markets. The bulk of Bolivia's Amazon aquaculture production comes from MLEs engaged in agribusiness and/or the catering industry. It is estimated that approximately 30% comes from RPFs who have initiated aquaculture activities with assistance from rural development and extension projects. On average MLE farms are significantly larger than those managed by RPFs, but, the type of aquaculture practiced by both groups is similar: mainly semi-intensive farming of fish in earthen ponds with a mixture of commercial feeds and home-made, vegetable-based, low-protein feeds. Most fish farmers sell a large part of their harvest in local and regional markets.

Up until the year 2000 there weren't any official Amazon aquaculture producer associations in the country, however, between 2000 and 2005, 8 associations came into being (Table 4-11). It is estimated that at the time of the interviews these associations represented about half of the region's fish farmers. The importance of producer associations as facilitators of information exchange and technology diffusion is noted in IFPRI's study of local innovation processes in four communities in Bolivia exposed to aquaculture extension projects (Hartwich et al. 2007). Despite the growing number of aquaculture associations, producers face important challenges. Out of the sample of MLEs interviewed, 46% declared themselves 'satisfied' with the performance of their businesses, 24% rated their experience in aquaculture as being 'OK', 10 % were 'unsatisfied' and 20% of the sample were unable to answer as they had not yet concluded their first production cycle at the time of the interview.

Table 4-11 Aquaculture producer associations in the Bolivian Amazon (2006)[38]

Producer association	**Members**	**Area of influence**
CAOR, Cámara de Acuicultores del Oriente	Set up by MLEs and input/service providers	Santa Cruz
CAISY, Cooperativa Agropecuaria Integral San Juan de Yapacaní	Represents rice and poultry farmers from the Japanese community in Santa Cruz. Also includes farmers trying out aquaculture.	San Juan de Yapacaní, Santa Cruz
CABE, Cámara de Acuicultores del Beni	Set up by MLEs and input/service providers	Trinidad, Beni
Asociación de Pescadores Río Mamoré	Association of fishermen that has become involved in promoting aquaculture amongst riverine communities	Trinidad, Beni
Asociación de Piscicultores Indígenas y Campesinos de San Andrés	Set up within project promoted by SIBTA's Humid Tropics Foundation. Represents RPF.	San Andrés, Beni
ASOPIM, Asoc. de Piscicultores Indígenas de Moxos	Set up within NGO HOYAM's aquaculture programme. Represents fish farmers in indigenous territories.	Moxos, Beni
Asoc. de Piscicultores TAMBAQUÍ	Promoted by EU & US bilateral cooperation programmes. Represents Campesino fish farmers	Chapare, Cochabamba
AIPANE, Asoc. Integral de Productores Agropecuarios Nueva Estrella	Promoted by EU & US bilateral cooperation programmes. Represents Campesino fish farmers affiliated to the Unión de Asoc. de Productores Agropecuarios de Carrasco	Chapare, Cochabamba

The contribution of RPFs to Amazon aquaculture production in Bolivia was still relatively small and, as mentioned above, more than half of the families interviewed that initiated the activity with aid from NGOs or the government abandoned it once external assistance was withdrawn.

Table 4-12 Main problems reported by fish farmers in the Bolivian Amazon. MLE = medium/large entrepreneurs, non-beneficiaries of aquaculture projects; RPF = resource-poor farmers that were involved in aquaculture projects at the time of the interview, 'beneficiaries'; RPF (Ex) = resource-poor farmers that had been involved in aquaculture projects in the past, 'ex-beneficiaries'.

INTERNAL PROBLEMS (N = 382)	**MLE** (%)	**RPF** Benef (%)	**RPF (Ex)** Ex-benef (%)
Limited access to information	24	10	44
Limited access to input markets	12	8	23
Limited access to output markets	2	0	0
Inadequate farming infrastructures	28	16	8
Lack of financial capital	9	38	10
Not profitable	4	2	13
Organisational problems	0	10	2
Theft	5	3	0
Others	1	0	0
None	15	13	0
TOTAL	100	100	100

[38] Fish farmers in Yungas, La Paz, and fish farmers along the Rurrenabaque-Yucumo-San Borja road, Beni, were not affiliated to any producer association.

The main problems identified by the fish farmers in the sample are: limited access to information and aquaculture inputs, such as fry and feed, inadequate farming infrastructures and lack of capital and credit to invest in pond construction and farm improvements.

According to producers, the main barriers to the sector's development include: the scarcity of qualified human resources; insufficient collaboration between producers, the state and NGOs and lack of information dissemination networks; immaturity of the associated input and output markets; and the absence of government support or credit for producers in Amazonia.

Table 4-13 Main barriers to the development of the Amazon aquaculture sector in Bolivia according to fish farmers.

EXTERNAL PROBLEMS (N = 380)	**MLE** (%)	**RPF** Benef (%)	**RPF (Ex)** Ex-benef (%)
Lack of qualified human resources	20	11	37
Embeddedness of information & isolation of actors	12	0	0
Lack of input markets and associated services	13	9	32
Expensive fish feed	10	0	0
The nature of output markets	10	5	0
Lack of favourable policies and credit	7	45	31
Poor roads and energy infrastructure	8	9	0
Political and social unrest	1	3	0
Others	2	0	0
None	17	18	0
TOTAL	100	100	100

4.4.9 (H) External assistance component

Donors, international research institutes and NGOs involved in Amazon fisheries management and aquaculture development

National and international NGOs, bilateral development programmes and international research institutes all play an important role in Amazon aquaculture development in Bolivia by financing or developing research and pro-poor aquaculture extension initiatives. Although agricultural NRM development programmes have tended to focus on agriculture and livestock farming, some external-aid organisations have recently become key actors in the introduction and adaptation of aquaculture generic technologies, training and extension services, including credit and/or subsidies for setting up fish farms, and the development of the necessary input and output markets for aquaculture.

The introduction of carp and tilapia generic technologies was favoured by the FAO in the late 1980s and further developed and adapted by the national research centers El Prado and Pirahiba. On the other hand, the development of indigenous species aquaculture has been aided, in part, by the work of international research centres, such as IRD (ex – Orstom), the French *Institut de Recherche pour le Développement*, and NGOs, such as HOYAM in Beni, which have been key entry channels for new knowledge and practices for the aquaculture sector in the Bolivian Amazon. The IRD worked in Bolivia for nearly a decade, contributing to the training of researchers and the development of technologies for artificial reproduction and pond rearing of native species including tambaquí, sábalo, tucunaré and surubí[39]. Unfortunately for BAAIS, in 2005 the IRD left Bolivia and moved to Iquitos, Perú. HOYAM, on the other hand, is responsible for the first artificial reproduction of pacú (*Colossoma* sp.) in Bolivia and has trained farmers and students in indigenous species aquaculture. Another NGO engaged in related research and development activities is FAUNAGUA, with headquarters in Cochabamba, which has become an important technical adviser to both national and regional governments with regards to fisheries management and conservation policy. The external assistance component has also contributed to equip public research stations such as Pirahiba and El Prado.

Furthermore, several national and international NGOs are engaged in project-based training and capacity building. Since the end of the 1980s there have been more than 30 pro-poor aquaculture development and extension projects in the region (see Appendix 6 for a detailed list of projects and section 4.7.2 for a summary of the history of pro-poor Amazon aquaculture in Bolivia). However, many of these projects have been isolated, short-term initiatives on behalf of local NGOs. Nonetheless, they have constituted one of the few sources of information on Amazon aquaculture innovations for resource-poor farmers. Some of the longer term projects include those of the US and EU bilateral development programmes aimed at developing alternatives to coca production in Chapare and Yungas and the aquaculture extension programmes

[39] From 2000 to 2004, the IRD developed the Programme UR080 *Interactions Génome/Populations/Environment chez les poisons tropicaux* in collaboration with the state universities of Beni and Cochabamba. Since 2005 the IRD has collaborated with the state university of Santa Cruz in the programme CAVIAR UR175, *Caractérisation et valorisation de la diversité ichtyologique pour une aquaculture raisonée*, which also involves the Peruvian 'Instituto de Investigaciones de la Amazonia Peruana' in Iquitos

implemented in Beni by the NGOs *Vétérinaires Sans Frontièrs* in Rurrenabaque and HOYAM in Moxos.

Joint project-based activities between NGOs and private consultants or state universities have been established in some cases[40]; nonetheless, national NGOs tend to operate in relative isolation and have to face insecure, insufficient funding and serious problems in recruiting qualified human resources to design and implement aquaculture projects. Collaboration tends to be scarce even among those NGOs engaged in pro-poor aquaculture extension projects in the same region.

To sum up, Table 4-14 brings together the opinions of different actors in the BAAIS components with regards to the main opportunities and challenges faced by Amazon aquaculture development in Bolivia (sections II.VI and II.VII in Appendix 2 and section IV in Appendix 3)

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[40] Examples include: Belgium's bilateral development programme in the provinces of Ichilo and Sara (Santa Cruz), which hired the services of El Prado, the autonomous university's research station, to design and implement aquaculture modules in campesino communities: the EU's alternative development programme in Chapare, which relied on the private consultancy firm *Agronegocios Tropicales JUASI* to devise their aquaculture extension scheme; and the NGO Man-B in Caranavi, which hired the services of an external consultant linked to the Catholic University of La Paz to implement the project *Ecopiscicultura en el Trópico Húmedo*

Table 4-14 Main opportunities and challenges for Amazon aquaculture development in Bolivia as seen by different groups of actors

COMPONENTS	OPPORTUNITIES	CHALLENGES
A. POLICY	* Growing demand for Amazon aquaculture * Favourable environmental and climatic conditions in the tropics * Growing interest in pro-poor aquaculture development by regional and local governments in the Amazon region * Growing interest in pro-poor aquaculture development by NGOs and external assistance organisations	* Political unrest. Lack of continuity of development schemes and institutional learning, high staff turnover * Anachronistic legal framework * Lack of coordination between central government and Prefecturas and among Prefecturas in the Amazon region * Centralization of the CIDAB, emphasis on the Altiplano basin. Amazonia not a priority * Unclear mandates in the Ministry & Prefecturas concerning policy design/enforcement * Lack of qualified human resources in fisheries management and aquaculture at all levels
B. RESEARCH	* Growing demand for Amazon aquaculture * Important recent developments in fry production for aquaculture * Key role of national research centres in the market for inputs and services for aquaculture	* Lack of funding for aquaculture R&D * Lack of qualified human resources in fisheries management and aquaculture * Lack of a unifying entity, isolation of research centres and universities
C. EDUCATION	* Recent introduction of aquaculture courses at the university level * Growing interest in the subject by university students	* Lack of qualified human resources in fisheries management and aquaculture * Lack of applied research facilities in most universities and technical schools
D. EXTENSION	* Budget increase for the Prefecturas and municipal governments due to the creation of a new direct tax on hydrocarbons * The creation of a new competitive funding system for agricultural technology development and extension: SIBTA * New channels for the flow of information and resources to fish farmers via a growing number of producer organisations and NGOs	* Lack of an operational unit & funding to enforce ministerial policies at the regional level * Lack of qualified human resources in the Prefecturas and municipal governments * Lack of continuity of development schemes and institutional learning, high staff turnover, political interference * Secrecy in the public aquaculture R&D centres, embeddedness of knowledge, lack of information dissemination * Poor roads and energy infrastructure in the Bolivian Amazon
E. INPUT & OUTPUT MARKETS *(E_n) national* *(E_a) abroad*	* Increasing demand for Amazon aquaculture inputs and services * Recent progress in the introduction and development of aquaculture generic technologies * Expansion and diversification of the market for fry and fish feed * Increasing role of the private sector in the market for inputs	* Difficulty for national firms to compete with subsidized public hatcheries and Brazilian input and service providers * Absence of government support for the sector's development in Amazonia, unfavourable policies, lack of credit * Poor roads and energy infrastructure in the Bolivian Amazon * Lack of qualified human resources in Amazon aquaculture
F. CREDIT	* The creation of an increasing number of regional aquaculture organisations might open new channels for financing fish farming	* Lack of a strategic plan to finance the agricultural/aquaculture sectors in Amazonia * Highly restrictive mortgages, very high interest rates
G. FISH FARMERS *(G_e) MLE* *(G_f) RPF*	* Favourable environmental conditions for aquaculture. Compatibility & complementarity between aquaculture & existing farming activities * The high market value of pacú and tambaquí in Bolivia * The recent expansion and diversification of the market for inputs and services for aquaculture	* Limited access to information, lack of qualified consultants, secrecy amongst experts * Restricted access to inputs, input and service providers still few, associated markets mostly centralised in Santa Cruz * Seasonality of the market for fish, insufficient marketing and processing services * Absence of government support and credit for aquaculture production in Amazonia
H. EXTERNAL ASSISTANCE	* Growing interest in aquaculture amongst farmers in Amazonia * Growing interest in aquaculture as a pro-poor development strategy by some Prefecturas and municipal governments * The formation of a growing number of indigenous and campesino aquaculture associations * Increasing access to inputs & services for aquaculture in rural areas	* Isolation of most NGOs and pro-poor aquaculture development projects * Lack of qualified human resources in most NGOs to carry out aquaculture projects * Short-termism of many pro-poor aquaculture projects, limited integration with input/output markets, ill-suited farming technologies * Very little institutional learning, very little self-evaluation, lack of continuity of projects

4.5 System competency & relationship dynamics

In the previous section an in-depth description was given of the range of actors shaping BAAIS, their roles, their participation and key achievements within the innovation process, the main challenges and opportunities they face and the broader environment in which they operate. But the different actors and components that form BAAIS do not exist in isolation, rather they influence and are influenced by other actors and elements of the system. This section centres on relationships and interactions among actors and their nature, that is, the system's workings (and non-workings) as a whole. Using a linkage matrix and its graphical representation we look at system competency and relationship dynamics. The linkage or interaction structure shows the degree of inter component connectedness (the density of BAAIS), which is an indication of the system's 'health' and potential effectiveness in developing and delivering innovations. The linkage matrix also highlights clusters/isolated actors and hence potential networks of information and other resources or, on the contrary, constraints to the flow of knowledge. The types of relationships existing within an innovation system also reflect organisational cultures and the broader national context.

The linkage matrix (Table 4-15) summarises the strength of interactions and the type of interactions that exist in and among the ten components of BAAIS (Section III in Appendix 2). Actors interviewed were asked to name who they had links with, what types of links they had and how strong they were. The types of interactions were coded and the strength of interactions were expressed in scales. The values assigned to 'strength of interaction' by different actors were averaged out to obtain a single value for each component. This data, obtained from the interviews with the 90 actors in BAAIS, was complemented and, when possible, triangulated with information provided by the sample of fish farmers (N=384), in particular that relating to their sources of information, inputs and credit (section III in Appendix 3).

Blank cells reveal that no links exist between components. The ten components of the system and key aspects of the links that exist among actors within the same component have been placed in the diagonal cells. Information on links between components is presented in the off diagonal cells. Moving clockwise, the first cell in the first column represents the policy component (A), the second cell in the first row summarises the information gathered from the actors in A about their links with the research component (B), the second cell in the second row represents B and the second cell in the first column summarises the links which actors within the research component claim to have with the policy component, and so on.

Table 4-15 BAAIS Linkage or Interaction matrix. Strength and type of interactions within and between components (following clockwise convention)

POLICY A Weak Info sharing, joint planning Very weak links between government bodies	Weak Info sharing, joint technology diffusion between regional govt. and research orgs.		Weak Joint program development & technology diffusion via SIBTA (isolated cases)					Weak Technology diffusion Participation in isolated projects via SIBTA & local govt. projects	Weak Info sharing, joint priority setting for fisheries &conservation at ministerial level
Weak Info sharing, joint technology diffusion. A few links with govt in Beni & Cochabamba	RESEARCH B Weak Info sharing & workshops Few links among actors in B	Medium Overlapping roles. Main actors in B also main actors in C (within state universities)	Weak Joint tech. diffusion. Participation in SIBTA's aquaculture project	Strong Overlapping roles. Key actors in B also important in E_n	Medium Commercial ties (fry, feed, hormones, lab. equipment, info.)		Strong Commercial ties & Overlapping roles. Key actors in B also key in producer orgs	Weak Technology diffusion Participation in SIBTA's aquaculture project	Medium Joint program, tech diffusion & commercial ties with NGOs & international research orgs
	Weak Overlapping roles. Some actors in C also key in B	EDUCATION C Weak Info sharing & workshops Few links within C						Weak Participation of some tech. schools in extension in Chapare & Yungas	Weak Joint program dev. in Cochabamba (ULRA, UMSS & Faunagua)
Weak Joint use of resources, info sharing	Weak Info sharing, joint technology diffusion		EXTENSION D Weak A few projects via SIBTA & municipal govt.	Weak Commercial ties (inputs, consultancies)				Weak Joint tech. diffusion Isolated cases	Weak Joint priority setting at Ministerial level (for SIBTA)
	Medium Overlapping roles. Some actors in E_n also key in B		Weak Commercial ties (inputs, consultancies)	MARKETS (National) E_n Medium Commercial ties, shared consultancies	Strong Commercial ties. All actors in E_n have links with E_a		Strong Commerc. ties & overlapping roles. Main actors in E_n also key in producer orgs.	Weak Commercial ties (fry, feed, info, often via NGOs)	Medium Commercial ties (fry, feed, info. for pro-poor aquaculture projects)
	Weak Commercial ties (fry, feed, hormones, lab. equip., info.)			Medium Commercial ties. Some in E_a have links with E_n	MARKETS (Abroad) E_a (?)		Medium Commercial relationship (fry, feed, info.)		Weak Commercial ties (fry, feed, equipment, info.)
						CREDIT F Almost inexistent	Very weak One case: CABE in Trinidad		
	Medium Commerc. ties & overlapping roles. Heads of producer orgs key in B			Strong Commercial ties (Fry, feed, info)	Medium Commercial ties (Fry, feed, info)	Very weak One case: CABE in Trinidad	PRODUCERS (Entrepreneurs) G_e Medium links among regional orgs		Weak Info sharing
Weak Technology diffusion via SIBTA	Weak Technology diffusion via SIBTA	Weak Info exchange	Weak Technology diffusion via SIBTA	Weak Commercial ties via NGOs				PRODUCERS (small farmers) G_f. Weak links	Strong Most G_f have had assistance from H
Weak Info sharing	Medium Joint tech diffusion, info sharing, commercial ties	Weak Training by international research orgs	Weak Info sharing	Medium Commercial ties (fry, feed, info)	Weak Commercial ties (info, equipment)		Weak Info sharing	Strong Most aquaculture projects work with G_f	EXTERNAL ASSISTANCE H Weak links among NGOs

Linkage matrixes are not necessarily symmetrical. For example, in this case whilst all public aquaculture research centres (within the research component B) maintain ties with some actors in the private sector, both with input and service providers (E) and with MLEs (G_e), the opposite is not always true. On the contrary, not all large farmers and service providers have ties with public research centres. Similarly, whilst all national suppliers of inputs and services for Amazon aquaculture (E_n) have ties with Brazilian and Peruvian aquaculture firms (E_a), only a very small percentage, in relative terms, of the latter maintain commercial links with Bolivian clients or providers.

The linkage or interaction matrix captures the nature and strength of the existing relations among the organisations that make up BAAIS. The data suggests that the system's internal cohesion is weak; organisational links, both in and among components, are by and large weak or nonexistent. When asked about potential barriers to collaboration, 52% of the BAAIS actors interviewed gave explicit examples of problems that limit cooperation with other actors. These included, in order of importance: lack of human and physical resources, high turnover rate of staff in public institutions, lack of a unifying entity, the market-oriented focus and inherent secretiveness of the research component, political tensions between regions (such as Beni and Cochabamba fighting over the Isiboro Sécure Territory) and political antagonism between the central government in La Paz and regional governments in the lowlands governed by rival parties. The remaining actors (48%) agreed that cooperation was normally difficult but did not identify specific examples for this.

As summarised in the interaction matrix and observed in the descriptive analysis of BAAIS' ten components in the previous section, networks among actors within the same component (intra-component) are often surprisingly few. Some coordination exists among MLEs (G_e) via producer organizations, and among input and service providers (E_n) via commercial ties and shared consultancies. But within all the other components links are weak.

A more condensed version of the BAAIS linkage matrix has been used to characterise the system's inter-component dynamics (links between sub-groups of actors), and the role of the different components in the development and diffusion of aquaculture innovations. This version has been constructed by representing only the strength of existing relations between components with numeric values: 3 for strong, 2 for medium, 1 for weak and 0 for none (Coded linkage matrix Figure 4-4).

The coded linkage matrix makes it possible to measure the degree of connectedness among BAAIS components and evaluate the system's competency. Out of a total of 90 potential links between components only 49 are being used with more or less intensity: 31 are weak links, 11 are medium and only 7 of the system's cross-component links are strong. The density of BAAIS is 0.54 (49/90), reflecting a low system competency.

A	1	0	1	0	0	0	0	1	1
1	**B**	2	1	3	2	0	3	1	2
0	1	**C**	0	0	0	0	0	1	1
1	1	0	**D**	1	0	0	0	1	1
0	2	0	1	**E_n**	3	0	3	1	2
0	1	0	0	2	**E_a**	0	2	0	1
0	0	0	0	0	0	**F**	1	0	0
0	2	0	0	3	2	1	**G_e**	0	1
1	1	1	1	1	0	0	0	**G_f**	3
1	2	1	1	2	1	0	1	3	**H**

Figure 4-4 Coded linkage matrix: weighing inter-component cohesion. (A) Policy; (B) Research; (C) Education; (D) Extension; (En) Input/service providers (National); (Ea) Input/service providers (Abroad); (F) Credit; (Ge) Producers (medium/large Entrepreneurs); (Gf) Producers (Resource-poor farmers); (H) External assistance. Strength of interactions between components are represented with numerical values and different shades of grey: Strong = 3, dark grey; Medium = 2, medium grey; Weak = 1, light grey; None = 0, white.

Strong links do seem to exist among the research component (B), private national suppliers of associated inputs/services (E_n) and MLEs (G_e), as shown by the value 3 in the corresponding off-diagonal cells. Several actors within research organisations are engaged in the sale of fish fry, feed and information, often in association with large producers. National suppliers of inputs and services for Amazon aquaculture also maintain close commercial ties with foreign providers of aquaculture inputs, mostly from Brazil (E_a). On the other hand, organisations within the external assistance component (H) tend to be closely linked with RPFs setting up aquaculture units via project-based activities (G_f).

The value 2 in some of the matrix's off-diagonal cells indicates that some links also exist between the research component and the education component (C). Research centres such as El Prado, Pirahiba and CIRA are all under the administration of the state universities Gabriel René Moreno, Mayor San Simón and Autónoma de Beni respectively. However, there is little interaction among the above mentioned research centres and the other public and private universities and technical colleges nationwide. On the other hand, the research component is also linked, to some degree, with the foreign market for aquaculture inputs (E_a) and the external assistance component (H), via the purchase/provision of aquaculture inputs and associated services. In turn, external assistance organisations maintain some direct links with national input and service providers (E_n), particularly with fry merchants and consultants; and MLEs (G_e) have some commercial ties with Brazilian input and service providers. Relations among all other components in BAAIS are either weak or nonexistent.

The extent to which the different components interact with others in absolute terms can be seen more clearly in the graphical representation of the linkage matrix (Figure 4-5). Total component connectedness (Y axis) is calculated by adding up the number of linkages claimed by the organisations in a given component Z (rows in the matrix) plus the number of linkages organisations in other components claim to have with Z (columns in the matrix).

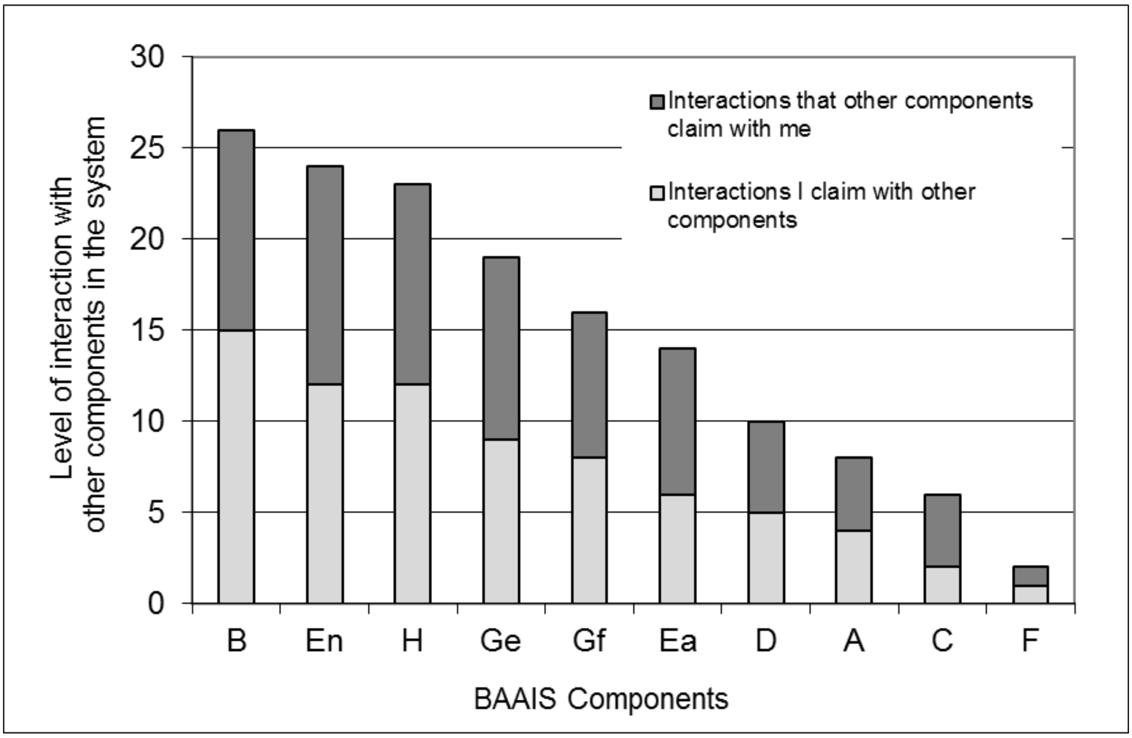


Figure 4-5 Connectedness of the ten BAAIS Components. From best to worst connected: (B) Research; (En) Input/service providers (National); (H) External assistance; (Ge) Producers (medium/large Entrepreneurs); (Gf) Producers (Resource-poor farmers); (Ea) Input/service providers (Abroad); (D) Extension; (A) Policy; (C) Education; (F) Credit

Figure 4-5 shows, in order of importance, that the best connected BAAIS components are: research (B), private national suppliers of associated inputs/services (E_n), external assistance organisations (H), fish farmers (MLEs slightly more than RPFs), and the market of inputs abroad (E_a). The policy, education and credit components (A, C, F) are almost totally isolated from the rest of the system. The public extension component (D) is also weakly connected.

On the whole research organisations claim to have more links with others in the system than the others claim to have with them, suggesting that the level of connectedness of the research component may be slightly lower than is portrayed here. On the other hand, national suppliers of aquaculture inputs and services may be better connected than they claim, as suggested by the level of interaction that other components allege to have with them.

The analysis suggests that, with the exception of the research component, which appears to have established close ties with some producers and the market for aquaculture inputs, most organisations operating under BAAIS' public-sector components are relatively isolated. This situation greatly limits their impact on the innovation process and greatly hinders institutional learning. There are few potential feed back loops between the policy component and the other organisations in BAAIS.

Despite these limitations, the production and dissemination of aquaculture innovations is taking place to some degree and Amazon aquaculture production seems to be growing. The analysis of the BAAIS linkage matrix suggests that key actors in the innovation process are those organisations which operate under the systems' private-sector components (input and service providers, farmers and NGOs) and those public research centres, such as El Prado and CIRA, that have managed to establish close ties with private-sector organisations or are directly functioning as private-sector organisations by taking on the function of producers and input and service providers. As has already been noted in the descriptive analysis of the research component (B) in the previous section, what appears in the interaction matrix as a strong link between research organisations and large-producers (G_e) and the market for aquaculture inputs (E_n) is often a case of 'multiple' and 'overlapping' roles. Frequently, the people in charge of research stations are also producers, they are on the board of directors of regional aquaculture organizations, and they sell fry produced in research stations as well as working as private consultants. It is not that strong ties exist between different actors in B, G_e and $E_{n,}$ but that the same actors are playing key roles in B, G_e and E_n.

Having said this, it is worth noting that although the degree of interaction among components would seem to be a precondition for the diffusion and exchange of information and other resources, component connectedness in itself is not sufficient to guarantee the dissemination of innovations, particularly if actors are not interested in sharing what they know. It is possible that well connected components, for example those connected by commercial ties, are less influential as information disseminators in the overall system than might be expected. In contrast, components that are less well connected may be essential to the development and diffusion of innovation.

4.6 The BAAIS Cause-Effect structure: uncovering information networks

All actors in BAAIS participate in the innovation process in some way or another, but some actors have greater influence over the process than others. Moving beyond the linkage matrix, the system's Cause-Effect structure helps to identify dominant/subordinate components in the dissemination of innovation. In this structure, data on the strength and frequency of interactions between components (connectedness) is crossed with data on the sources of information (directionality). Cause (C) is understood as the influence of a single component on the rest of the system in terms of its role as a disseminator of information on aquaculture innovations. Effect (E) is understood as the influence that the rest of the system has on a single component, in terms of its role as a receiver of information. At its simplest the system's CE structure (Figure 4-7 and Figure 4-8) is built by merging the linkage matrix (Figure 4-4) with the information sources-sinks matrix (Figure 4-6). It shows which components exert the greatest control over the system, i.e., those with the greatest capacity to influence others. It can also show the directionality of knowledge flows and help trace pathways of information and other inputs.

The information sources-sinks matrix is based on data collected from the interviews with fish farmers (N = 384) and other key actors in BAAIS (N = 90) with regards to their main sources of information on innovations[41]. Figure 4-6 presents the results in the format of a refined matrix where values in the off-diagonal cells reveal the level of

[41] See actors' questionnaire in Appendix 2 (Section II.III) and fish farmers' questionnaire in Appendix 3 (Section III).

importance of the different components as sources of information for others: 1 represents an important source of information, 0.66 a source of medium importance, 0.33 a source of low importance and 0 a negligible source of information.

A	0	0	0	0	0	0	0	0.33	0
0.33	**B**	0.66	0.33	0.66	0	0	0.66	0.33	0.66
0	0	**C**	0	0	0	0	0	0.33	0
0	0	0	**D**	0	0	0	0	0.33	0
0	0.33	0	0	**E_n**	0.33	0	1	0.33	1
0	0.66	0	0	1	**E_a**	0	0.66	0	0.33
0	0	0	0	0	0	**F**	0	0	0
0	0.33	0	0	0.33	0.33	0	**G_e**	0	0.33
0	0	0	0	0	0	0	0	**G_f**	0.33
0.66	1	0.33	0.33	0.33	0	0	0.33	1	**H**

Figure 4-6 Information source-sinks matrix: identifying important sources of information for the different components. (A) Policy; (B) Research; (C) Education; (D) Extension; (En) Input/service providers (National); (Ea) Input/service providers (Abroad); (F) Credit; (Ge) Producers (medium/large Entrepreneurs); (Gf) Producers (Resource-poor farmers); (H) External assistance. Importance of the source of information represented with numerical values and different shades of grey: High = 1, dark grey; Medium = 0.66, medium grey; Low = 0.33, light grey; None = 0, white.

As mentioned above, interaction is a prerequisite for an information exchange to exist. If information pathways between specific components are indicated by a value other than zero in the corresponding off-diagonal cells of the source-sinks matrix, this means interactions will have taken place and will be reflected by a value other than zero in the same off-diagonal cells of the linkage matrix. However, the same principle does not apply in reverse. For example, the coded linkage matrix (Figure 4-4) reveals the existence of a weak link (value of 1) between the policy component and the research component (second cell, first row), whereas in the information source-sinks matrix the second cell in the first row has a value of zero. This is because none of the organisations in the research component claimed to have received any relevant information about aquaculture innovations from the policy component, despite the existence of some degree of formal relations.

To obtain the BAAIS Cause-Effect structure, the information sources-sinks matrix is weighted by crossing it with the coded linkage matrix presented in the previous section; the value in each of the off-diagonal cells of the former is multiplied by the value in the equivalent cell of the latter. Figure 4-7 shows the BAAIS Cause-Effect matrix and Figure 4-8 its graphical representation.

A	0	0	0	0	0	0	0	0.33	0
0.33	**B**	1.33	0.33	2	0	0	2	0.33	1.33
0	0	**C**	0	0	0	0	0	0.33	0
0	0	0	**D**	0	0	0	0	0.33	0
0	0.66	0	0	**En**	1	0	3	0.33	2
0	0.66	0	0	2	**Ea**	0	1.33	0	0.33
0	0	0	0	0	0	**F**	0	0	0
0	0.66	0	0	1	0.66	0	**Ge**	0	0.33
0	0	0	0	0	0	0	0	**Gf**	1
0.66	2	0.33	0.33	0.66	0	0	0.33	3	**H**

Figure 4-7 BAAIS' Cause-Effect matrix: Information sources – sinks matrix (weighted values). Rows in the CE matrix represent the influence of a single component on the rest of the system (Cause) and columns represent the influence which the rest of the system has on a single component (Effect).

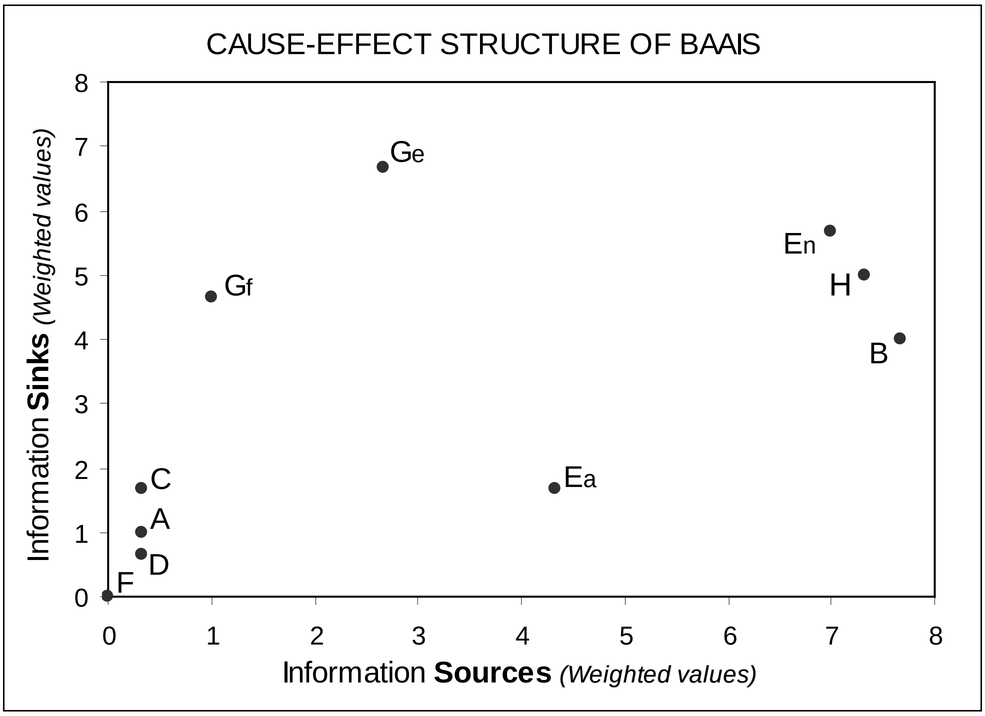


Figure 4-8 Graphical representation of BAAIS' Cause-Effect matrix.
The X-axis represents 'Cause' and the Y-axis represents 'Effect'. In order of importance as a source of information: (B) Research; (H) External assistance; (En) Input/service providers (National); (Ea) Input/service providers (Abroad); (Ge) Producers (medium/large Entrepreneurs); (Gf) Producers (Resource-poor farmers); (C) Education; (D) Extension; (A) Policy; (F) Credit

As might have been expected, the system's dominant components include: B (research), H (external assistance), E_n (input/output markets – national) and, to a less extent, E_a (input/output markets – abroad). On the other hand, the system's main sinks of information are fish farmers: G_e (MLEs) and G_f (RPFs). But fish farmers are also important disseminators of aquaculture innovation in BAAIS, particularly MLEs (G_e). Finally, the cluster of points around the origin of the graph suggests that several components within the system are currently playing a negligible role in the development and extension of Amazon aquaculture: C (education), D (extension), A (policy) and F (credit).

The graphical representation of the BAAIS C-E structure highlights the polarisation between private and public sector components, with the exception of state funded research organisations (B). In fact, the C-E matrix (Figure 4-7) shows that information and other inputs from the Policy (A) and Extension (D) components do not reach MLEs (G_e) at all, and only reach a few RPFs (G_f) via isolated, externally funded, pro-poor aquaculture projects where municipal governments have participated with a small counterpart (San Andrés and Ivirgarzama) or via the one short-term, pro-poor aquaculture project that has been realized under SIBTA in Beni (see descriptive analysis of BAAIS' ten components in the previous section). It is also important to note that there are very few 'feedback pathways' to the Policy and Extension components; these components are only saved from total isolation by some information reaching them via the External Assistance component and a tiny trickle via the Research component.

Despite the challenges faced by public sector organisations, it is still surprising just how isolated the Education component is, given the fact that some of the country's aquaculture R&D centres run by state universities are remarkably dynamic and well connected with private-sector organisations. One would expect that a dynamic and well connected Research component would translate into an equally dynamic and well connected Education component, able to secure the innovation process with qualified fisheries and aquaculture specialists. But, strangely, this is not the case and universities are failing to train much needed specialists and supply the private sector's demand for consultants and farm administrators. This can be seen in the C-E matrix where the 'expected' flow of information: Research (B) → Education (C) → Associated markets

(E_n) or Producers (G), simply does not take place. Information does not appear to leave C at all, except in a few isolated cases where technical schools are participating in aquaculture extension projects funded by the External Assistance component (H) (e.g. in Chapare and Yungas). But on the whole nobody claims to receive any relevant information or any other sort of inputs from Universities or other organisations within the Education component (C).

The Education component's failure to ensure the much needed human capital for BAAIS can be partially explained by insufficient physical and financial resources. Another reason may be the absence of a national organization that could unite universities, technical schools and research organisations under a common goal, promoting collaboration and a more effective Education component. The analysis of BAAIS suggests that a third reason could also be the market-oriented focus of some research centres. Key actors running the Research component are employed by state universities and are responsible for the few courses in tropical aquaculture offered by the universities. In other words, the people shaping the Research component (B) are the same people that are shaping the Education component (C) and, as has already been pointed out, several of the public research centres are competing in the national market for aquaculture inputs and services. Their interaction with other actors in BAAIS is, to a great extent, via commercial ties. This has encouraged greater dynamism in the sector and allowed the Research component to become a dominant component in BAAIS. However, this *modus operandi* also discourages information sharing as the control of information gives them the cutting edge over their competitors. It is surprising that some national research stations have been producing and selling tambaquí fry for over a decade and yet, at the time of the interviews, only half a dozen people in Bolivia knew how to induce the spawning in captivity of this Amazon species.

However, despite the negligible role of the public sector component in BAAIS and other challenges, aquaculture is gradually gaining some weight in the Amazon region thanks to private-sector initiatives. Important information networks include those that go from the Research component to large producers and input/service providers and, to a less extent, to the External Assistance component, in all cases via the sale of fry and private consultancies ($B \rightarrow E_n/G_e/H$). And vice versa, the main source of information for the Research component is the External Assistance component ($H \rightarrow B$)

where international research organisations, such as the French IRD, have provided valuable collaboration and technical training. External Assistance organisations, in particular NGOs, are also the main source of information for RPFs via the implementation of pro-poor aquaculture development projects (H $\rightarrow$ G_f) and, to a less extent, national input/service providers. In turn, national input/service providers are the main source of information on innovations for H (E_n $\leftrightarrow$H). Last but not least, foreign input/service providers, particularly from Brazil, are also an important source of information for national input/output markets and MLEs (E_a $\rightarrow$ E_n/G_e) and also, indirectly to RPFs via the External Assistance component (E_a $\rightarrow$ E_n $\rightarrow$ H $\rightarrow$ G_f).

In terms of fish farmers' access to information, the BAAIS C-E matrix reveals that the main direct providers of information for MLEs (G_e) are, in order of importance: national input and service providers (E_n), the research component (B) and foreign input and service providers (E_a), all via commercial ties. Some MLEs also said they had received relevant information and assistance directly from the External Assistance component (H) but, on the whole, the importance of H for G_e is mainly via B (H $\rightarrow$ B $\rightarrow$ G_e). It is worth noting that MLEs (G_e) are in turn sources of information for national input/output markets and the Research component. In the case of RPFs (G_f) access to information depends almost entirely on the External Assistance Component (H) and, to a much less extent the Policy, Research, Education and Extension components. Indirectly G_f also receives information from national input and service providers and the Research component via the External Assistance component (E_n/B $\rightarrow$ H $\rightarrow$ G_f). RPFs, in turn, are also a relevant source of information on innovations for the External Assistance component.

4.6.1 Accessing the market for Amazon aquaculture inputs and services: a bottleneck

One of the results of the analysis of the BAAIS Cause-Effect structure is the identification of important sources of information on Amazon aquaculture innovations for producers and other actors. However, this does not reveal much about the number and diversity of sources of information available to individual producers: Are producers in a particular region or context relying on a single source of information to set up fish farms or do they have access to several independent sources? Are these sources reliable over time or are they likely to disappear? And what about other inputs, such as fry and feed?

Interviews with fish farmers revealed that access to information and input markets is limited (Table 4-12 and Table 4-13). A useful indicator to help evaluate the health and robustness of the Amazon aquaculture sector is to examine the number and diversity of sources of information and other inputs available to fish farmers. Table 4-16 sums up the results of interviews with RPFs and MLEs with regards to their sources of information, fry, feed, equipment and services for pond construction (A full description of Amazon aquaculture input/output markets in Bolivia is given in section 4.4.5)

Table 4-16 Access to information and Amazon aquaculture inputs

Type of producer	**Information** sources (Nº)	**(%)**	Sources of **inputs & services***(Nº)	**(%)**
Medium/large entrepreneurs (N = 135)	0	20	0	0
	1	21	1	6
	2	47	2	21
	3	9	3	26
	4	3	4	27
			5	13
			6	6
			7	1
	TOTAL	*100*	*TOTAL*	*100*
Resource-poor farmers (N = 249)	0	2	0	0
	1	95	1	77
	2	3	2	21
			3	2
	TOTAL	*100*	*TOTAL*	*100*

* Fry, feed, equipment, services for pond construction

As might have been expected, MLEs had greater access to information and the market of inputs than RPFs. However even the former seemed to rely on a very limited number of providers. In terms of sources of information on aquaculture technologies, 20% of MLE had none, 21% one, 47% two and 12% three or four. In terms of access to associated markets, the majority of MLEs had access to two (21%), three (26%) or four (27%) input and service providers, including distributors of fry, feed, equipment (such as fish farming nets) or services for pond construction.

In the case of RPFs, interviews revealed that the vast majority of them relied exclusively on a single source of information and a single source of Amazon aquaculture inputs and often these sources were the same, a local NGO. The fact that small farmers in specific areas are all relying on the same single source of information and inputs inevitably makes pro-poor aquaculture production highly volatile and susceptible to changes in the structure or dynamics of BAAIS.

4.7 Targeting the poor in BAAIS

4.7.1 Targeting the poor: changes in the BAAIS Cause-Effect structure

In the method used to construct the System's Cause-Effect matrix the fish farmers interviewed were divided in 2 categories: MLEs and RPFs. This made it possible to carry out a distributional or poverty analysis of BAAIS and explore changes in the system's structure and dynamics in relation to the group of producers being targeted. It has already been shown how key sources of Amazon aquaculture innovations for RPFs differ from those of MLEs. Figure 4-9 shows two different graphical representations of the system's Cause-Effect matrix, one built using only the data provided by RPFs and another based only on the data provided by MLEs. The arrows highlight changes in the system's Cause-Effect structure and shifts in the influence of the different components when focusing on RPFs or MLEs.

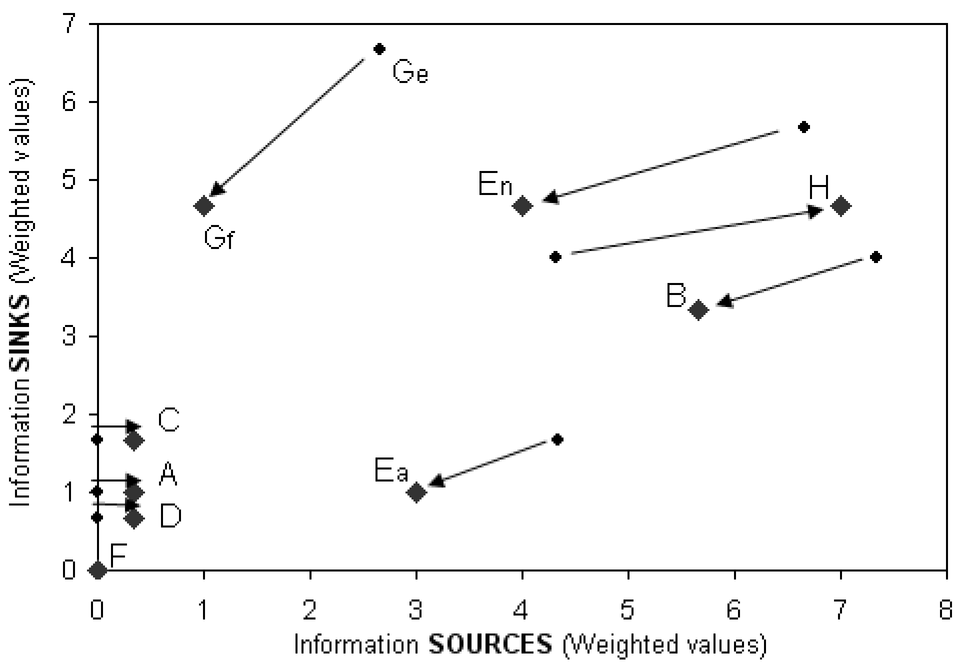


Figure 4-9 Changes in BAAIS' Cause-effect structure when focusing on different groups of producers. The small quadrangles show what the system's Cause-Effect structure looks like when looking at only the data that relates to MLEs. The large quadrangles show what a 'pro-poor BAAIS' looks like, the system's Cause-Effect structure when considering only the data from RPFs. The arrows highlight shifts in the influence of the different components in BAAIS when focusing on one or other group of producers.

When looking at only the data that relates to RPFs it is easier to get an idea of what a 'pro-poor' BAAIS looks like. If we focus only on RPFs' sources of information and inputs, the External Assistance component (H) becomes the dominant component, displacing research organisations (B) and the national input and service providers (E_n) to secondary roles. Similarly, international input and service providers (E_a) lose influence in a 'pro-poor' BAAIS as small producers do not access inputs directly via E_a. For RPFs the credit component's role in the system remains unimportant and the public sector components gain a little ground but their influence as sources of information on innovations remains very weak indeed.

A key aspect of many pro-poor aquaculture development projects is to facilitate RPFs' access to information and other inputs, such as fry, necessary to adopt fish farming. As has already been noted, this is particularly important as the technology is relatively new to the region and input and service providers are few and mainly centred in and around Santa Cruz and other cities. As we can see in the BAAIS linkage and C-E-matrixes (Figure 4-4 and Figure 4-7) RPFs' direct links to input/output markets are very weak. Large producers have developed important links with the few providers of Amazon aquaculture associated inputs and services that operate in BAAIS: national and international input/output markets and research organisations involved in the provision of inputs. But this is not the case for RPFs. The latter only maintain strong links with the external assistance component and in most cases their access to input/output markets is via NGOs acting as a go-between. In fact, the vast majority of RPFs (if not all) have received some sort of support from pro-poor aquaculture development projects to set up the activity.

Drawing from the interviews with fish farmers and other key actors in BAAIS, the following section puts together the short history of rural development projects aimed at promoting fish farming amongst indigenous and campesino communities and weighs their success.

4.7.2 Pro-poor Amazon aquaculture in Bolivia: a short history

Between the 1980s and 1990s there were a series of initiatives to engage RPFs in aquaculture activities, mostly artisanal trout production (*Oncorhynchus sp.*) in the

Altiplano basin[42]. Although of secondary importance, a few aquaculture development projects were also promoted in the Amazon basin by the central government's Regional Development Corporations[43] and bilateral cooperation agencies. In this period the first experimental research stations were set up: 'Pirahiba' (Cahapre, Cochabamba), 'El Prado' (Santa Cruz) and 'Minachi' (Yungas, La Paz). These extension projects' main priority was food security and they favoured the development of community-based fish farms around the extensive culture of exotic species (carp and tilapia), introduced by the FAO and USAID. Unfortunately there is little information available about the exact dimension and impact of these initiatives. No follow-up study was ever carried out and the central government's Development Corporations were absorbed by the regional governments (Prefecturas) with the passing of the 1995 Law of Decentralised Administration, reassigning the technicians that were involved in these projects to other units. The aquaculture station in Yungas, 'Centro de Servicios Integrados y Hatchery Minachi', was abandoned by the mid-1990s and has never been operative since. As already noted in the descriptive analysis of the BAAIS Research component, 'Pirahiba' and 'El Prado' continue to function as research and experimental centres under the administration of the state universities 'Gabriel René Moreno' in Santa Cruz and 'Mayor de San Simón' in Cochabamba.

Since the early 1990s, the regions of Yungas and Chapare (Cochabamba) have been targeted by pro-poor aquaculture development projects, a subsidiary strategy in Bolivia's Alternative Development programmes aimed at replacing the coca-cocaine economy with other crops (Brun and Camacho, 2003; Cabrera, 2004; Castañón et al., 2002; IAS, 2003; PDAR, 1994; Van Damme, 2001). More recently, the Departments of Santa Cruz and Beni have also benefited from aquaculture development and extension initiatives in Rurrenabaque, San Borja, San Ignacio de Moxos, Trinidad, San Julián and the provinces of Ichilo and Sara (Canal, 2003; Egüez et al., 2006; Pascual, 2005a; PRODISA-Belga, 2005; Sakamoto and Suárez, 2005; UTB, 2004, 2005; Viruez, 2005; Viruez and Lacoa, 2005).

Interviews with fish farmers, input and service providers, government and external assistance organisations identified 29 pro-poor aquaculture promotion and extension

[42] For further information see: www.fao.org/docrep/field/003/AC188S03.htm
[43] Corporaciones Regionales de Desarrollo Departamentales.

projects carried out in the Bolivian Amazon since the mid-1990s, 17 of which were still operative at the time of the interviews. However, in most cases these have been short-term initiatives providing funds for pond construction and/or training in fish farming. Few initiatives have taken a more 'sectoral approach', allowing for all aspects and stages of fish production, including access to fry, feed, information and output markets. It is estimated that these external-aid projects have spent a minimum of 3.5 million US$ in promoting aquaculture development in indigenous and campesino communities in the Amazon region of Bolivia. The table in Appendix 6 lists the 29 aquaculture projects and summarises their main characteristics, area of influence and sources of funding.

Although aquaculture began to develop in Beni a decade later than in the rest of the country, since 2000 Beni has become the target of numerous pro-poor aquaculture projects, involving NGOs, the Prefectura and the Autonomous University. This increase in aquaculture development initiatives in the region has been favoured by two factors: the establishment of the first operative hatchery in Beni, the Estación Piscícola Mausa, run by HOYAM, a Bolivian NGO (Hurtado, 2003; Pascual, 2005a) and the recent interest of the Prefectura and some municipal governments in supporting the sector. The most important projects in Beni in terms of scope and size include: VsF *Vétérinaires sans Frontiers* (between Rurrenabaque and Yucumo); HOYAM (Moxos and Cercado); SIBTA's Humid Tropics Foundation[44] (San Andrés and Trinidad) and the municipality of San Andrés (Marbán). However, local production of fry and fish feed has only been accomplished in Moxos. The hatchery built by VsF in Piedras Blancas has not been able to ensure a regular supply of fry and the Horeb hatchery built by PRODSIB in San Borja never became operative. Pro-poor aquaculture initiatives in the region generally favour the farming of native species such as pacú and tambaquí, but there are important differences in terms of the farming technologies and organisational systems being promoted, as well as their level of market integration.

In Santa Cruz pro-poor aquaculture extension initiatives have been fewer, despite the presence of the research centre 'El Prado', which has been producing native and exotic

[44] http://www.infoagro.gov.bo/sibta/sibta.htm

species for aquaculture since the 1990s. At the time of the interviews the Prefectura of Santa Cruz had no aquaculture or fisheries unit in operation and was not involved in any aquaculture development initiative. However, the municipalities of Comarapa and Pailón have recently shown an interest in supporting aquaculture development, while Belgium's bilateral cooperation programme *Desarrollo Rural Integral* in the provinces Ichilo and Sara, included aquaculture extension in campesino communities. Pro-poor aquaculture development initiatives in Santa Cruz have mostly pursued greater food security through the farming of exotic species, predominantly carp.

In the tropical regions of Cochabamba and La Paz some aquaculture projects had already been initiated in the early 1990s as a part of Alternative Development programmes. In both regions most pro-poor aquaculture development projects aimed to contribute to food security through community based farming of exotic species. Whilst ongoing projects in Yungas continue to have this approach, in Chapare aquaculture development has turned to family based farming of native species for the local and regional markets. Chapare has the largest and best equipped hatchery in the Bolivian Amazon, Pirahíba, one of the first to successfully reproduce tilapia and carp in captivity in the 1980s and tambaquí in the late 1990s. However, the tropical region of Cochabamba was, at the time of this study, importing large quantities of fish fry for aquaculture from Santa Cruz, suggesting that Pirahiba was unable to satisfy local demand. Yungas, on the other hand, has been without a source of fry since the mid 1990s when the Minachi experimental station was closed down. Nonetheless, a decade later a few initiatives to promote carp farming in rural communities reappeared (Castañón et al., 2002). However, the problem of the region's limited access to input markets and associated services has not been resolved; pro-poor aquaculture projects tend to focus exclusively on providing subsidies for pond construction and training in fish farming, whilst fry is imported from Santa Cruz, Beni or Tarija by those organisations responsible for project implementation. Several Evangelical churches are involved in this activity in and around Coroico and Caranavi.

4.7.3 Pro-poor Amazon aquaculture in Bolivia: lessons from the field

The majority of the 141 farmers who were participating in pro-poor aquaculture extension projects at the time of the interviews claimed to be 'satisfied' with the outcome. According to this group, the activity is beneficial as it provides a source of fish meat which is increasingly scarce and prohibitively expensive.

However, interviews with 108 ex-beneficiaries of aquaculture projects in Beni, Santa Cruz and the tropical regions of Cochabamba and La Paz revealed that in most cases withdrawal of external support led to the farmers giving up the activity. A close analysis of the experience of those who had abandoned aquaculture once external support had been withdrawn shows that the main reason for pulling out was the difficulty of accessing the necessary inputs, in particular fish fry. Sixty seven percent identified **limited access to inputs and information** as the main barrier to continue with the activity. In many cases rural aquaculture extension projects have imported fish fry from other regions, monitored the first production cycle and soon after withdrawn, without considering that input and output markets might be hundreds of kilometres away from the farmer's pond. Another problem identified by farmers has been the project staffs' lack of experience in Amazon aquaculture. **Lack of qualified personnel** is particularly marked in small and diversified NGOs and government agencies.

Examples of short-lived, pro-poor aquaculture development projects include the PRODESIB initiative in the Tsimané Indigenous Territory, which concluded in the year 2000; by 2005 none of the 40 ex-beneficiaries interviewed continued with the activity. PRODESIB built a hatchery in San Borja to supply the region with seed for aquaculture; however no species were ever reproduced successfully. Fish fry were imported from Brazil via a middleman in Trinidad who also worked as an external consultant to the project. Once project funds were withdrawn, fry stopped being imported, depriving the region of its only source of seed. Those farmers who were involved in the initiative also pointed out that fish farming infrastructures were deficient: small, shallow ponds that dried up during the dry season and cages built with poor materials. The Norwegian NGO, MAN-B and BIDECA, its Bolivian counterpart, were engaged in a small, fish farming project in Yungas from 2000 to 2003. Three years later, only 12% of the farmers who had benefited from the project to set up a fish pond were still involved in fish production. MAN-B and BIDECA did not set up a hatchery and fry was introduced mostly from Santa Cruz, so when support was withdrawn, once again, farmers' access to inputs and information became increasingly difficult. However, some producers managed to consolidate their activity due to the fact that Caranavi and Coroico have recently been targeted by several pro-poor aquaculture initiatives (Appendix 6), attracting a couple of fry and fish feed traders to the area.

Other attempts to develop aquaculture amongst indigenous and campesino communities have been somewhat more successful, particularly those that have stressed the need to ensure farmers' access to input and output markets via one or a combination of the following strategies: a) Targeting areas where the markets for inputs and associated services already exist; b) Setting up and/or strengthening local markets for aquaculture inputs and fish processing and marketing services in areas where these were not consolidated or c) Strengthening producer organisations so as to reduce individual farmers' transaction costs of accessing input and output markets. An example is the *Vétérinaires sans frontiers* project in Beni. Interviews with ex-beneficiaries of the fish farming project developed by the French NGO as part of the larger rural development scheme named after the Biosphere Reserve 'Pilón Lajas' seem to suggest that more farmers have managed to continue with the activity after support was withdrawn in 2001. About 30% of the ex-beneficiaries interviewed along the road that links Rurrenabaque and Yucumo were engaged in fish production at the time of the interview. VsF built a hatchery in the area, Piedras Blancas, where they successfully reproduced carp, tilapia and tambaquí. Once the project ended, the administration of Piedras Blancas was transferred to a local campesino family, who, despite limited training and experience, has managed to supply some of the neighbouring farmers with carp fry. The family has made great efforts to increase their stock of breeders and obtain a regular supply of tambaquí fry as they think local producers are very interested in tambaquí farming. However, all the fish farming production in the area depends on their success. Their failure would greatly jeopardize the activity of the local fish farmers.

The majority of the 249 RPFs interviewed (whether they were still active in fish farming or not) were interested in producing at least partially for the market[45]. They thought that projects should favour a more commercial approach to aquaculture development

[45] However, the production goals are very different in the indigenous communities of *Oriente* and the campesinos of *Occidente*. The campesino families tend to be more integrated in the market and give more priority to commercial fish production than the indigenous families.

and work with larger fish farming areas per household. The experience of Alternative Development programmes in Chapare and Yungas seems to conclude with the lesson that promoting subsistence fish farming aimed at increasing food security in rural areas is, by and large, ineffective; the costs of accessing the necessary inputs and services tends to be greater than the benefits extensive aquaculture can provide. For this reason, aquaculture development projects in the coca-growing region of Cochabamba, such as PRAEDAC, have shifted their approach towards more intensive, commercial forms of aquaculture. In Yungas, however, Alternative Development projects are still mainly built upon the premise of 'farming for food'.

Another recurring problem in most of the pro-poor aquaculture development projects examined is the organisational system put forward for managing fish farms. The majority of projects to date have favoured community based farming, due to the high costs of pond construction and the fact that in many cases existing common property water bodies are recycled for aquaculture. There are some cases where community based farming has been relatively successful, such as small communities in the *Mojeño Ignaciano* and *Multiétnico* indigenous territories in Beni, where most members belong to the same family group and/or there is an influential community leader. However, in many other cases community farming has been unsuccessful, particularly in campesino settlements in Yungas and Chapare. One of the main causes of project failure and farmers' withdrawal from aquaculture activities can be traced down to **organisational problems** in the managing of communal ponds. There are many reasons for organisational problems, but on the whole, they tend to increase with group size. Projects that have encouraged the formation of large groups, such as those of PRAEDAC in its initial stages, or the Prefectura of Beni in TIPNIS, have illustrated how joint management of fish ponds by thirty or forty families can require such Herculean efforts as to render them unworkable.

Indigenous and campesino producers manifested a clear **preference for native fish species** such as pacú and tambaquí, although in rural areas their fry is not always available. Tilapia is the least appreciated as there is little demand for its meat, and insufficient knowledge of how to farm this species has often led to low growth rates. A clear example is once again the coca-growing region of Cochabamba, Chapare, where after a decade of aquaculture development initiatives based upon tilapia farming, this species had been almost completely displaced by tambaquí in but a few years.

5 Pro-poor aquaculture technology development in indigenous territories

5.1 Introduction

In the previous chapter, Innovation Systems Theory was used to explore the different elements influencing the process of Amazon aquaculture development and diffusion at a national level and its relevance to poverty reduction. The following chapter turns to investigate the innovation process at the project and farm levels.

Focusing on fish farming initiatives being implemented in two Indigenous Territories in the province of Moxos, Beni, it attempts to address some of the research questions introduced in Chapter 2:

A. Does aquaculture represent a positive net addition to the livelihood portfolio of rural families and communities, and does its livelihood contribution vary according to the initial livelihood circumstances of its adopters? If so, what type of aquaculture technologies should be favoured and who should be targeted?

B. Does the organisation of production, broadly distinguished between individual, kinship-based, and communal alternatives affect the uptake, livelihood contribution and sustainability of aquaculture in the Bolivian Amazon setting?

As has already been discussed in Chapter 3, in order to inform the process of pro-poor technology development in Moxos and assess how appealing and accessible aquaculture might be to indigenous communities and families, the study draws on the concept of rural livelihoods, and the recognition that livelihoods are constructed from a portfolio of (sometimes competing) activities. In light of the evidence of increasing diversity in livelihoods in rural Amazonia and many other parts of the rural world (Barrett et al., 2001; Bryceson, 1996, 2000; Ellis, 2000, 2005, 2006; Ferreira and Lanjouw, 2001; Lanjouw and Lanjouw, 2001; Lanjouw, 2001; Ruben and Pender, 2004; Ruben and Van Den Berg, 2001; Steward, 2007; Sumberg et al., 2004), efforts to develop useful agricultural/NRM innovations for the rural poor will be faced by important challenges. Increasing attention must be given to the complex and changing realities of rural populations and how these affect farmers' interest in and access to innovations. Furthermore, matching technologies with potential end-users also requires a full understanding of what innovations entail. Debates about the contribution of a particular innovation for rural development are often fuelled by differing views about what the innovation involves. In the case of aquaculture, it is seen by some as an attractive money-making NRM innovation that requires relatively precise management, whilst others portray it as a robust low-input activity with a wide solution space suited for subsistence farming (see sections 2.1.4 and 4.7).

The Knowledge Engineering Approach to technology development (KEA) (Reece and Sumberg, 2003; Reece et al., 2003; Sumberg and Reece, 2004), which is used in this case study, focuses on both sides of the technology transfer equation: the realities of potential users on the one hand and the characteristics of proposed innovations on the other (see section 3.3). In the first place, aquaculture technologies being promoted and reinvented in the area are described in terms of 'benefits' associated with them and 'resources' required for adoption. Secondly, potential 'end-users' of aquaculture technologies in TIMI and TIM are described in terms of key aspects of their livelihoods and the wider context that will influence adoption: their interest in the potential benefits to be derived from aquaculture, access to the resources required for its adoption and the physical characteristics of their production environment. Once 'potential users' and technologies have been described in the light of benefits/resources it is possible to begin to evaluate the attractiveness and usefulness of fish farming as a pro-poor NRM innovation for the region.

The chapter is divided into six sections. Section 5.2 introduces the methods used for data collection and analysis. Section 5.3 provides the first comprehensive assessment of the technologies entailed in pacú and tambaquí farming in Moxos. For three major types of farming the 'benefits' they bring and the 'resources' required for their effective use are identified. Section 5.4 explores organizational aspects of aquaculture in the region and the different strategies used by the indigenous communities to organise and maintain fish farms, particularly the main challenges and opportunities of collective work. Section 5.5, focuses on the description of potential 'end-users' of aquaculture technologies in Moxos based on the analysis of a household livelihoods survey. The survey includes fish farmers and non-fish farmers to identify why some families decide to take up aquaculture or not, and identify people that tend to be excluded from the innovation process. Section 5.6 brings in the voices from the communities, allowing fish farmers and non-fish farmers to evaluate the experience with aquaculture in their own words.

The pro-poor aquaculture development programme in Moxos, which is the focus of this chapter, was set up in the early 2000s with the underlying rationale that fish farming could contribute to increase food security and rural incomes (see section 2.2.3). At the time of field work, 220 families in 24 communities in the Indigenous Territories TIMI and TIM were involved in initial stages of aquaculture activities. The Bolivian NGO HOYAM involved in aquaculture technology development and extension in these communities was at the same time running a hatchery and experimental farm in Moxos and producing fish feed locally. HOYAM was also involved in training fish farmers, providing economic support for the capital investment needed to build ponds or adapt existing ones, building up a local market of input supplies and opening up commercial channels for farmed fish.

5.2 Data collection & analysis

Aquaculture is a recent development in the Bolivian Amazon, particularly in Indigenous Territories. In the Department of Beni, the TIMI and TIM communities (Figure 5-1) were among the first to participate in aquaculture research and development projects and take up pacú farming. Their experiences offer an excellent opportunity, first, to identify the main challenges and opportunities of aquaculture as a pro-poor NRM innovation for the region and, second, to develop good practices that could help improve the intervention of extension organisations such as HOYAM and the growing number of pro-poor aquaculture development initiatives being implemented in the Bolivian Amazon (See Agropeces, 2004; Brun and Camacho, 2003; Canal, 2003, 2007; Castañón et al., 2002; Corcuy, 2005; Egüez et al., 2006; FDTA-JICA, 2003; Hartwich et al., 2007; IAS, 2003; Pascual, 2005a; PRODISA-Belga, 2005; Romero et al., 2003; Sakamoto and Suárez, 2005; SIBTA, 2006; UTB, 2004, 2005; Viruez, 2005; Viruez and Lacoa, 2005).

The analysis of pro-poor aquaculture development in Moxos draws from: 1) on-farm research carried out in the indigenous communities and in HOYAM's experimental centre and hatchery MAUSA; 2) semi-structured group interviews with fish farmers in TIMI and TIM and: 3) a livelihoods household survey and individual evaluation of aquaculture carried out among fish farmers, 'non-fish farmers' and 'ex-fish farmers' in the Indigenous Territories.

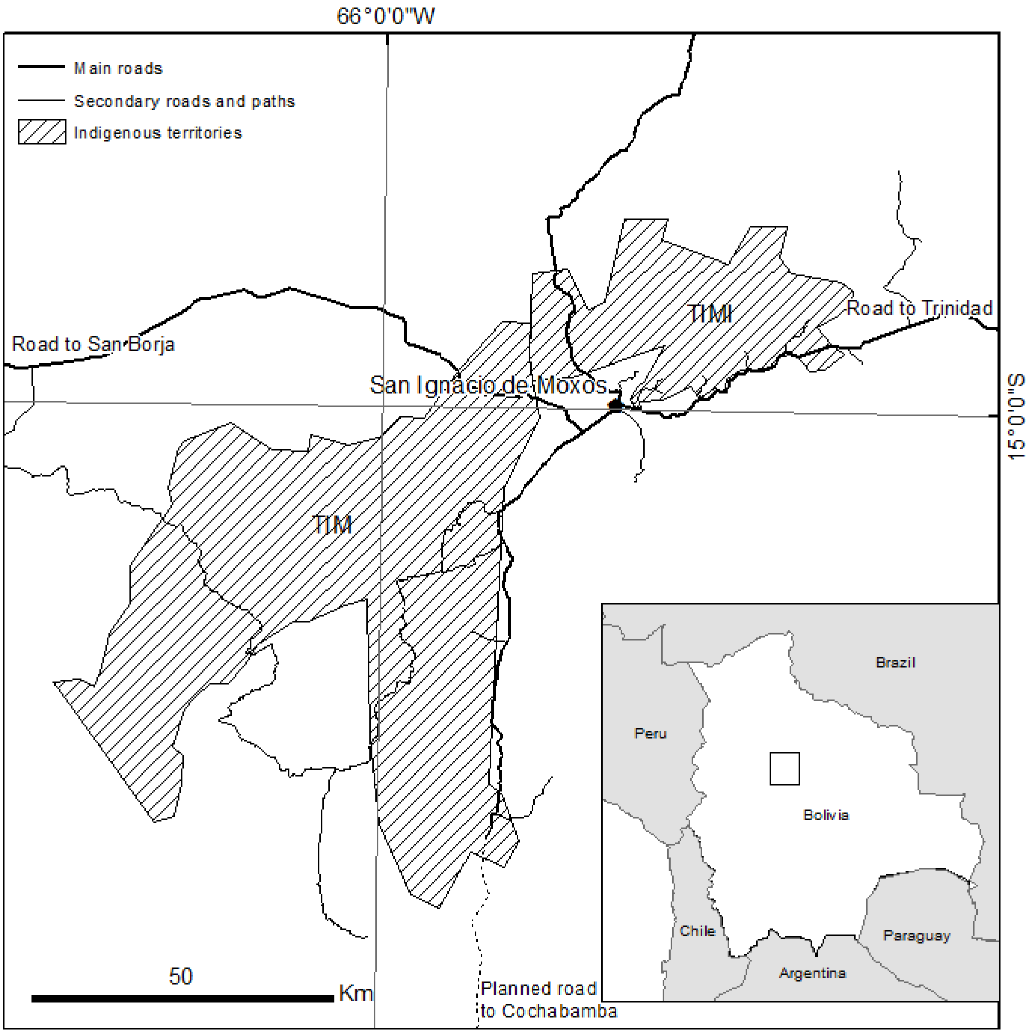


Figure 5-1 Indigenous Territories 'Mojeño Ignaciano' (TIMI) and 'Multiétnico' (TIM).
The location of the indigenous communities is shown in Appendix 7.

5.2.1 Defining technologies: on-farm & on-station research and semi-structured group interviews

On-farm research was carried out in the communities in TIM and TIMI involved in fish farming between 2003 and 2006. Aquaculture investments and harvests were recorded in 23 fish farming ponds throughout this period. Investments and harvests were also recorded in 5 experimental ponds in the research station and hatchery Mausa managed by HOYAM in San Ignacio de Moxos. The qualitative aspects of the innovation process, such as, the development of fish farming groups and how running the fish farming units affected women, non-fish farming families and communal institutions, were monitored by the author through regular visits to communities engaged in aquaculture throughout this period. Follow-up analysis of the innovation process was undertaken between June 2005 and January 2006, through household and group interviews with fish farmers and non-fish farmers.

In order to complement and triangulate the quantitative data produced by the on-going on-farm research, groups of fish farmers with a minimum of two years' experience were interviewed using a semi-structured format to help characterise the different types of aquaculture being practised in the area and to include the farmers' point of view. In total, 16 groups of fish farmers from 8 TIMI communities and 4 TIM communities were interviewed, involving 116 people (Table 5-1). A map of the communities of TIM and TIMI is presented in Appendix 7.

Table 5-1 Interviews with TIMI and TIM fish farmers

FISH FARMING GROUPS INTERVIEWED (Semi-structured group interviews. Questionnaire in appendix 1)			
TCO	**Community**	**No. Groups**	**No. Participants**
TIMI	Argentina	1	7
	Bella Brisa	1	8
	Bermeo	1	20
	El Buri	2	5
	Fátima	2	12
	Monte Grande Km. 5	2	9
	San Miguel del Mátire	1	12
	Villa Esperanza	1	6
TIM	Palmar Aguas Negras	1	2
	Retiro	1	9
	San José del Cavitu	1	14
	Santa Rosa del Apere	2	12
Total		**16**	**116**

Each interview took two to three hours and they were held at night so as not to interrupt the participants' working day. Importance was given to the participation of both the man and the woman from every household. The visit to each community lasted two days, giving the author time to chat informally about the experience with the families not involved in fish farming, the community authorities and those families who had been actively involved in fish farming, but who had given up this activity.

The full questionnaire in Spanish is presented in Appendix 4. The objectives of this group exercise were as follows:

a) To identify what motivated the farmers' initial decision to try out aquaculture. What were their objectives and expectations related to fish farming before they started? Which needs and/or opportunities did this decision respond to?

b) To complete the data collected by the on-farm research in the communities by including investments that were often not registered in the budget sheets during the follow-up process, such as the cost of labour. To help characterise the production system used in relation to inputs (farm or *chaco* products, money, labour, etc.), outputs (quantity/type of benefits obtained) and the organisational strategy used to carry out the work.
c) To record the fish farmers' evaluation of their experience and the results obtained, including those more subjective and unquantifiable elements that influenced their own motivation and the results and yields obtained. To assess whether these results measured up to their initial expectations (a)?
d) To identify the main problems encountered and reach a consensus on possible strategies to solve them.
e) To identify the fish farmers' objectives and expectations for the future.
f) To update a census of the community and differentiate fish farmers from non-fish farmers and ex-fish farmers in order to build up a stratified random sample for a second household livelihood survey aimed at defining 'end-users' in TIM and TIMI and uncover potential patterns in the innovation process.

5.2.2 Defining end-users and trends in the innovation process: livelihoods household survey

Between June 2005 and January 2006, a second set of interviews were carried out to help characterise the communities and families living in the indigenous territories, assess aquaculture's impact on livelihoods and identify trends in the innovation process. The livelihoods household survey involved a total of 131 families living in communities where aquaculture had been established for at least two years (Table 5-2). The survey included fish farming families (N=42), families that had started and then abandoned fish farming (N=37) and families that had never started fish farming (N=52). A stratified sample was taken to ensure that the three types of families were represented. The size of the sub-samples was fixed proportionally in relation to the size of each strata (proportional allocation).

Table 5-2 Stratified random sample of households interviewed in those communities in TIMI and TIM with fish production. (Livelihoods survey. Questionnaire in appendix 5)

	TIM+TIMI		TIM		TIMI	
SUB-SAMPLES	**No.**	%	No.	%	No.	%
(1) Families that never tried fish farming	**52**	39.7	26	52.0	26	32.1
(2) Families that tried fish farming and then gave up	**37**	28.2	12	24.0	25	30.9
(3) Established fish farming families	**42**	32.1	12	24.0	30	37.0
Total	**131**	100	50	100	81	100

The full questionnaire in Spanish is presented in Appendix 5. The Box 5-1 presents a summary in English of the main topics covered in the survey:

Box 5-1 Main topics in the livelihoods household (HH) survey

Section A: HH demography (Family members, roles, normal residence, schooling, seasonal/permanent migration)
Section B: Goods and savings (livestock and poultry, tools, HH utensils and other possessions, ownership of land outside the community, houses, bank savings, credits)
Section C: Social cohesion (HH involvement in group/communal productive activities, such as herding communal cattle or brick production, and perceptions about community life)
Section D: Size and sources of income (agricultural production, livestock and poultry production, hunting and timber and non-timber extraction, non-farm production, buying and selling of labour, remittances from migrants)
Section E: Livelihood changes and expectations
Section F: Evaluation of aquaculture in the community

In order to obtain a more representative sample of TIMI and TIM households and help characterise the indigenous territories, the livelihoods survey also included six communities that had not been exposed to the fish farming project and that differed in some important characteristic from most of the fish farming communities. For example, they were more isolated, or their production specialised in activities that were not shared by the majority of the other communities, such as timber extraction. Clearly, interviewees from these communities were not asked to complete section F of the HH survey (i.e. evaluation of aquaculture in the community).

The data generated by the HH livelihoods survey was analysed using the *Statistical Package for the Social Sciences* (SPSS version 11). Table 5-3 shows the sample of families that took part in the survey. A total of 154 families were interviewed, representing 27% of all the families living in TIM and TIMI (for a map of the communities see Appendix 7.

Table 5-3 Sample of households interviewed in TIMI and TIM

HOUSEHOLDS INTERVIEWED IN TIMI and TIM (Livelihoods survey. Questionnaire in appendix 5)			
COMMUNITIES WITH FISH PRODUCTION			
TCO	**Community**	**No. of households in the community**	**No. of households interviewed**
TIMI	Argentina	44	12
	Bella Brisa	38	10
	Bermeo	44	14
	El Buri	20	9
	Fátima	50	12
	Monte Grande Km. 5	31	12
	San Miguel del Mátire	29	9
	Villa Esperanza	10	3
TIM	Palmar Aguas Negras	11	7
	Retiro	30	10
	San José del Cavitu	85	20
	Santa Rosa del Apere	53	13
Subtotal		*445*	*131*
COMMUNITIES WITHOUT FISH PRODUCTION			
TIMI	Algodonal	8	3
	Chanequere	16	3
	Flores Coloradas	10	4
TIM	San Pablo Cuverene	6	4
	Mercedes del Cavitu	20	3
	Monte Grande Apere	60	6
Subtotal		*120*	*23*
Total		**565**	**154**

5.3 Defining technologies: inputs and benefits of pacú farming in Moxos

This section describes the different types of fish farming technologies being developed and adopted in the Indigenous Territories in Moxos, in terms of their agricultural logic, associated benefits and inputs and time required for adoption. What do they really entail? How might they fit in with indigenous peoples' livelihoods and production environment?

All fish farming in Moxos to date is based on farming native species in rain fed earth ponds. The ponds tend to be approximately 2 meters deep and are stocked at relatively low densities: 0.40 to 0.66 fish/m^2. The farming cycle is annual, with a one month rest period in between harvesting and stocking. This period is used to prepare the pond for the new fingerlings. Lime ($CaOH_2$) and gypsum ($CaSO_4 \cdot 2H_2O$) are used to eliminate possible predators and increase water transparency by precipitating clay. Two main species are farmed: pacú (*Colossoma macropomum*) and tambaquí (*Piaractus brachypomus*). Pacú and tambaquí are fruit and seed eating omnivorous species and when farmed under the same conditions they have similar growth rates. In some ponds the main species was supplemented with a small quantity of sábalo (*Prochilodus nigricans*) or boga (*Schizodon sp.*). The farming process includes feeding the fish daily, monitoring their growth every few months and keeping the pond clean and free from predators. Some ponds are fertilised with cattle manure[46], usually those where supplementary feed is home-made and often poor in protein content.

However, the aquaculture technologies vary among the different communities and groups of producers, not only in relation to how experienced the farmers are and how they are organised (which is discussed in the next section), but also in relation to their objectives, the type and amount of supplementary feed used, where and if the production is sold, and, ultimately, the degree to which fish farming is integrated into other farm activities and/or the market.

Figure 5-2 Individual Household pond. San Ignacio de Moxos

Figure 5-3 Communal pond. Santa Rosa del Apere, TIM

The following section describes the types of aquaculture being practiced in the indigenous communities. Secondly, the farm budgets of the 28 fish ponds monitored are presented and discussed. The last section examines the financial feasibility of aquaculture in Moxos. The organisational aspects of aquaculture in Moxos are discussed in the next section.

[46] Fertilising the pond contributes to the proliferation of zooplankton that is filtered by the pacú and tambaquí, providing an important source of proteins.

5.3.1 Types of fish farming

A *grosso modo* three types of technologies can be differentiated in relation to the degree of reliance on the market and external inputs and the type of supplementary feed used, as feed is the main investment for TIM and TIMI fish farmers.

A. The Chaco System

This type of fish farming is integrated into other farm activities, ponds are fertilised with livestock dung and supplementary feed consists of products and sub products from the *chaco,* so its dependence on external inputs is small. The farmers normally use a mixture of yucca and plantain cooked with maize flour and rice as the basic supplementary diet. When available, a variety of fruits are added to the diet and producers may also add a small percentage of toasted flour of frijol, soy, or other *Leguminosae* to their home-made fish feed. However, many traditional crops, such as yucca, plantain and rice, have poor protein content so fish growth is relatively slow. The goals of the *Chaco* system are to diversify agricultural and livestock production, reduce risks (obtain greater food security) and to take advantage of synergies amongst different activities in order to make the whole farm more efficient. Assuming you have a water body suitable for aquaculture, this kind of fish farming does not require much investment in cash, but it does require products from the *chaco* and labour to prepare the supplementary feed. In order to produce home-made feed, the different ingredients have to be cooked or ground, mixed, made into pellets and dried (usually in the sun). The Chaco system is characteristic of those communities and/or families that are more isolated.

B. The Mixed System

Mixed systems are also integrated in other farming activities, but a higher per cent of the feed is bought in the form of commercial pellets and/or products that are rich in proteins (such as soya flour or cakes). In this study, Mixed systems include all those cases where “commercial feed” makes up more than 30% of the total. The commercial feed and/or the soya added to the home-made feed, provide the protein needed to ensure faster growth rates. In the Mixed system at least part of the fish harvested tends to be reserved for sale in order to recover the investment made to buy feed or soy. As the amount of home-made feed is reduced in favour of commercial feeds or soy flour, the investment in time and *chaco* products is also reduced, but cash investment increases. As protein rich ingredients are added to the feed, fish yields increase considerably. The Mixed system is characteristic of those communities and/or families with better access to the market and for whom generating cash income is an important objective of aquaculture.

C. The Commercial System

This type of fish farming is less integrated in other farming activities and relies almost exclusively on commercial feeds. Fish feed produced in the small plant in San Ignacio by HOYAM and the local association of indigenous fish farmers (*Asociación de Piscicultores Indígenas de Moxos*) is made up of soy (30%), maize (30%), rice bran (20%), rice germ (10%) and wheat (10%). The feed is pelletized and dried in an oven but it is not extruded. The amount of feed recommended per day is 3% of the pond's estimated fish biomass. Under the Commercial system growth rates are significantly higher and good sized fish can be produced for market in less time. A larger cash investment is required to buy fish feed in San Ignacio, but the investment is minimum in labour and *chaco* products. The main objective of this system is to sell fish, generate cash income and obtain a positive balance in terms of costs and returns.

5.3.2 Costs and returns of pacú farming

This section presents the farm budgets of aquaculture under the Chaco, Mixed and Commercial systems in Moxos, drawing from the group interviews with producers in 2005-2006 and the monitoring of the production process in 28 fish farming units between 2003 and 2006. The 28 units studied included 21 fish ponds in TIM and TIMI communities, 2 ponds in boarding schools in San Ignacio and 5 ponds in HOYAM's research centre *Estación Piscícola Mausa*. In terms of technologies used, 11 were managed using the *Chaco* system, 8 using the Mixed system and 9 the Commercial system (Table 5-4).

Table 5-4 Fish farming units studied (2003-2006).

CHACO SYSTEM (11)		MIXED SYSTEM (8)		COMMERCIAL SYSTEM (9)	
FAT1	Fátima I (2003/4)	**MGK1**	M.G. Km5 I (2004/5)	**EPM1**	EPM R1 (2003/4)
FAT2	Fátima II (2003/4)	**MGK2**	M.G. Km5 II (2004/5)	**EPM2**	EPM R2 (2003/4)
BB1	Bella Brisa (2003/4)	**FAT3**	Fátima I (2004/5)	**EPM3**	EPM C1 (2005/6)
BB2	Bella Brisa (2004/5)	**FAT4**	Fátima II (2004/5)	**EPM4**	EPM C3 (2005/6)
RTO1	Retiro v.1. (2003/4)	**MOY**	Moy SMM (2004/5)	**EPM5**	EPM C4 (2005/6)
RTO2	Retiro v.2. (2003/4)	**SJC2**	San José (2005/6)	**VILLA**	Villa Esp. (2004/5)
SRA1	Santa Rosa (2003/4)	**SAM**	Santa Anita (2005/6)	**FDV**	U. E. FdV (2004/5)
ARG1	Argentina I ((2003/4)	**MUS**	Museruna (2004/5)	**ARAJ**	Internado S.I. (2004/5)
ARG2	Argentina II (2003/4)			**ALG**	Algodonal (2005/6)
SJC1	San José (2004/5)				
SMM	San Miguel (2004/5)				

The sale price of fish varies with the size of the fish, the season and the year[47]. For the purpose of this study, a standardised price has been established to facilitate comparisons of the different fish farming systems. The price calculated for fresh, gutted fish sold at the production site is 1.7 US$/Kg, which is equivalent to the average price of fish sold in 2006, at the time of the interviews[48]. Similarly, labour was calculated at 2.75 US$/day, which is equivalent to the average wage earned by unskilled labourers in the local market in 2006. Finally, the value of the home-made feed used in the Chaco and mixed systems was calculated for each individual case based on the composition of the feed and the ingredients used and their price in the local market.

The 28 fish farm budgets under the Chaco, Mixed and Commercial systems are presented in Table 5-5, Table 5-6 and Table 5-7.

[47] The price of farmed fish has risen considerably in the local market. Whereas in 2003 it was sold at 1.25 US$/kg, in 2006 it was sold at 1.5 to 2 US$/kg.

[48] According to INFOPESCA's market study, the Moxos farmers should be able to sell fish at 1.81 US$/Kg at the production site, taking into account the price for fish in 2006 in the most important markets in the country and the profit margins of the intermediaries (Wiefels, 2006)

Table 5-5 Farm budget of pacú farming: the Chaco system. Average percentage home-made feed: 96; average percentage commercial feed: 4; average price of feed: 0.12 US$/kg; average feed conversion ratio: 4.4 : 1

Costs and returns per pond and year	Unit	FAT1	FAT2	BB1	BB2	RTO1	RTO2	SRA1	ARG1	ARG2	SJC1	SMM	Mean
Pond size	m^2	1,000	1,000	1,200	1,200	1,200	1,200	750	1,200	1,000	1,250	1,250	1,114
Pacú/tambaquí fingerlings	Unit	500	500	600	700	500	500	400	600	500	600	600	545
Boga/sábalo fingerlings	Unit	80	80	100	0	100	100	75	100	75	0	0	65
Death rate/theft (approximate value)	%	12	10	6	7	12	14	8	4	18	15	66	16
Harvested (gutted)	Kg	137.4	168.6	299.9	239.0	379.1	353.5	263.2	422.0	294.0	480.0	196.0	293.9
Home consumption	Kg	107.4	128.6	99.9	35.0	79.1	33.5	53.2	280.0	115.0	75.0	40.0	95.2
Sold	Kg	30.0	40.0	200.0	204.0	300.0	320.0	210.0	142.0	179.0	405.0	156.0	198.7
Returns (Sale price 1.7 US$/Kg gutted)	US$	233.6	286.6	509.8	406.3	644.5	601.0	447.4	717.4	499.8	816.0	333.2	499.6
Water treatment (0.225 US$/Kg lime)	US$	0.0	0.0	54.0	54.0	54.0	54.0	33.8	54.0	45.0	70.3	70.3	44.5
Fingerlings (0.0875 – 0.0625 US$/u)	US$	43.8	43.8	52.5	61.3	43.8	43.8	35.0	52.5	43.8	52.5	52.5	47.8
Organic fertilizer (cow dung 12.5 US$/ton)	US$	1.3	1.3	0.0	0.0	2.3	2.3	1.9	1.3	0.0	1.9	1.9	1.3
Supplementary feed	Kg	324	38	1,995	1,962	1,308	1,308	1,255	2,111	1,715	1,538	338	1,294
Supplementary feed	US$	41.1	49.1	209.2	228.4	177.4	177.4	159.8	237.9	214.0	227.0	45.3	160.6
Cash Costs (CC)	US$	86.2	94.2	315.7	343.7	277.5	277.5	230.5	345.7	302.8	351.7	170.0	254.1
Net returns (after CC)	US$	147.4	192.4	194.1	62.6	367.0	323.5	216.9	371.7	197.0	464.3	163.2	245.5
Labour Costs (LC) (2.75 US$/day)	US$	112.8	129.3	237.3	234.3	275.3	275.3	256.6	357.2	297.6	327.0	110.8	237.6
Net returns (after CC and LC)	US$	34.6	63.1	-43.2	-171.7	91.7	48.1	-39.7	14.5	-100.6	137.3	52.4	7.9
Costs and returns per Ha, Kg and day	**Unit**	**FAT1**	**FAT2**	**BB1**	**BB2**	**RTO1**	**RTO2**	**SRA1**	**ARG1**	**ARG2**	**SJC1**	**SMM**	**Mean**
Production (ton gutted fish/hectare)	T/Ha	1.37	1.69	2.50	1.99	3.16	2.95	3.51	3.52	2.94	3.84	1.57	2.64
Returns per hectare	US$/Ha	2,336	2,866	4,249	3,386	5,371	5,008	5,966	5,978	4,998	6,528	2,666	4,486
Cash costs (CC) per hectare	US$/Ha	862	942	2,631	2,864	2,313	2,313	3,073	2,881	3,028	2,814	1,360	2,280
Labour costs (LC) per hectare	US$/Ha	1,128	1,293	1,978	1,953	2,294	2,294	3,421	2,977	2,976	2,616	886	2,165
Net returns per hectare (after CC)	US$/Ha	**1,474**	**1,924**	**1,618**	**522**	**3,058**	**2,695**	**2,893**	**3,098**	**1,970**	**3,714**	**1,306**	**2,206**
Net returns per kilo (after CC)	US$/Kg	1.07	1.14	0.65	0.26	0.97	0.91	0.82	0.88	0.67	0.97	0.83	0.83
Net returns per hectare (after CC & LC)	US$/Ha	**346**	**631**	**-360**	**-1,431**	**764**	**401**	**-529**	**121**	**-1,006**	**1,098**	**419**	**41**
Net returns per kilo (after CC and LC)	US$/Kg	0.25	0.37	-0.14	-0.72	0.24	0.14	-0.15	0.03	-0.34	0.29	0.27	0.02
Value of labour in fish farming	US$/day	**3.59**	**4.09**	**2.25**	**0.73**	**3.67**	**3.23**	**2.32**	**2.86**	**1.82**	**3.90**	**4.05**	**2.96**

Table 5-6 Farm budget of pacú farming: the Mixed system. Average percentage home-made feed: 62; average percentage commercial feed: 38; average price of feed: 0.18 US$/kg; average feed conversion ratio 3.0 : 1

Costs and returns per pond and year	Unit	MGK1	MGK2	FAT3	FAT4	MOY	SJC2	SAM	MUS	Mean
Pond size	m²	1,150	1,150	1,250	580	300	2,500	1,250	1,400	1,197
Pacú/tambaquí fingerlings	Unit	500	500	700	400	180	1510	650	700	643
Death rate/theft (approximate value)	%	24	3	29	38	3	7	12	1	15
Harvested (gutted)	Kg	340.0	549.0	355.0	184.0	170.0	1,144.0	526.0	544.3	476.5
Home consumption	Kg	80.0	48.0	100.0	150.2	34.0	300.0	20.0	51.3	97.9
Sold	Kg	260.0	501.0	255.0	33.8	136.0	844.0	506.0	493.0	378.6
Returns (sale price 1.7 US$/Kg gutted)	US$	578.0	933.3	603.5	312.8	289.0	1,944.8	894.2	925.3	810.1
Water treatment (0.225 US$/Kg lime)	US$	56.3	56.3	45.0	32.6	16.9	140.6	70.3	78.8	62.1
Fingerlings (0.0875 – 0.0625 US$/u)	US$	43.8	43.8	61.3	35.0	15.8	132.1	56.9	61.3	56.3
Organic fertilizer (cow dung 12.5US$/ton)	US$	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Supplementary feed	Kg	766	1,690	614	323	500	5,124	841	1,705	1,445
Supplementary feed	US$	151.3	273.5	104.9	59.2	92.3	864.8	180.3	371.8	262.3
Cash Cost (CC)	US$	251.4	375.9	211.2	126.8	125.0	1137.5	307.5	511.9	380.9
Net returns (after CC)	US$	326.6	557.4	392.3	186.0	164.0	807.3	586.7	413.4	429.2
Labour Costs (LC) (2.75 US$/day)	US$	166.9	249.4	149.9	110.6	92.7	618.8	187.0	272.3	231.0
Net returns (after CC+LC)	US$	159.7	308.0	242.4	75.4	71.3	188.5	399.7	141.1	198.3
Costs and returns per Ha, Kg and day of work	**Unit**	**MGK1**	**MGK2**	**FAT3**	**FAT4**	**MOY**	**SJC2**	**SAM**	**MUS**	**Mean**
Production (ton gutted fish/hectare)	T/Ha	2.96	4.77	2.84	3.17	5.67	4.58	4.21	3.89	4.01
Returns per hectare	US$/Ha	5,026	8,116	4,828	5,393	9,633	7,779	7,154	6,609	6,817
Cash costs (CC) per hectare	US$/Ha	2,186	3,269	1,690	2,186	4,167	4,550	2,460	3,656	3,020
Labour costs (LC) per hectare	US$/Ha	1,451	2,169	1,199	1,907	3,090	2,475	1,496	1,945	1,967
Net returns per hectare (after CC)	**US$/Ha**	**2,840**	**4,847**	**3,138**	**3,207**	**5,467**	**3,229**	**4,694**	**2,953**	**3,797**
Net returns per kilo (after CC)	US$/Kg	0.96	1.02	1.11	1.01	0.96	0.71	1.12	0.76	0.95
Net returns per hectare (after CC and LC)	**US$/Ha**	**1,389**	**2,678**	**1,939**	**1,300**	**2,377**	**754**	**3,198**	**1,008**	**1,830**
Net returns per kilo (after CC and LC)	US$/Kg	0.47	0.56	0.68	0.41	0.42	0.16	0.76	0.26	0.47
Value of labour in fish farming	US$/day	**5.38**	**6.15**	**7.20**	**4.62**	**4.87**	**3.59**	**8.63**	**4.18**	**5.58**

Table 5-7 Farm budget of pacú farming: the Commercial system. Average percentage home-made feed: 0; average percentage commercial feed: 100; average price of feed: 0.28 US$/kg; average feed conversion ratio 2.3 : 1

Costs and returns per pond and year	Unit	EPM1	EPM2	EPM3	EPM4	EPM5	VILLA	FDV	ARAJ	ALG	Mean
Pond size	m^2	600	600	3,200	2,072	1,875	2,500	1,000	2,300	1,250	1,711
Pacú/tambaquí fingerlings	Unit	400	350	1,600	1,413	1,250	1,200	550	1,150	650	951
Death rate/theft (aproximate value)	%	2	3	2	0	18	33	26	30	23	15
Harvested (gutted)	Kg	341.0	257.0	1,250.1	1,158.7	1,026.1	770.0	330.3	560.0	381.0	674.9
Home consumption	Kg	0.0	0.0	0.0	0.0	0.0	20.0	20.0	95.0	30.0	18.3
Sold	Kg	341.0	257.0	1,250.1	1,158.7	1,026.1	750.0	310.3	465.0	351.0	656.6
Returns (sale price 1.7US$/Kg)	US$	579.7	436.9	2,125.2	1,969.8	1,744.4	1,309.0	561.5	952.0	647.7	1,147.4
Water treatment (0.225 US$/ Kg lime)	US$	45.0	0.0	94.5	90.0	99.0	72.0	45.0	168.8	56.3	74.5
Water treatment (0.075 US$/Kg calcium sulphate)	US$	0.0	0.0	27.0	22.5	27.0	0.0	0.0	0.0	2.8	8.8
Fingerlings (0.0875 – 0.0625 US$/u)	US$	35.0	30.6	100.0	88.3	78.1	105.0	48.1	100.6	56.9	71.4
Organic fertilizer (cow dung 12.5US$/T)	US$	3.8	3.8	0.0	0.0	0.0	0.0	1.8	3.0	3.0	1.7
Supplementary feed	Kg	989	611	2,793	2,793	2,795	1,426	828	966	635	1,537
Supplementary feed	US$	126.8	78.3	904.3	834.8	835.6	387.5	225.0	262.5	182.3	426.3
Cash costs	US$	210.6	1,12.7	1,125.8	1,035.6	1,039.7	564.5	319.9	534.9	301.3	641.5
Net returns (after cash costs)	US$	369.1	324.2	999.4	934.2	704.7	744.5	241.6	417.1	346.4	564.6
Labour (2.75 US$/day)	US$	72.9	70.1	220.3	273.9	254.7	139.6	103.8	145.8	118.3	155.5
Net returns (after total costs)	US$	296.2	254.1	779.1	660.3	450.0	604.9	137.8	271.3	228.1	409.1
Costs and returns per Ha, Kg and day of work	**Unit**	**EPM1**	**EPM2**	**EPM3**	**EPM4**	**EPM5**	**VILLA**	**FDV**	**ARAJ**	**ALG**	**Mean**
Production (ton gutted fish/hectare)	T/Ha	5.68	4.28	3.91	5.59	5.47	3.08	3.30	2.43	3.05	4.09
Returns per hectare	US$/Ha	9,662	7,282	6,641	9,507	9,303	5,236	5,615	4,139	5,182	6,952
Cash costs (CC) per hectare	US$/Ha	3,510	1,878	3,518	4,998	5,545	2,258	3,199	2,326	2,410	3,294
Labour costs (LC) per hectare	US$/Ha	1,215	1,168	688	1,322	1,358	558	1,038	634	946	992
Net returns per hectare (after CC)	**US$/Ha**	**6,152**	**5,403**	**3,123**	**4,509**	**3,758**	**2,978**	**2,416**	**1,813**	**2,771**	**3,658**
Net returns per kilo (after CC)	US$/Kg	1.08	1.26	0.80	0.81	0.69	0.97	0.73	0.74	0.91	0.89
Net returns per hectare (after CC and LC)	**US$/Ha**	**4,937**	**4,235**	**2,435**	**3,187**	**2,400**	**2,420**	**1,378**	**1,180**	**1,825**	**2,666**
Net returns per kilo (after CC and LC)	US$/Kg	0.87	0.99	0.62	0.57	0.44	0.79	0.42	0.48	0.60	0.64
Value of labour in fish farming	US$/day	**13.92**	**12.72**	**12.48**	**9.38**	**7.61**	**14.67**	**6.40**	**7.87**	**8.05**	**10.34**

Table 5-8 sums up the costs and returns of pacú farming in Moxos under the Chaco, Mixed and Commercial systems, assuming that there already was a suitable pond for farming in all cases and that no credit was needed to access inputs. The data includes the average values for each system as well as the results for the ponds with the best and worst performance in terms of net returns after cash costs and labour costs per hectare.

Table 5-8 Costs and returns of pacú farming under the Chaco, Mixed and Commercial systems. (Assuming existence of suitable pond for farming and no credit needed to access inputs)

CHACO SYSTEM	Unit	**Worst (BB2)**	**Average**	**Best (SJC1)**
Production per Hectare	T/Ha	1.99	2.64	3.84
Returns per Hectare	US$/Ha	3,386	4,486	6,528
Cash Costs (CC) per hectare	US$/Ha	2,864	2,280	2,814
Labour Costs (LC) per Hectare	US$/Ha	1,953	2,165	2,616
CC+LC per Hectare	US$/Ha	4,817	4,445	5,430
Net returns (after CC) per hectare	US$/Ha	522	2,206	3,714
Net returns (after CC) per kilo gutted fish	US$/Kg	0.26	0.83	0.97
Net returns (after CC + LC) per hectare	US$/Ha	-1,431	41	1,098
Net returns (after CC + LC) per kilo gutted fish	US$/Kg	-0.72	0.02	0.29
Value of labour in fish farming	**US$/day**	**0.73**	**2.96**	**3.90**
MIXED SYSTEM	Unit	**Worst (SJC2)**	**Average**	**Best (SAM)**
Production per Hectare	T/Ha	4.58	4.01	4.21
Returns per Hectare	US$/Ha	7,779	6,817	7,154
Cash Costs (CC) per hectare	US$/Ha	4,550	3,020	2,460
Labour Costs (LC) per Hectare	US$/Ha	2,475	1,967	1,496
CC+LC per Hectare	US$/Ha	7,025	4,987	3,956
Net returns (after CC) per hectare	US$/Ha	3,229	3,797	4,694
Net returns (after CC) per kilo gutted fish	US$/Kg	0.71	0.95	1.12
Net returns (after CC + LC) per hectare	US$/Ha	754	1,830	3,198
Net returns (after CC + LC) per kilo gutted fish	US$/Kg	0.16	0.47	0.76
Value of labour in fish farming	**US$/day**	**3.59**	**5.58**	**8.63**
COMMERCIAL SYSTEM	Unit	**Worst (FDV)**	**Average**	**Best (EPM1)**
Production per Hectare	T/Ha	3.30	4.09	5.68
Returns per Hectare	US$/Ha	5,615	6,952	9,662
Cash Costs (CC) per hectare	US$/Ha	3,199	3,294	3,510
Labour Costs (LC) per Hectare	US$/Ha	1,038	992	1,215
CC+LC per Hectare	US$/Ha	4,237	4,286	4,725
Net returns (after CC) per hectare	US$/Ha	2,416	3,658	6,152
Net returns (after CC) per kilo gutted fish	US$/Kg	0.73	0.89	1.08
Net returns (after CC + LC) per hectare	US$/Ha	1,378	2,666	4,937
Net returns (after CC + LC) per kilo gutted fish	US$/Kg	0.42	0.64	0.87
Value of labour in fish farming	**US$/day**	**6.40**	**10.34**	**13.92**

The farm budgets for the different types of farming practiced in Moxos highlight the differences which exist in terms of inputs required (in time, *chaco* products, cash, access to markets and commercial feed) and benefits generated (in terms of contributions to food security and/or increased cash income).

Home-made fish feed might appear to be an attractive option for those communities that are far from the San Ignacio and Trinidad markets, have limited access to commercial feed and are primarily interested in aquaculture as a means to improve food security. In Moxos, the average value of a day's labour in fish farming using the *Chaco* system (2.96 US$/day) is similar to what can be earned on a cattle ranch or in a timber mill (2.75 US$/day). But, it has the added advantage of being a 'part time' activity that can be combined with the other agricultural or livestock activities without leaving the community. However, under the *Chaco* system, fish yields per hectare are generally low, because home-made feed is often deficient in quantity and quality. Once the cash costs of preparing the pond, buying fingerlings and preparing the feed using chaco products have been subtracted, the net returns (after cash costs) are approximately 2,200 US$ per hectare and 0.83 US$ per kilo of gutted fish. In practice, fish harvested at the end of the production cycle are often smaller than what the local and regional markets demand and hence would be difficult to sell for a good price.

In addition to access to input/output markets for aquaculture and cash, one of the main differences between the *Chaco* system and the Mixed system compared to the Commercial one is the amount of time required to prepare supplementary feed (Table 5-9). Contrary to what one might think, low external-input systems are the most labour and information intensive. They require experience and know-how in order to be able to produce an inexpensive but successful and balanced home-made feed that will not disintegrate or precipitate immediately when thrown into the water, accumulating at the bottom and reducing oxygen availability (Figure 5-4 shows fish farmers in two TIMI communities preparing home-made feed).

Figure 5-4 Home-made supplementary fish feed production in Fátima (a, b) and San Miguel (c). Some of the farm products such as maize, rice, yucca and plantain are cooked or ground, mixed, pelletized and sun dried.

The following Table 5-9 sums up the average amount of time invested in managing a pond of 1,500 m^2 under the Chaco, Mixed and Commercial systems for an 11 month cycle.

Table 5-9 Labour invested in fish farming in Moxos

Average labour invested to manage a 1,500 m² **pond** (11 month cycle)	**Average number of days laboured**		
	Chaco	**Mixed**	**Commercial**
Pond cleaning and treatment (lime)	2.8	4.1	4.4
Preparation of supplementary feed*	84.5	53.5	0.0
Feeding	22	29.4	30.2
Sampling	5.6	7.3	7.8
Pond maintenance	3.0	5.7	6.5
Harvesting and gutting	3.0	5.1	5.2
TOTAL	120.9	105.1	54.1
***Hours worked for *quintal* (46 kg) of supplementary feed produced**	**18.8**	**15.0**	**0.0**
Kilos of gutted fish (average for 1,500 m²)	372.5	524.0	613.4
Days worked/kg gutted fish	**0.3060**	**0.1803**	**0.0882**

Whereas the *Commercial* fish farming system only invests on average 0.088 days of work for every kilo of fish harvested and gutted, the *Chaco* system invests as much as 0.306 days/kg. Therefore, under the *Chaco* system, if imputed labour is taken into account net returns are close to zero. “Net returns (after total costs)” refers to the profit generated by the activity after having subtracted imputed family labour.

But as can be seen in Table 5-5 and Table 5-8, under the Chaco system there is great variability in the returns obtained by different farmers and communities. The success of fish farming under the *Chaco* system depends to a great extent on the quality of the home-made feed used. The quality of the feed varies in relation to the producer's experience and access to high protein crops, such as soya and frijol. As it is a new activity, the communities have not yet built up enough experience or know-how. Nevertheless, some of the first trials have been quite successful. Some communities, such as Retiro and San José del Cavitu, have managed to produce 3 to 4 tons/hectare, most of which was sold, and net returns (after total costs) were 0.25 US$/kg. In these communities, the value of a day's labour producing fish with home-made feed is 4 US$, considerably more than what they would earn by selling their labour. However, this is not the norm, as *Chaco* system yields are often low and the harvested fish too small to ensure a good sale price. In some cases the time and skills required might not be justified if the end result is limited to fish for household consumption, particularly if the farmer has other sources of animal protein such as hunting, fishing or raising fowl. Furthermore, under the *Chaco* system the potential for growth is limited, as the surface area that a household can manage will be always conditioned by the amount of labour that the household can provide, not to mention the amount of agricultural products that they are able to allocate to the fish and the size of their *chaco*.

Under the *Mixed* system of fish farming, the families who combine *Chaco* products with commercial feed, or who buy raw materials, such as soya cake, to improve the protein balance in their home-made feed, obtain much higher yields. Average yields are around 4 tons/hectare and returns (after cash costs) reach 3,797 US$/ha, which is even higher than under the *Commercial* fish farming system, as the feed costs are lower. However, the *Mixed* system saves in the cost of feed by investing more time in its preparation. By buying part of the fish feed or raw materials in the form of flours, the feed preparation is less labour intensive than in the *Chaco* system, but the time spent is still considerable: 0.180 days/Kg compared with 0.088 days/Kg in the *Commercial* system. If imputed labour is added to the farm budget, net returns (after cash costs and labour costs) are 1,830 US$/ha and 0.47 US$/Kg of gutted fish. Thus, in fish farming based on the *Mixed* system, the value of a day's labour is 5.58 US$, about twice the value of labour in the local market.

Fish farming with commercial feed is definitely the most successful system from the point of view of net returns once the producer's investment in time has been accounted for. The fish reach commercial size in less time and with minimum imputed labour. However, to be able to use this system the families need to have access to commercial feed throughout the farming cycle and to have the cash to buy it. The net returns (after total costs) for the *Commercial* system are 2,666 US$/ha and 0.64 US$/Kg of gutted fish. The value of a day's labour reaches 10.34 US$, nearly four times higher than the value of labour in the local market.

Table 5-10 summarises the different types of technologies being developed in terms of associated benefits; required inputs and agricultural logic (see Reece *et al.*, 2003). The different benefits and resources associated with each technology are defined using a descriptive scale. Technologies are also described in terms of the production context for which they would be appropriate, or using the terminology of Reece *et al.* (2003), their agricultural logic. A strong logic of intensification can be created by push and/or pull factors: pressure on resources and/or increased market access. In the absence of push or pull factors there will be little logic for intensification.

Table 5-10 Defining aquaculture technologies: associated benefits, required inputs and agricultural logic (Adapted from Reece *et al.* 2003). In parenthesis the values of different benefits and inputs associated with technology type using a descriptive 6 point scale: 0=none, 6=a lot

Technology	Associated benefits	Required resources	Agricultural logic
Chaco system	- Reduced reliance external inputs (4) - Increased food security (4) - Increased cash income (1) - Increased pond productivity (2) - Increased labour productivity (0) - Improved produce quality/size (2)	- Labour (6) - Technical information (5) - Access input/output markets (2) - Access cash or credit (3)	Weak-intermediate intensification
Mixed system	- Reduced reliance external inputs (3) - Increased food security (2) - Increased cash income (3) - Increased pond productivity (4) - Increased labour productivity (4) - Improved produce quality/size (4)	- Labour (5) - Technical information (4) - Access input/output markets (5) - Access cash or credit (5)	intermediate intensification
Commercial system	- Reduced reliance external inputs (0) - Increased food security (1) - Increased cash income (5) - Increased pond productivity (5) - Increased labour productivity (6) - Improved produce quality/size (5)	- Labour (2) - Technical information (3) - Access input/output markets (6) - Access cash or credit (6)	Intermediate-strong intensification

In sum, the Chaco system is more appropriate for a production context with weak-intermediate logic of intensification; it reduces reliance on external inputs and can contribute to HH food security but is information and labour intensive. The Mixed and

Commercial systems require greater access to markets and capital, and are more suitable for production environments with a stronger logic of intensification. The Mixed system increases pond and labour productivity whilst still limiting dependence on external inputs. However, requirements in time and knowhow remain relatively high. The Commercial system requires capital and a reliable access to external inputs, but is substantially less demanding in time and know-how and can represent an important source of cash income.

The Mixed and Commercial systems have significant growth potential, but how feasible are they in communities without fish ponds where the capital investment can only be acquired through credit? The following section examines the financial feasibility of aquaculture in Moxos under the Mixed and Commercial systems.

5.3.3 Financial feasibility of pacú farming

Fish farming requires a big capital investment to build and/or adapt ponds. However, 40% of the producers starting this activity in lowland Bolivia take advantage of existing water bodies, such as semi-natural lagoons or reservoirs, which reduces the initial outlay considerably. A quarter of the farmers build their own ponds with their own farming equipment. Only 30% hire a tractor or a caterpillar excavator to dig their ponds (see input/output markets in the analysis of BAAIS in section 4.4.5). In the Moxos aquaculture development project, existing water bodies were used for fish farming, but the project includes the possibility of building new ponds in communities where there are none, or where producers want to expand the farming area.

In this analysis of the financial feasibility of the *Mixed* and *Commercial* fish farming systems the costs of building a hectare of ponds by farmers using their own machinery are compared with the costs using a rented tractor and trailer. In Moxos, building costs for farmers with their own tractor and trailer is 0.4 US$/m^3 of pond[49] and if the service is rented 0.8 US$/m^3. Capital investment in this analysis also includes fencing the pond and buying a fishnet (Table 5-11).

Maintenance costs include changing the water in the pond every five years, mending the fence and replacing the fishnet (Table 5-12).

[49] A pond measuring 25m x 50m x 2m can be built in 100 hours. The cost of using a tractor is 12 US$ an hour, half of which, 6 US$, goes on operational costs (driver, diesel, oil, filters) and the rest is the calculated cost of wear and tear on a tractor working for five years, 8 months a year, 24 days a month, 8 hours a day. The cost of renting a tractor is 25 US$ an hour.

Table 5-11 Capital investment for a 1 hectare fish farm in Moxos.

CAPITAL INVESTMENT PER HECTARE	Unit	US$/Unit	Quantity	Total US$
Pond construction WITH OWN TRACTOR	m^3	0.40	20,000	8,000
Fencing pond	m	0.54	1,250	675
Fishnet	unit	275	1	275
Total				**8,950**
Pond construction WITH A RENTED TRACTOR	m^3	0.80	20,000	16,000
Fencing pond	m	0.54	1,250	675
Fishnet	unit	275	1	275
Total				**16,950**

Table 5-12 Maintenance costs for a 1 hectare fish farm in Moxos

MAINTENANCE COSTS PER HECTARE	US$/Year
Pond maintenance (changing water every 5 years)	100
Fence maintenance	135
Fishnet replacement	55
Total	**290**

Table 5-13 compares the hypothetical payback periods needed to recover capital investment under the Mixed and Commercial systems.

Table 5-13 Payback periods for the Mixed and Commercial systems

MIXED SYSTEM	Unit	Worst	Average	Best
Returns per hectare and year	US$/Ha/yr	7,779	6,817	7,154
Total costs per hectare (CC + LC + Maintenance)	US$/Ha/yr	7,315	5,277	4,246
Net returns after total costs	US$/Ha/yr	464	1,540	2,908
Payback period (OWN TRACTOR)	**years**	**19.29**	**5.80**	**3.07**
Payback period (RENTED TRACTOR)	**years**	**36.53**	**11.01**	**5.83**

COMMERCIAL SYSTEM	Unit	Worst	Average	Best
Returns	US$/Ha/yr	5,615	6,952	9,662
Total costs per hectare (CC + LC + Maintenance)	US$/Ha/yr	4,527	4,576	5,015
Net returns after total costs	US$/Ha/yr	1,088	2,376	4,647
Payback period (OWN TRACTOR)	**years**	**8.23**	**3.77**	**1.93**
Payback period (RENTED TRACTOR)	**years**	**15.58**	**7.13**	**3.65**

Table 5-14 below shows the **annual payment** the producer would have to make to the bank or credit institution if a ten year loan was taken out to set up a 1 hectare fish farm in Moxos. Real interest rates are considered (i.e. the nominal interest rate minus inflation). The last column shows the annual payment for a 10 year bank loan at an 8% real interest rate, which was the interest rate normally applied for commercial loans in Bolivia in 2006 (BCB, 2006). Inflation in 2006 was 4.4% (INE, 2006).

Table 5-14 Annual payments for a 10 year loan at different real interest rates.

Real interest rates	0%	1%	2%	3%	4%	5%	6%	7%	8%
Rented tractor	1,695	1,783	1,873	1,965	2,060	2,159	2,259	2,363	**2,469**
Own tractor	895	941	988	1,037	1,087	1,139	1,192	1,247	**1,303**

The comparison between the average net returns after total costs for the Mixed and Commercial systems (Table 5-8) and the annual payments (Table 5-14), shows that the financial feasibility of pacú farming will to a great extent depend on the credit conditions and on whether the producer or groups of producers own a tractor (or can access construction services at cost price). When looking at the average performance of all the fish farming units studied, it becomes clear that if the producer can access pond construction services at cost price then pacú farming under both the Mixed and Commercial systems is feasible under all loan conditions. If the producer was to build a one hectare fish farm with a rented tractor and trailer (and pay approximately double the estimated cost price), then pacú farming under the Commercial system would only be feasible if the producer secured a loan at a 7%, or less, real interest rate. If the producer was to build a one hectare fish farm with a rented tractor and manage it using a Mixed system then pacú farming would not be feasible under any circumstances.

It is important to note, however, that there is great variability in pond performance and that significant differences exist between the net returns obtained in different fish farming units managed under the same 'system'. The comparison between the 'worst' and the 'best' ponds in terms of net returns (Table 5-8) suggests that there is still much room for improving fish farming performance. Under the Mixed system the 'best' pond obtained more than 6 times the net returns per hectare obtained by the 'worst' pond. And under the Commercial system net returns obtained by the 'best' pond were about 4 times greater than those obtained by the 'worst' pond. In the case of the best managed ponds, both the Mixed and Commercial systems could afford a loan at an 8% real interest rate regardless of how the ponds were built. This suggests that (i) pacú farming in Moxos can be an attractive investment and that (ii) access to information and training in aquaculture is still very much needed in order to improve farmers' technical skills and ensure better results.

If a producer, or group of producers, had the capital to construct a hectare of ponds, they would probably consider buying, rather than renting, a tractor and trailer to dig the pond, with the option of selling the vehicles when the work was done. In order to encourage aquaculture with growth potential, priority should be given to developing a local market for fish feed and strengthening producers' associations to give them access to pond construction services at cost prices. Some associations are already working in this direction, for example, the San Juan de Yapacaní cooperative of producers in Santa Cruz (CAISY), which had acquired agricultural machinery to benefit all their associates.

Similarly, aquaculture could benefit noticeably by increasing producers' access to output markets and commercialisation channels. According to a recent INFOPESCA study of the market for fish in Bolivia (Wiefels, 2006), the profits for a fish farming business in Moxos could be bigger if producers were to have direct access to the Santa Cruz market. The sale price of fish in Santa Cruz city is more than double that of the local Moxos market. For the TIM and TIMI communities, the opening of new marketing channels could mean a significant rise in the sale price of farmed fish.

Finally, as with most entrepreneurial initiatives, the financial feasibility of aquaculture will be influenced by the banking system and credit conditions, and by farmers' access to government credit schemes and other private non-regulated financial institutions.

5.4 Defining technologies: organisational aspects of pacú farming in Moxos

In TIM and TIMI productive activities are usually organized around the household. However, group and community work still plays an important role in some communities, particularly in TIM, where 39% of the families take part in group activities, such as rotational systems of clearing and harvesting agricultural land, or the farming of communal cattle (see livelihoods in TIM and TIMI in section 5.5.1). When the TCO fish farming extension project was started, it focused on the communities and use was made of existing communal ponds. As the area available for fish farming in the communities increased, many of the farming groups split to create smaller work groups. The first ponds managed by individual households appeared in 2003 on the initiative of some enterprising families who built their own ponds.

5.4.1 Organisational systems for pond management in the communities

As was seen in the previous section, the labour and/or money needed to set up aquaculture varies considerably, depending on the type of farming. Nevertheless, all types of pacú farming in rain-fed ponds in Moxos include: preparing the pond for fingerlings, building a fence around the pond to keep out predators such as nutrias/coypus and caimans, preparing and/or purchasing fish feed, feeding the fish regularly and gutting and cleaning them at harvest time. In the TCOs, fish farmers use different organisational strategies.

Community fish farming

Community fish farming here means that the fish ponds belong to the community and all or most of the households who live permanently in the community participate in working the ponds and share the profits. The size of the communities vary, they can range from 5 or 6 up to 30 or 40 households. There are obvious advantages to community fish farming: the poorer households are able to participate and it is easier for producers to access the necessary inputs and distribution channels by pooling resources. In the literature of collective action it has also been suggested that promoting cooperation in one area, such as communal ponds, can help strengthen cooperation capacity in other spheres of community life (see Mearns, 1996). A good example of communal farming is Villa Esperanza, where, in three years, the community managed to set up nearly half a hectare of ponds and obtain higher yields than any other community.

However, the success of a community enterprise (be it aquaculture, low-impact logging or brick making) is conditioned by many factors, including the size of the community, the degree of cohesion amongst families, the presence of strong leaders etc. (Agrawal, 2001). Villa Esperanza is a small, united community and eight of the ten families are directly related. Furthermore, it is on the road from San Ignacio to Trinidad and from the beginning they were able to use commercial feed, which made the work much easier. With the growth of aquaculture in the TCOs, the general tendency has been towards smaller groups of fish farmers, rather than community fish farming.

Group fish farming

The most common organizational system for pond management in the TCOs is based on groups of five to ten households. A smaller group makes coordination amongst the partners easier. This is particularly important under the *Chaco* and Mixed systems, which require important organisational skills to develop a system that will guarantee an equitable input of farm products and labour among group members (see section 5.6.3). Furthermore, a smaller group also maintains many of the advantages of the community system, such as facilitating access to capital and the inputs needed to start fish farming by pooling resources.

Individual household fish farming

In TIM and TIMI most productive activities are organized around the household and in some TIMI communities where cooperative productive activities are not so common, some individual households are particularly interested in fish farming. However, individual household fish farming is limited because small scale producers find it very difficult to finance the capital investment needed to build or adapt ponds. At the time of the interviews, there were 29 TIM and TIMI households that had managed to build their own fish ponds and initiate fish farming.

5.4.2 Distribution of tasks

Fish farming requires buying and/or preparing supplementary feed for the fish, feeding them and pond control and maintenance. Men, women and children participate in these activities, but women tend to play a central role in the daily care of the ponds. The women's role is especially important in those communities that use the *Chaco* and/or Mixed system of fish farming, where home-made feed is used. In these communities it is usually the women who get together to prepare the feed and they are often in charge of the organization of the group and keeping the register of the contributions made by each partner. Even though it is unusual for women to hold "official" positions in the community, in the *Cabildo* or other communal institutions, it is not unusual for a woman to lead a group of fish farmers. In TIM and TIMI, 31% of the "technicians" chosen by the community to train as fish farmers, lead and represent a group of producers, are women.

5.4.3 Evolution of the fish farming groups

The success rate of communal or group enterprises varies in the different communities and territories and these differences have raised many questions about the institutional settings and social cohesion required for these types of initiatives to flourish.

Figure 5-5 Group of fish farmers from the community of Retiro, TIM. Association is often a requirement in order to access ponds and inputs.

Willingness to engage in collaborative behaviour can be seen in terms of the benefits and costs it will entail. As mentioned earlier, the benefits of group/community based farming are many. Costs, however, are also important. It has been highlighted that cooperation entails costs for *negotiating* collective agreements, and *monitoring* and *enforcing* the implementation of these agreements (Aggarwal, 2000). In fact, it will be peoples' perceptions of the benefits and costs associated with cooperation that will influence their decision (as opposed to the costs and benefits themselves)[50]. In light of limited knowledge about the potential material payoffs of collective activity, a person's internal values with regards to the group, such as 'sympathy' for its members, may be an important factor in shaping decisions (Cárdenas and Ostrom, 2004). This is particularly relevant to the case of aquaculture development in Moxos as many farmers lack information and understanding about what fish farming entails due to its recent introduction.

Organizational problems are the main reason why some communities and groups abandon fish farming (see section 5.6). Understanding how the farmers work and their group dynamics is essential in order to establish effective strategies. The following analysis is based on the behaviour and dynamics of fish farming groups who have

[50] Cárdenas and Ostrom (2004) stress the notion that peoples' decisions are influenced by different layers of information: their perception of the material benefits at stake (what can I gain?), the dynamics of the game (what are the rules?), the composition of the group (can members be trusted?) and internal values (how do I feel about other members?).

completed two or more farming cycles. It is not possible to discuss here (or pretend to understand) all the underlying causes for the evolution of the TIM and TIMI groups of fish farmers, why some have split, others grown in size and others disappeared altogether, as the causes are likely to be many and diverse (see Agrawal, 2001). Nevertheless, the analysis of their development over the years suggests two interesting tendencies:

1. **The average size of the groups has decreased.**
2. **The degree of kinship amongst the partners has increased.**

In some cases, the groups have become smaller because some households have given up aquaculture and abandoned the group after the first or second year; in other cases it is because the group has split into two or more sub groups so as to be able to manage a larger farming area. At the same time, there is a tendency for the groups to become more homogeneously "family groups" that share kinship ties. Those households that take part in a fish farming group with other family members (siblings, parents, uncles and aunts) tend to remain in the group over the years, whereas the households with few kinship ties with the rest of fish farmers tend to withdraw.

This process of homogenization is very clear in the fish farming groups belonging to the TIMI communities of Fátima (Figure 5-6) and San Miguel del Mátire (Figure 5-7).

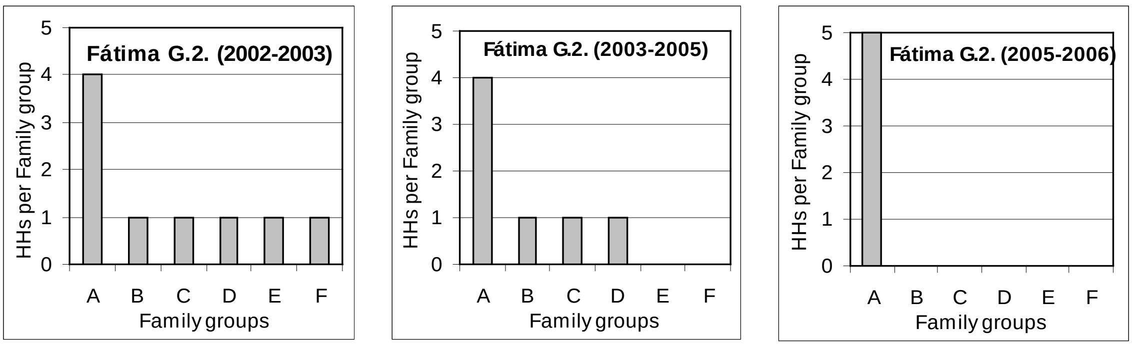
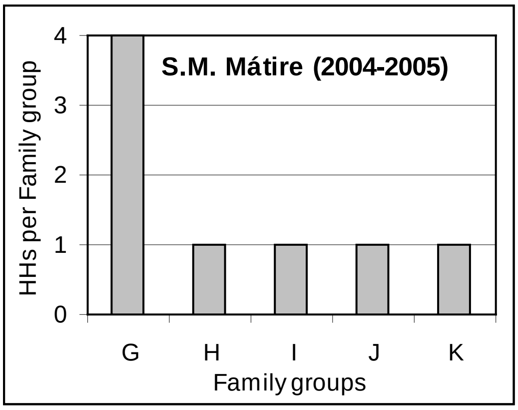


Figure 5-6 Evolution of fish farming group in Fátima: group ii (2002-2006). Fish farming was started in Fátima in 2002 by a group of nine households, four of which were related (Family Group A). In the second year of the project, two of the households who were not related to any of the other fish farmers withdrew from the activity (Family Groups E and F). In the third year, the remaining households with no kinship ties with other members withdrew and a new household belonging to Family Group A joined the activity. In 2006, the management of the ponds was in the hands of five households who were all related.



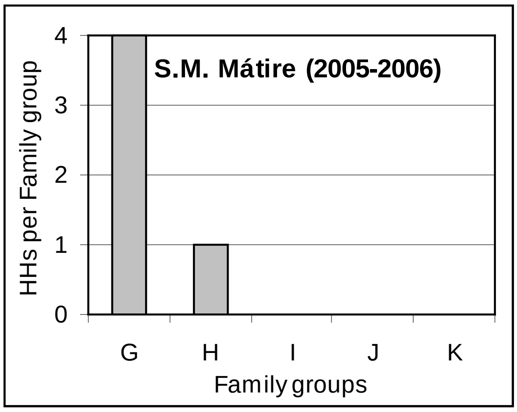


Figure 5-7 Evolution of fish farming group in San Miguel del Mátire (2004-2006). In San Miguel del Mátire the evolution of the group was similar to Fátima. Three of the households with no kinship ties withdrew after the first harvest. In 2006, the management of the ponds was in the hands of five families, four of which shared kinship ties.

This tendency is reflected in all the TIM and TIMI fish farming groups that have completed several farming cycles. Figure 5-8 illustrates the experience of the nine groups, from seven Moxos indigenous communities[51], that, at the time of the interviews, had been involved in aquaculture for at least 3 years. In the first year of the project, the fish farming groups were, on average, made up of 5.5 different Family groups, whereas in the third year, the number of Family groups working together on the same pond had been reduced to 2.8. Furthermore, the average number of households with kinship ties working on the same pond had increased from 1.8 to 3.5 over three years.

[51] Bella Brisa, Fátima groups I and II, Retiro, San José del Cavitu, San Miguel del Mátire, Santa Rosa del Apere and Monte Grande Km5 groups I and II. Villa Esperanza is not included in the analysis as, right from the beginning, all the households that participated in the fish farming group were related.

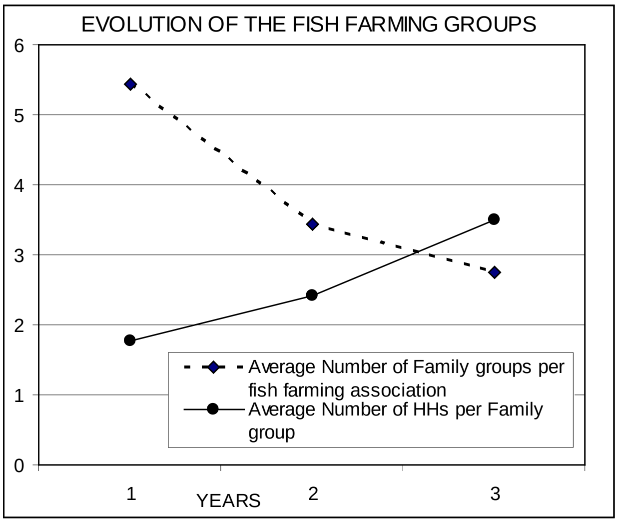


Figure 5-8 Evolution of the fish farming groups in TIM and TIMI. This graph shows (dotted line) the decrease over three years of the average number of different Family groups (groups of households that share kinship ties) farming together, and (continuous line) the increase of the average number of households that make up each Family group.

5.5 What does it take to innovate? Identifying the fish farmers in the indigenous territories

Who can afford and is willing to adopt fish farming in TIM and TIMI? Rural livelihoods around the world are increasingly diverse and complex, often relying more and more on non-farm sources of income (Barrett et al., 2001; Bryceson, 1996, 2000; Ellis, 2005, 2006; Lanjouw, 2001; Ruben and Van Den Berg, 2001; Steward, 2007). As discussed in section 2.1.3, rural peoples' interest in and access to a particular natural resource management innovation will be influenced by the degree and nature of livelihoods diversification (Renkow, 2000; Sumberg et al., 2004; Tripp, 2001).

The aquaculture project in TIM and TIMI provides support to set up fish farming units (resources and biophysical conditions permitting) in those communities where the *Cabildo* (community authorities) or groups of families have made a formal request for assistance to introduce aquaculture. All the people living in the community are potentially eligible for support, including training in aquaculture and subsidies to help recover existing water bodies or build new ponds. However, in practice, some families decide to give aquaculture a try and others do not. Furthermore, some of the families who decide to try out aquaculture give up after their first attempt, whereas others continue with the activity. It is clear that many factors influence farmers' interest in and access to aquaculture, including group dynamics (see sections 5.4.3 and 5.6.3).

Nevertheless, even if group farming was equally appealing to all families, both the functionality and utility thresholds[52] of the different aquaculture technologies being promoted and farmers' access to resources required for adoption are likely to vary among and within communities due to socio-economic and institutional differences (Sumberg et al., 2004; Tripp, 2001).

Understanding the sources and type of livelihood diversity is essential for effective pro-poor technology development. Drawing from the livelihoods survey carried out in TIM and TIMI by the author, the following section draws a picture of life in the indigenous communities and addresses some of the research questions outlined in chapter 2: which families adopt fish farming and to what end? Are there any significant differences between the households that take it up and those that do not? Which households are excluded? Are there any patterns that can help to identify 'potential fish farmers' in the indigenous territories? What does a fish farmer look like in TIM and TIMI?

5.5.1 Livelihoods in TIM and TIMI

TIM and TIMI share many characteristics, including the organisational and institutional structures of their communities, their main productive systems and economic activities. Nevertheless, differences do exist between communities, for example with regards to their degree of isolation, market integration and access to natural resources, such as timber and fish. In TIM there are 20 communities (550 families) in an area of approximately 340,000 hectares. The main ethnic group is Mojeño-Trinitario, although there are also families of Movima, Yuracaré and Chimán origin. In TIMI there are 19 communities (357 families) in an area of approximately 98,000 hectares and the main ethnic group is Mojeño- Ignaciano. The population in TIM and TIMI is very young, the average age of the inhabitants of the communities is 21.6 (SD 16.9), and of the household heads is 40.8 (SD 14.5). The average family size is 5.9 members (SD 2.9) (this only considers family members living in the community at the time of the interview). Very few of the inhabitants have been to secondary school, less than 8% of those over 18 years old. Forty percent have received less than 3 years of schooling and in the case of women, this percentage reaches 50%.

[52] See section 3.3.2

Sources of income

Figure 5-9 shows the average income portfolio for families in the indigenous territories. In 2005 the value of **HH annual gross incomes**[53] in TIM and TIMI was, on average, 892 US$/family (SD 1,283), of which 390 US$ (SD 1,110) was cash income. Whereas the **cash income per HH**[54] was similar for both territories, it should be pointed out that the value of the gross income (including subsistence production and extraction) was 11% higher for TIM families than for TIMI families[55].

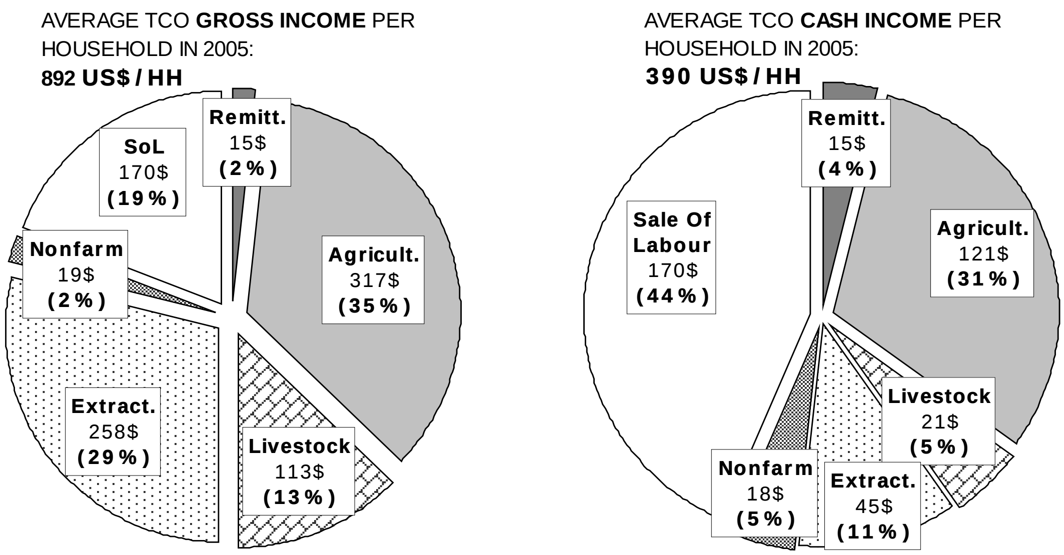


Figure 5-9 Income portfolios in the TCO (*Tierras Comunitarias de Origen*) TIM and TIMI. Average HH annual gross income and average HH annual cash income (Innovation in aquaculture is not accounted for in livestock production)

Agriculture represents, on average, 35% of the gross value of the families' production in TIM and TIMI and 31% of their cash income. The main crops are rice, yucca or cassava, plantain and corn. The families also often plant trees for fruit and timber in their *chacos*. The size of the *chaco* varies between 0.5 and 1.5 hectares per family. The principle factor that limits the size of the *chaco* is shortage of labour to clear land and

53 The value of HH annual gross income is the value of all goods generated by all sources of production in a year (farm and non-farm subsistence production and subsistence extraction + farm and non-farm production and extraction sold + wage labour + remittances)

54 Household annual cash income is the amount of money generated from the sale of farm and non farm products, commercial extraction, wage labour and remittances)

55 It is possible that the average HH annual income for the indigenous territories is higher than what the survey reveals because the income generated from timber extraction by some families is likely to be underreported, particularly in TIM where valuable species are still abundant. Community members are often unwilling to give information about logging activities because they are frequently undeclared (See CIPCA-Beni, 2005).

to harvest crops. However, pull factors such as proximity to markets also conditions agricultural production. About a quarter of the agricultural production is sold within the community or in nearby towns. Communities closer to San Ignacio and/or Trinidad tend to have larger *chacos* and sell a higher percentage of their production.

Most indigenous families raise poultry and, to a lesser extent, pigs, cattle and horses. Livestock accounts for 13% of the total gross value of their production and nearly all is reserved for their own consumption. Chicken and ducks account for 70% of the total production, followed by pigs (15%) and cattle (12%). However, in the last few years, livestock production has diversified and new activities have been introduced, such as breeding some types of dairy goats and aquaculture.

Hunting, fishing, and the extraction of timber and non-timber forest products represent 29% of the HH annual gross income in TIM and TIMI. With the exception of timber, most of the products extracted are for family consumption.

A few indigenous families (7%) have diversified their production and moved away from agriculture and livestock towards non-farm sources of cash income, such as handcrafts, brick making or the commercialisation of products from the city. Nevertheless, these activities still only make a very small contribution to family incomes, only 2% of HH annual gross income in TIM and TIMI and 5% of cash income.

The main source of cash income is the sale of temporary labour in ranches, timber mills and urban centres. Wage labour represents 19% of the HH annual gross income and 44% of the HH cash income. Nearly half (45%) of the household heads work as wage labourers on a regular basis, on average 127 days per year. The average wage for a day's labour in TIM and TIMI is 22 Bs (2.75 US$).

Emigration is a phenomenon that affects all the indigenous communities and young people in particular. Seventy five percent of young people over 24 have emigrated. Twenty two percent emigrated to continue their education, the rest to look for work. In TIM, most go to San Ignacio, whereas in TIMI they go to Trinidad. Other destinies include cattle ranches, other communities, and, less frequently, Santa Cruz, San Borja, Cochabamba, la Paz and Spain. A quarter of the emigrants send money home regularly. The average amount sent is US$ 120 per year (SD 105).

Goods and savings

The indigenous families do not have many savings in goods and/or money. Given the communal system of ownership in the indigenous territories, few families have legal proof of ownership of land or properties. Only 8% own land or properties outside the territories, or in San Ignacio or Trinidad. Very few families save money, only 5% have a bank account. If we take into account the value of properties or plots of land privately owned, animals, tools, household utensils and cash savings, the average value of savings is 528 US$/family (SD 812).

Changes and expectations

As can be seen in Table 5-15, there are different opinions in the communities about how the changes that have taken place in the indigenous territories in the last decades have affected their lives. There is a general consensus that in the past it was easier to acquire protein through hunting and fishing and that agriculture was more productive because the crops suffered less from pests and diseases. This change was attributed to the extension of grazing land for cattle, the introduction of timber companies, the opening of new paths, over-fishing in the main rivers of the Mamoré basin and the *de facto* privatisation of the lagoons by the ranchers. Nevertheless, many people also thought that the situation had improved because they now have easier access to education and health centres, as well as new crops and economic activities that permit increased sources of cash.

Table 5-15 Evaluation of the changes in the lives of indigenous families.

When was life better?	N	%
Now	68	45
10 years ago	29	19
In our grandparents time	23	15
Always the same	31	21
Total	151	100

Economic Situation in 2005 vs. 2000	N	%
Better	45	30
Worse	18	12
Same	87	58
Total	150	100

When presented with the hypothetical situation of being able to work outside the community (in San Ignacio, Trinidad, Santa Cruz or on a cattle ranch) earning a wage comparable to what they earn in the community (accounting for differences in the cost of living), 78% of parents with children still living with them preferred to stay where they were. The remainder chose to migrate, in the first place to assure a good education for their children and in the second place to earn more money. One of the main reasons given for staying in the community was the fact that in the community they worked for themselves (*no se tiene patrón ni se es mozo de nadie*) and that life was more easy going (*tranquilo*). However, access to education and health care and the gradual integration in the markets of San Ignacio and Trinidad are generating new economic needs, as can be seen in the migration rate of the new generations. Another factor to be added to this process is that hunting is growing less and less productive. This has also contributed to a gradual diversification of sources of income, often tending towards activities with greater commercial potential. Sixty three percent of those interviewed said that in the last few years they had started new economic activities or made innovations in existing activities[56].

5.5.2 What does a fish farmer look like?

Figure 5-10 Fish farmer from the community of Argentina with pacú (*Colossoma sp.*) (a). Fish farmer from Monte Grande Km5 with tambaquí (*Piaractus sp.*) (b)

The following section compares the income portfolios and other variables, such as household demography and involvement in community life, of fish farmers, non-fish farmers and households who adopt aquaculture for one or two cycles and then

[56] This data does not include aquaculture.

abandon the activity (see variables analysed in Table 5-16, the full questionnaire in Spanish is presented in Appendix 5).

Table 5-16 Summary of the variables analysed to compare the groups of non-adopters, those who adopt & quit and those who adopt & repeat.

	VARIABLES (per HH in 2005)
Leadership	% heads of HH with positions of responsibility in the community
Group work	% of HH which participate in group productive activities (other than fish farming)
Innovate in other farm activities	% of HH which participate in natural resource management innovations (other than fish faming)
HH demography	HH size; years of residence in the community; age of head of HH; % single-parent HH; years of schooling of head of HH
Isolation/Market integration	Mobility of head of HH to buy and sell goods (% absent > 2 months/year to buy and sell goods)
Goods and savings	Value of farm animals; number of cows; value of cows; value household goods and work tools; total value of goods (land and houses outside the TCO + animals + household goods and tools); savings in cash; total value of goods and savings.
Sources of income	
Agricultural production	Size of *chaco* (agricultural plot); number of crops in *chaco*; gross income from agriculture; cash income from agriculture
Livestock production	Gross income from livestock; cash income from livestock
Extraction	% HH that hunt and fish; gross income from fishing; gross income from extraction; cash income from extraction
Non-farm production	% families with non-farm production; gross income from non-farm production; cash income from non-farm production
Sale of labour	% heads of HH who sell their labour; number of days worked; cash income from labour sold
Remittances	Cash income from remittances
Total annual income	Total gross income from all economic activities; total cash income; Total gross income and cash income from agricultural and livestock production (*chaco* + cattle + poultry); Total gross income and cash income from on-farm and non-farm production (- sale of labour); Access to cash (- sale of labour + remittances + savings + sale of own production); Access to cash (+ sale of labour + remittances + savings + sale of own production).

In order to be able to make valid comparisons between the three sub-groups, returns from fish farming were excluded from sub-sample 3 (fish farming households). After studying the degree of dispersion of the data related to family incomes, it was decided to exclude three extreme cases from the study[57]. Two of these families, one from the group of fish farmers (sub-sample 3) and the other from the group of those who tried and gave up (sub-sample 2), worked full time in a timber mill and they earned more than US$ 2,250 per year from the sale of labour. The third family, from the group of non-fish farmers (sub-sample 1), had a chainsaw and sold timber directly making more than US$ 2,750 per year from extraction.

[57] In a box plot those values that are more than 3 degrees beyond the 75th percentile.

The descriptive statistics are summarised in Figure 5-11. The figure shows the average income portfolio of non-fish farmers, those who tried aquaculture and subsequently abandoned it and established fish farmers.

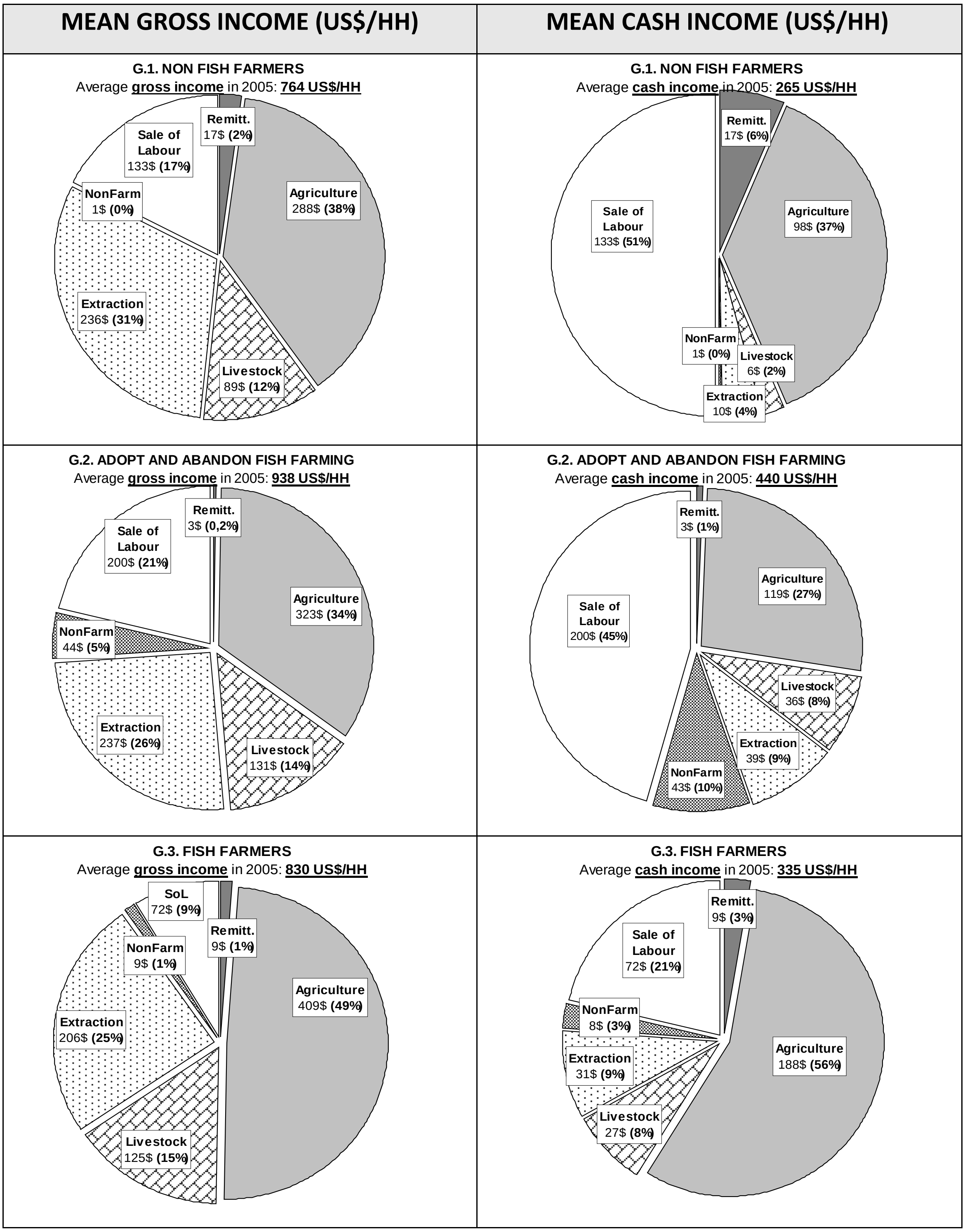


Figure 5-11 Livelihood portfolios of non-fish farmers (G1, N=52), those who adopt and quit (G2, N=37) and established fish farmers (G3, N=42). Income portfolios for 2005 do not include fish farming returns.

5.5.3 Statistically significant differences between fish farmers and non-fish farmers

The **Table 5-17** sums up the results of the statistical analysis. Those variables that are significantly different between the three groups of farmers at a 95% and 99% C.I. are starred. However, it is important to note that, as shown in Table 5-16, 41 variables were analysed and that multiple testing was not accounted for, hence, results that show a significant difference at 95% CI should be interpreted with caution.

Table 5-17 Identifying the fish farmers in the community: differences between adopters and non-adopters. The analysis excludes fish farming returns. Variables that are significantly different between sub-groups of households (CI±95%) are in bold and marked with an asterisk (*)

Categorical variables (% of HH in 2005)	χ^2 3 cat. **P Value**	χ^2 1 vs. 3 **P Value**	**1. NON-ADOPTERS** (N = 51)		**2. ADOPT & QUIT** (N=36)		**3. ADOPT & REPEAT** (N = 41)	
			%	**-**	**%**	**-**	**%**	**-**
HH heads leaders*	**0.022**	**0.007**	**35**	**-**	**42**	**-**	**63**	**-**
Innovate in other sectors*	**0.0001**	**0.0001**	**43**	**-**	**75**	**-**	**83**	**-**
Participate in communal work	0.547	0.357	17	-	17	-	26	-
Single parent HH	0.140	0.061	31	-	19	-	15	-
Travel to town >56 day/year*	**0.105**	**0.042**	**37**	**-**	**53**	**-**	**59**	**-**
Continuous variables (US$/HH for 2005)	**Anova** 3 cat. **P Value**	**T-test** 1 vs. 3 **P Value**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Value goods + savings	0.136	-	390	629	750	1143	474	747
Agriculture gross income*	**0.053**	**0.023**	**288**	**186**	**323**	**211**	**409**	**309**
Agriculture cash income *	**0.037**	**0.018**	**99**	**130**	**119**	**146**	**188**	**223**
Livestock gross income	0.126	-	89	94	131	124	125	99
Livestock cash income*	**0.022**	**0.006**	**6**	**22**	**36**	**79**	**27**	**47**
Fishing gross income	0.174	-	91	127	67	74	54	69
Extraction gross income	0.810	-	236	195	237	301	206	241
Sale of labour cash income	0.106	-	133	251	200	364	72	147
Agric.+livest. gross income*	**0.046**	**0.015**	**378**	**233**	**454**	**288**	**534**	**368**
Agric.+livest. cash income*	**0.027**	**0.008**	**105**	**139**	**154**	**187**	**215**	**248**
Total gross income	0.294	-	764	423	938	608	830	508
Total cash income	0.113	-	265	288	440	527	335	328

The analysis reveals a statistically significant difference amongst the three groups (fish farmers, non-fish farmers and those who adopt and quit) in relation to several of the variables analysed:

<u>Innovations in agriculture and livestock production.</u>

Those who engage in aquaculture tend to be involved in several other on-farm innovations too. Eighty three percent of the established fish farming households and 75% of those who started but later gave up aquaculture have recently set up new farm activities (new crops, agro-forestry systems, hair sheep, bee keeping, etc.). In the sub-sample of households who never adopted fish farming, the percentage that has recently been involved in other NRM innovations is significantly smaller (43%).

Market integration and cash income from agriculture and livestock production. Another difference between groups is how much agriculture and livestock production is integrated into the market (p = 0.027 when comparing the three samples; p = 0.008 when comparing non-adopters vs. farmers who adopt & repeat). The fish farming households make more cash (US$ 215 per year) from agricultural and livestock production than those who adopt and quit (US$ 154 per year) and non-fish farmers (US$ 105 per family per year). There is also a significant difference (p = 0.042) between groups in relation to the number of days they leave the community to buy and sell products in San Ignacio and/or Trinidad. Only 37% of non-adopters leave the community for more than two months a year, compared with 59% of the established fish farming households.

These results coincide with the findings of the IFPRI study of local innovation processes in four communities in Bolivia where aquaculture extension projects were underway (Hartwich et al., 2007). The study looked at factors influencing adoption of aquaculture among farmers in these communities and found a positive link between adoption rates and farmers with a positive attitude toward change and interest in experimenting and better market access.

Gross income from agricultural production.

The analysis reveals a significant difference between established fish farmers and non-adopters with respect to gross income from agriculture (p = 0.023) and with respect to gross income from agriculture and livestock production combined (p = 0.015). The agricultural production (home consumption + sales) of fish farming households is on average greater than that of the other households. This tendency is maintained in agricultural and livestock production (agriculture + cattle, pigs, sheep and poultry).

Leadership.

A significantly higher percentage of fish farming households have positions of responsibility in the communal institutions, for example, in the *Cabildo*, the School Council and the Health and Literacy Team (p = 0.022 when comparing the three samples; p = 0.007 when comparing non-adopters vs. farmers who adopt & repeat).

5.5.4 Other variables analysed

Experience in group/communal productive activities. Fish farming ponds in the communities are often managed jointly by several households. One of the main causes for giving up fish farming is that the partners have problems coordinating their work and getting along with each other (see Table 5-21). Therefore, the survey examined farmers' participation in group or communal productive activities, such as *chaqueo* (rotational systems of clearing and harvesting agricultural land), managing *potreros* (large areas where cattle are left to pasture) or looking after communal livestock. However, differences are not statistically significant.

HH demography. No difference seems to exist between groups with regards to HH size, age of members, years of residence in the community, schooling or family structure. However, there were twice as many single-headed households among the group of non-adopters than among the group of fish farmers.

Goods and savings. There is no significant difference between groups with respect to savings and the value of their goods.

Sources of income. As mentioned above, fish farmers' cash income from agriculture and livestock production is significantly higher than that of non-fish farmers. No significant difference seems to exist with regards to gross and cash income from extraction, non-farm production or cash income from the sale of labour or from remittances.

Total annual income. Although fish farmers' mean gross and cash income from agriculture production is significantly higher than that of non-fish farmers and those who adopt and quit, their total annual income from all activities is similar to that of the other TIM and TIMI households. Whereas there is a statistically significant difference between the three groups of farmers with regards to some of their sources of income, there is no significant difference in relation to their total income. This finding seems to suggest that interest and access to aquaculture is not so much determined by the size of the households' income but rather could be influenced by how that income is being generated (type of livelihood).

5.5.5 A note on the methods

As mentioned earlier, the purpose of this analysis was to identify differences among groups of households that may have led to their decision to fish farm. However, it could be argued that as the interviews were performed *after* aquaculture had been 'adopted' by some households then results might be measuring differences in groups as the result of fish farming. In fact, the impact of aquaculture on income and livelihoods at this early/experimental stage is not likely to be significant. Income from aquaculture is not accounted for when comparing total gross/cash income or income from livestock production. Furthermore, at this initial stage, most households start out in aquaculture as part of a large group and the farming area per capita is small, so the amount of time invested or income generated per household is also relatively small. Finally, very few have reinvested their earnings from their first or second fish farming production cycle into other productive activities (Table 5-18).

Table 5-18 Expenditure from fish farming income

Uses given to fish farming income	Families % (N = 116)
Basic necessities	27
Children's education	15
Health	8
Clothing	8
Cattle	4
Electrical appliances	3
Pond extension	2
Fingerlings	33
TOTAL	100

To sum up, households involved in aquaculture are also involved in many new forms of agricultural and livestock production and extraction, such as new crops, agro-forestry systems (coffee and chocolate), hair sheep, bee keeping, community-based low-impact timber extraction etc. These households have larger gross incomes from agriculture than the rest. Furthermore, the amount of cash income they generate from agriculture and livestock production is significantly larger than that generated by the other households; their *chacos* are more commercially oriented and they travel to town more often to buy and sell products. Finally, farmers who adopt aquaculture, very often in association with others, appear to have stronger commitments to communal institutions such as the *Cabildo*, the School Council or indigenous political and land rights organisations at a regional level.

5.6 Voices from the communities: an inside evaluation of aquaculture

This section brings in the voices from the communities, allowing a space for fish farmers and non-fish farmers to describe their experience with aquaculture, problems, expectations and opinions on ways to improve the work to increase benefits in the future. The section combines data from the household survey and semi-structured group interviews as well as more informal individual chats with fish farmers, non-fish farmers and those who tried aquaculture and then gave it up, in those communities with two years or more experience with fish production (see methods section 5.2).

Most of the households with fish farming experience think that it is an activity that can contribute to improve their livelihoods in TIM and TIMI (Table 5-19).

Box 5-2 Voices from the communities: benefits from aquaculture

Cosechando bien hay adelanto. Aportando productos del lugar estamos yendo bien, es como un ahorro. (San Miguel)
We're getting good yields and making progress. Using local products helps, it's a saving.

Es parecido a las gallinas lo de la cría de los pescaditos, pero tiene más valor el pescado y se cría en más número. Las gallinas es difícil tener más de 20, en cambio el pez se puede tener en cantidad, se pueden cavar más pozas, tres o cuatro por comunidad, y ahí la zurda a las gallinas. (Santa Rosa)
Fish farming is like raising chickens, but the fish are worth more and there are more of them. It's difficult to keep more than 20 chickens, but you can raise lots of fish, you can dig more ponds, three or four for each community, that's why they're better than chickens.

Nos gustó comer pacú, pero lo que más nos gustó es que se generó plata, no hay duda que la piscicultura da, lo hemos visto, eso es indudable. (Retiro)
We like eating pacú, but what we like most is the money we can make, there's no doubt that fish farming is profitable, we've seen that, no doubt at all.

Table 5-19 Evaluation of fish farming potential (N = 116)

Can fish farming contribute to improve your livelihood?	Fish farming Households %
Not at all able (Nada)	0
Slightly able (Algo)	37
Moderately able (Bastante)	56
Very able (Mucho)	7
TOTAL	100

However, the producers think that the present pond area is still insufficient and that pond management could and should be improved:

Box 5-3 Voices from the communities: benefits from aquaculture

(La piscicultura) *Sirve, pero muy michi* (pequeña) *la cría, son hartos los que quieren criar y al final se queda en nada.* (Bella Brisa)
(Fish farming) It's OK, but the production is very small, there are so many who want to join in and at the end there's nothing left.

Sí da, pero tendríamos que ensayar con balanceado para vender y ver cómo nos va, tendríamos que darle otro enfoque, trabajar más para le venta, y tener más pozas. (Fátima)
Yes, it's productive, but we should experiment with commercial feed and sell the fish and see how we do, we should look for another approach, work more towards sales and have more ponds.

La piscicultura da, pero no así como lo hemos hecho nosotros, hay que haber más coordinación y usar alimento balanceado, no yuca y cheruje de plátano; así como han hecho en Villa (Villa Esperanza)*, ellos han sacado harta plata con dos pozas como las nuestras.* (Bermeo)
Fish farming is productive, but not the way we did it, we need more coordination and to use commercial feed, not yucca and mashed platano. We should follow the example of Villa. They've made a lot of money with two ponds like ours.

5.6.1 Purpose of production

In the communities, fish farming may be based on home-made or commercial feed, for the purpose of home consumption or sale. Often the households that start fish farming for the first time often make their own fish feed from *chaco* products and aim to use most of their production for home consumption, especially in those communities with limited access to rivers and lakes and/or markets

Box 5-4 Voices from the communities: purpose of production

Es importante la crianza porque acá en Bermeo no se conoce el pescau. (Bermeo)
Fish farming is important because, here, in Bermeo we don't have any fish.

Hay que criar para la carne, aquí no hay dónde pescar, ni río ni laguna, solo cuneta. Ahora hay menos monte y la carne de monte no se encuentra así nomás (…) Nos agrada lo de criar esos pescaditos porque no cuesta, dos veces se le da (de comer) *al día y listo, ellos se mantienen. Cuando uno tiene deseo de probar* (comer) *tiene de dónde sacar.* (Bella Brisa)
We need to raise fish for its meat, there's nowhere to fish here, no rivers or lagoons, only the ditches. Now there are fewer hunting grounds and it's harder to hunt (…). We like raising these little fish because they're no trouble, just feed them twice a day and that's it, they look after themselves. When you want something to eat you've got a supply.

Esta cría de peces yo lo he hallado bien porque estos peces son bien lindos, no son kiavó (de mal sabor/olor). *El* (río) *Sénero queda a trasmano, a 5 Km, se saca bentón y palometa una vez al mes, cuando falla la carne, pero no se consume mucho pescau porque no hay.* (El Buri)
I think this fish farming is fine because the fish are very good, they taste and smell good. The Sénero (river) isn't very close at hand, 5kms away, we fish *bentón* and *palometa* once a month when we haven't any meat, but we don't eat much fish because there isn't much.

However, as the farmers gain experience, many choose a more commercial approach with the purpose of generating a larger cash income through the sale of fish:

Box 5-5 Voices from the communities: purpose of production

Al inicio no sabíamos bien, todo era para la olla (consumo)*, pero ahora ya hemos visto que da* (dinero) *y queremos vender más.* (Monte Grande Km5)
At first we didn't know what we were doing and all the fish went into the pot, but now we've seen that we can make money and we want to sell more.

Hay que vender, porque es lo más necesario, la ficha (dinero). *Nosotros aquí para comer todavía se consigue* (pescado), *del* (río) *Apere, de los bajíos, sacamos blanquillo, bentón, hay veces que surubí, en los remansos; lo que no hay es ficha.* (Santa Rosa)
We have to sell, because that's what we need most, cash. Here we can still catch fish to eat, in the Apere (river) we can catch *blanquillo*, *bentón*, sometimes *surubí* in the pools, but there's no cash.

Más la venta nos interesa, para poder crecer hay que venderlo el pescado, para hacer más pozas, ya hemos visto que da (dinero). (Villa Esperanza)
We're interested in selling the fish, if we want to grow we have to sell it, to make more ponds, we've already seen that it's profitable.

For the TCO families with fish farming experience, generating cash income from their ponds is the main goal of both men and women (Table 5-20).

Table 5-20 Main purpose of production. The difference between men and women in relation to the purpose of fish farming is not significant (IC±95%)

Main purpose of fish farming for "established" farmers (N = 84)			
Purpose of production	**% Men**	**% Women**	**REASON**
Mainly home consumption	3	0	Because meat is hard to find
Home consumption and sale	5	10	We need fish to eat and to earn money
Mainly to sell	**92**	**90**	**We have to sell to earn Money**

Figure 5-12 Fish farmers harvesting (a) and counting their money (b) from the sale of pacú in Retiro, TIM.

5.6.2 Type of production

The TIM and TIMI fish farmers would like to enlarge their farming area and consolidate fish production for the market, i.e. to produce commercial size fish (1Kg) in an eleven month farming cycle.

Box 5-6 Voices from the communities: type of production

En soñando nos gustaría tener de a 600 pescaditos para cada familia, así como una de las pozas comunales (de 25 m x 50 m) *para cada uno. Con unos 600 pacusitos* (pacú) *ya tiene uno cómo defenderse de la pobreza.* (Monte Grande Km5) Our dream would be to have 600 fish for each family, and also one of the communal ponds (25 m x 50 m) for each one. 600 pacús are enough to fight off poverty.

However, most of the producers still use the *Chaco* system, making supplementary feed from products and sub-products of their agricultural production, although they are aware that the limited area of *chaco* and the shortage of manual labour make it difficult for them to increase fish production using this system:

Box 5-7 Voices from the communities: type of production

Para criar hartos el chaco se quedaría chico, con papayita, guineo y plátano da para unos 300 (peces) *a lo más. Aquí nadie tiene soya, se sembró pero el ganado se lo comió. El frejol se siembra poco, por eso es difícil el alimento así del chaco, falta la proteína.* (El Buri) If we want to raise a lot, it isn't enough with crops from the *chaco*; papaya, banana, platano can't feed more than about 300 (fish). Nobody here has soya, we planted some but the cattle ate it. We don't usually plant frijol and so the *chaco* produce isn't enough, not enough protein. *Con el chaco no da para hartos. Lo que limitaría* (el crecimiento) *sería los aportes del chaco. A veces no hay o no se siembra mucho. Además hay gente que está con los chanchos* (cerdos)*, las gallinas, las ovejas… nada se desperdicia, cuesta juntar los productos para la crianza* (de los peces) *y si son chicos cuesta vender*. (Fátima) The *chaco* isn't enough for lots. What limits growth is the produce from the *chaco*. Sometimes there isn't any or not much has been planted. Some people also raise pigs, chickens, sheep … nothing goes to waste, it's difficult to get together the feed for the fish and if they don't grow big enough they're hard to sell.

Some producers, particularly in the most isolated TIM communities, think that the solution is to increase the *chaco* area and introduce new crops with a higher protein content, such as soya and frijol, i.e., to consolidate fish farming while maintaining the *Chaco* system and to keep dependence on external supplies to a minimum:

Box 5-8 Voices from the communities: type of production

Para criar mucho lo que haría yo es prepararme con un chaco grande, sembrar soya, arveja, maíz, y producir más, hay que sembrar lo que cuesta (los cultivos que son caros)*, así uno no gasta* (en la alimentación de los peces). (Retiro) To raise a lot of fish, what I would do is to prepare a big *chaco* and sow soya, arveja, maize, and produce more. We have to sow the expensive crops, that way one doesn't have to spend (on feeding the fish).

Nevertheless, in other communities with better access to the supplies market, the majority opinion is that growth in fish production requires access to commercial feed and they should change from the *Chaco* system to the *Mixed* or *Commercial* systems:

Box 5-9 Voices from the communities: type of production

Es bueno hacerse para sus dos hectáreas (de chaco) *para que no le falte producto a los peces. Luego cuando ya son grandecitos se puede uno ayudar con torta de soya* (comercial) *y mezclarlo con lo que es de acá, así se puede criar harto'* (San Miguel del Mátire).
It's good to plant your two hectares (of *chaco*) to have enough products for the fish. Later, when they are bigger you can help with (commercial) soya cake and mix it with what we have here. That way we can raise a lot.

Para criar hartos mejor fuera con balanceado (comercial), *como los de Villa* (Villa Esperanza), *se crían rápido y no cuesta venderlos, con puro masaco* (potaje de plátano y/o yuca) *no sirve.* (Fátima)
To raise a lot it would be better with (commercial) feed, like those in Villa (Villa Esperanza), they grow quickly and are easy to sell. It's not enough with just a mix of platano and yucca.

Según yo no hay un límite para la cantidad, depende de la capacidad de cada uno, nosotros en Villa así con balanceado (comercial) *podemos criar hasta 5000, más bien lo que limita son las pozas* (falta de pozas), *con balanceado* (comercial) *uno no brega*. (Villa Esperanza)
I think there are no limits to the quantity of fish, it only depends on our own capacities, in Villa, we can raise up to 5000 with (commercial) feed, although we are limited by the ponds (not enough of them), with (commercial) feed it's not hard work.

5.6.3 Organizational strategies

The many advantages to group fish farming have already been mentioned: It is easier for poorer households to participate and for producers to pool resources to construct and enlarge ponds, to access necessary supplies and the channels needed to commercialize the fish. Nevertheless, association is not cost-free. In Moxos, organizational problems are the main reason for giving up fish farming in communal and group projects. Thirty nine percent of the families that have given up group fish farming are interested in taking it up again in the future, but most of them are only interested in it as a family activity.

Table 5-21 Reasons for giving up fish farming

HH that adopt and abandon aquaculture (N=35) (Household survey)	
Reasons for giving up	**(%)**
Not profitable	3
Not enough time	38
Problems with the group	**44**
Spend too much time away from the community	12
House is too far from the community/pond	3

In the analysis of group farming in section 5.4.3, a trend was identified in the evolution of fish farming groups: the average size of the groups tends to get smaller and the degree of kinship amongst the partners within the groups tends to increase. The producers' views vary with regards to their experience with group farming. Many would prefer to work on the family level if they were able to, but other producers think that the advantages of group work outweigh the disadvantages (Table 5-22).

Table 5-22 Organizational strategies preferred to manage fish ponds. The difference between men and women in relation to the organizational system preferred is not significant (IC±95%)

Organizational system preferred by established fish farmers (N = 84)			
Which system would you prefer?	**% Men**	**% Women**	**REASON**
On my own (200 fish)	65	55	It is better to work alone to avoid disagreements
Five HH (1,250 fish)	20	15	It is better to work in a small group, there are fewer disagreements
Ten HH (3,000 fish)	15	30	It is better to work together, pool resources and afford more fish

More than half the producers would prefer to work on their own, even if this meant having fewer fish.

Box 5-10 Voices from the communities: organizational strategies

En grupo se aporta por desigual, no se trabaja parejo (equitativamente). *Yo prefiero hacerme lo mío para no tener discusión ni rabia. Mucho peor en un solo grupo* (grande) *donde la mitad son mirones* (socios que no trabajan)*, mejor era compartido en grupos chicos, o de a uno* (familiar). (San Miguel del Mátire)
In a group not everyone makes the same contribution or works equally. I prefer to work on my own to avoid arguments and anger. It's much worse in one big group where half of them are lay-abouts, it's better in small groups or with your own family.

However, 35% of the men and 45% of the women prefer to continue the activity in association with other farmers, despite recognizing the challenges of group fish farming.

Box 5-11 Voices from the communities: organizational strategies

Porque es difícil hacer una poza solito, cuesta harta plata. Entre toditos podemos trabajar mejor porque tenemos más pescado y menos gasto. Ya nos hemos organizado para poder participar todos así divididos en tres grupos, así se siente más liviano (el trabajo)*, se comparte y toditos participan.* (San José del Cavitu).
Because it's difficult to build a pond on your own, it's very expensive. All together we can work better because we have more fish and fewer expenses. We've organised ourselves to participate this way, divided into three groups, this way the work is easier, we share and everyone participates.

Nosotros ya teníamos algo de experiencia con el trabajo comunal (en proyectos productivos)*, el plan de manejo* (forestal) *de* (la ONG) *Ciddebeni, también la tejería, y ahora la asociación de piscicultura. Es bueno para la comunidad, así nos fortalecemos todos y se siente la mejora.* (Villa Esperanza)
We already had some experience with communal work, the forest management plan with Ciddebeni (an NGO), the brick works, and now with the fish farming association.

A nosotras nos gusta así en grupo porque se chistea (bromea)*, se comparte y el trabajo no se siente.* (Argentina).
We like working in groups because we tell jokes, share the work and it doesn't seem so hard.

All partners usually work together on pond maintenance, controls and harvests. Normally, a rota is established with one household responsible for feeding the fish every day for a week. However, organizational strategies vary among the different communities and groups in the most labour intensive activity, which is making the fish feed under the *Chaco* and Mixed systems[58].

All together. In some communities all the partners get together regularly to help prepare the supplementary fish feed. Each brings a contribution of products from their *Chaco*. The advantage of this system is that all the partners participate in supervising the contributions and work of the others so there is less concern about cheating the system.

Box 5-12 Voices from the communities: organizational strategies (all together)

'Nosotros preferimos todos juntos, si lo hacemos por turnos puede que algún socio falle y no haya seguimiento' (Monte Grande Km5).
We prefer to do it all together. If we take turns, perhaps one of the associates lets us down and the system breaks down.

However, this system is not usually very efficient with the bigger groups (more than 5 partners) as it is difficult to get everyone together and coordinate the work.

Together but separate. In order to make the process more efficient, some groups of fish farmers have opted for a system in which each household processes its own products and prepares its corresponding amount of feed separately, but always under the supervision of the technician and/or another associate.

Box 5-13 Voices from the communities: organizational strategies (together but separate)

Al principio era todo entre todos, y no funcionaba bien porque unos trabajaban y otros no. Entonces decidimos que cada uno haga lo suyo. Nos juntamos todos el día de la hechura (preparación del balanceado)*, así hay supervisión, pero cada socio gusanea* (pelletiza) *su parte, es decir, sus propios aportes, y cuando termina se puede marchar. Así no hay mirones* (socios que no trabajan) *ni hay que esperar, porque de moledora* (moledora de carne para moler y pelletizar el alimento) *solamente hay una. Para la secada se ha hecho turnos, en cada hechura le toca a una familia tender los fideos* (pellets) *y espantar las gallinas, luego recoger los fideos y guardarlos donde el técnico.* (en casa del técnico) (Retiro)
At first we did it all together, but it didn't work well because some worked and others didn't. Then we decided that each one should prepare their own contribution. We all get together on the day we prepare the feed, that way there is some supervision, but each of the associates pellitizes their own part, and when they have finished they can go away. This way there are no lay-abouts and no need to wait around, because there is only one mill (to pellitize the feed). Turns have been fixed to dry the pellets, every time we prepare the feed, one family has to spread the pellets out, keep the chickens away, then collect the pellects and store them in the technician's house.

[58] To prepare home-made fish feed some of the farm products such as maize, rice, yucca and plantain need to be cooked or ground, then they are mixed, pelletized and sun dried

Divided in sub-groups. Often, when there are many households participating in managing the pond, the group is divided into sub-groups (according to zones or kinship ties) to prepare the feed.

Box 5-14 Voices from the communities: organizational strategies (divided in sub-groups)

El año pasado se hizo el grupo en conjunto, se citaba a toditos los socios para la hechura (preparación del balanceado)*. Este año es diferente, nos dividimos en 3 grupos más chicos, por zonas, para que sea más fácil reunirse, y nos turnamos, para que toditos participen en el trabajo. Es mejor así.* (San José del Cavitu).
Last year we did it all together, every one of the associates was told to turn up to prepare the feed. This year it's different, we divided into 3 smaller groups, according to where we live, so it's easier to get together, and we took turns so everyone should do their share of the work. It's better like this.

Nosotros empezamos trabajando en grupo grande, pero lo hallamos mejor dividirnos en grupos de tres y repartirnos las tareas. Funcionó bien dividirnos en grupos, así no tenemos que reunirnos todas las semanas para hacer el alimento y se pierde menos tiempo. (Bella Brisa)
We started out working in a big group, but we found it was better to divide into three groups and share out the work. It works well, this way we don't all have to get together every week to prepare the feed and we don't waste so much time.

Dividing the big groups into smaller ones would seem an efficient way to make the work easier and to make the best use of time, but in some cases it has led to the disintegration of the group as suspicions have arisen related to inequalities in the amount of time and *chaco* products invested by the different sub-groups.

Divided into individual households. Finally, some communities have decided to rotate the work among the families that make up the group.

Box 5-15 Voices from the communities: organizational strategies (divided into individual households)

'Primeramente era todos en grupo, pero no funcionó porque unos no venían o no trabajaban igual, además solo había una máquina (moledora/pelletizadora)*, luego se decidió hacer el alimento por familia, a quien le tocaba dar el alimento, esa misma familia preparaba el gusanito* (pellet) *en su casa, así funcionó mejor. Todos los socios aportan sus productos a la familia que le toca hacer el alimento, y así nos turnamos en la hechura* (preparación del balanceado). (San Miguel del Mátire)
First of all we were all together in one group, but it didn't work because some didn't come or didn't work so hard, also there was only one mill to make the pellets. Later we decided the families should make the feed and the family whose turn it was to feed the fish also had to prepare the pellets at home, and this worked better. All the associates take their products to the family who has to prepare the feed, and this way we take turns to prepare the feed.

However, this system could lead to the same problem as in the previous example. As there is no collective control of contributions and work, some people might suspect that a partner/neighbour is not contributing sufficient products or work.

Distributing the returns. Regardless of the organizational system chosen to manage the ponds, nearly all the fish farming groups have opted for dividing the harvest in equal parts amongst the partners. In some cases, this distribution of the harvest has caused discontent amongst the partners that consider they have contributed more time and supplies than the others. Therefore, they have tried to establish systems to distribute benefits in relation to the contribution of each household. However, most of the producers consider that these systems are problematic and that it is better to construct collective control mechanisms so that all the partners make an equal contribution from the beginning.

Box 5-16 Voices from the communities: organizational strategies (distributing the returns)

La primera cosecha fue todos por igual. La segunda cosecha se hizo en función de los aportes, pero fue un problema porque alguno se enojó porque llevó poco (pescado). *Este año lo pensamos repartir todos por igual, no queremos que unos tengan más y otros menos porque la gente se enoja. Si uno no trabaja mejor es sacarlo del grupo nomás, pero al final es mejor que todos saquen de a igual* (cosechen lo mismo). (San José del Cavitu).

The first harvest was divided equally among all. The second was divided in relation to contributions, but this was a problem because some people got angry because they didn't get much fish. This year we are thinking of dividing it equally, we don't want some to have more and others less, because people get angry. If someone doesn't work, it's better just to leave them out of the group, but in the end it's better if we all have the same share of the harvest.

Ideal size of group. According to the producers, the size of the group is decisive for the success of the activity. The bigger the group is, the more difficult the coordination becomes.

Box 5-17 Voices from the communities: organizational strategies (ideal size of group)

Ya hemos visto que cuando se es poquitos hay mejor coordinación. (Bermeo).
We've seen that when the group is smaller the coordination is better.

Si somos muchos a veces no se trabaja parejo (equitativamente)*, aquí hemos trabajado en grupos de hasta veinticinco personas, haciendo chaco, y de veinticinco terminan trabajando seis. Ya sabemos, no sirve tan grande* (el grupo)*'* (Retiro).
Sometimes, when there are a lot of us not everyone does their fair share of the work. Here we have worked on *chaco* in groups of up to twenty-five people, and only six of the twenty-five end up working. We already know that such a big group doesn't work.

The majority of the farmers working under the *Chaco* or Mixed system think that a group of 5 or 6 partners is the ideal size.

Box 5-18 Voices from the communities: organizational strategies (ideal size of group)

Así se trabaja parejo (equitativamente)*, se coordina bien y no cuesta, y si uno falla* (en el trabajo) *siempre hay* (un) *reemplazo.* (Monte Grande Km5)
This way everyone does their fair share of the work, the coordination is good and it's not hard, and if one doesn't turn up there's always someone to take their place.

Groups that farm under the Commercial system do not consider the size of the group to be a problem because investment in labour is kept to a minimum and this simplifies coordination amongst the associates:

Box 5-19 Voices from the communities: organizational strategies (ideal size of group)

Si es con balanceado (comercial) *pueden ser grupos grandes, hasta de a quince se puede. Cuanto más grande es el grupo es más mejor porque da para hacer más pozas, para tener más pescado.* (Villa Esperanza)
With commercial feed the groups can be big, as many as fifteen is alright. The bigger the group is the better, because we can build more ponds and have more fish.

5.6.4 Impact on the rest of the community

There are few communities where fish farming is communal as it is in Villa Esperanza. In most of the communities there are households that are not involved in fish farming. These households are often not comfortable working in association with other people or, for some reason, others are not comfortable working in association with them, so they are not part of fish farming groups. On the other hand, they consider that the high cost of building a pond limits their access to fish farming on their own (Table 5-23).

Table 5-23 Reasons for not participating in fish farming

NON fish farming HH (N = 53)	(%)
Why don't you farm fish on your own?	
Not profitable, risky	6
Pond digging expensive, lack of capital	43
There are fish in the river/lake	4
There's nowhere to sell them	2
No time, work outside the community	25
I don't have a *chaco* to feed the fish	6
Don't know/No response (DK/NR)	14
Why don't you farm fish in a group?	
Not interested in fish farming	17
I prefer to work alone	49
Uncomfortable with the group	4
Don't know/No response	30

Nevertheless, the majority of the non-fish farming households seem to think that the activity benefits their community and they would like the production to increase (Table 5-24).

Box 5-20 Voices from the communities: impact of aquaculture on the rest of the community

Vemos que sale el producto (se vende)*, les va bien* (a los piscicultores)*, y ahora cuando uno desea va y les compra, antes había que ir a Trini* (Trinidad) *para probarlo este pescau'* (el pacú). (Monte Grande Km5)
We see that the product sells, the producers do well, and now when we want to buy fish we can buy from them, before we had to go to Trinidad to buy this fish (pacú).

Table 5-24 Evaluation of the activity by NON fish farming HH

NON fish farming HH (N = 53)		
	(%)	**REASON**
Impact of fish farming on community		
Good	68	The community benefits from the fish and a lot are sold
Regular	8	They produce some fish but it's difficult
Bad	4	The investment is very expensive
DK/NR	20	Don't know/No response
Would you like more ponds in the community?		
Yes	76	So more HH can benefit and there are more sales
No	9	It doesn't seem a good investment
Don't care	11	It doesn't affect us because we are not often in the community
DK/NR	4	Don't know/No response
Is there conflict over the use of communal water?		
Yes	17	Some neighbours get angry because they dirty the water
No	4	There are special ponds for the fish
DK/NR	79*	Don't know/No response

* 79% of non-fish farmers were unwilling to answer the question whether tensions exist with regards to the use of communal ponds by fish farmers, which probably reflects the fact that it is an uncomfortable question and that they are annoyed.

However, in several communities, **problems** have emerged between the fish farmers and the other households, in particular in relation to **use of communal ponds and the theft of fish.**

In many of the communities use has been made of existing ponds that belong to the community to set up group fish farming. These ponds are normally used as water holes for cattle or for washing clothes in some TIMI communities where there is a shortage of water during the dry season. Some households that do not participate in fish farming feel aggrieved by the fish farmers' use of the communal ponds.

Box 5-21 Voices from the communities: impact of aquaculture on the rest of the community

En la (época) *seca se saca* (agua) *del pozo* (aguada) *para lavar y desde que hay los peces* (el agua) *está kiavó* (maloliente)*, ya no está claringa* (transparente)*, y a veces* (los piscicultores) *le echan candado* (al enrejado)*, como si fueran sus dueños.* (Bella Brisa)
In the dry season we take water from the pond to wash, but ever since there are fish in the water it smells and isn't clear, and sometimes the fish farmers put a lock on it as if they owned it.

In contrast, the fish farmers consider that their activity does not limit the use others might make of the pond and that the complaints of some of the other families are unjustified.

Box 5-22 Voices from the communities: impact of aquaculture on the rest of the community

Algunas familias no querían la segunda siembra, decían que lo mezquinábamos el pozo (aguada)*, pero eso no es verdad, nosotros recién a las seis de la tarde le echamos candado* (al enrejado) *para que no se entren los animalitos.* (Bella Brisa)
Some families were against the second seeding, they said that we didn't share the pond, but this isn't true, punctually, at six in the evening we lock the fence so that animals can't get in.

Sí, ha habido problemas, por la cuestión de la poza. La gente usa el agua para lavar y dicen que mezquinamos el pozo, pero no es así, nadie les prohíbe de sacar agua, solo les pedimos que no se champen (bañen) *ni boten* (tiren) *el ACE* (detergente)*, porque se perjudican los peces.* (Fátima)
Yes, there have been some problems over the pond. People use the water to wash and say that we don't share the pond, but it's not like that, nobody stops them taking water out, we only ask them not to wash in the pond or put detergent in, because this can hurt the fish.

A problem common to many communities is the theft of fish:

Box 5-23 Voices from the communities: impact of aquaculture on the rest of the community

Dicen que en Retiro se les entró el lobito (la nutria) *y hasta un lagarto* (cocodrilo) *han sacado* (del vivero)*, pero a nosotros lo que más nos ha perjudicado es el animal de dos patas* (el hombre)*, ese es el que se piratea* (roba) *los pacuses.* (Monte Grande Km5)
They say that in Retiro a nutria/coypu got in and they even took out a caiman from the fish pond, but the animal that has caused us most damage is the two-legged animal, that's who steals the pacús.

Lo que no nos gustó (de la cría de peces) *es que sacamos varios* (peces) *estropeados por el anzuelo* (con herida de anzuelo)*, algunos hasta mandan a sus hijos para que saquen* (pescado). (Fátima)
What we don't like about this is that we have harvested several fish that had been spoilt by a fishing hook, some people even send their children to take fish.

El primer año no hubo este problema pero parece que la gente ya ha aprendido que aquí se saca fácil el pez y ya le meten su liñada (hilo de pescar). (Santa Rosa del Apere)
The first year this wasn't a problem, but it seems that people have learnt that it's easy to catch a fish here and they are starting to use their fishing rods.

The fish farmers think it is important to involve the communal authorities in solving the problem of theft by members of the community. They also consider that they should improve the fences and, in the future, build ponds closer to their homes to protect them from other human and animal predators.

The following and final chapter discusses the thesis' main findings in light of the wider debates introduced in Chapters 2 and 3 and concludes with recommendations for aquaculture development in the Bolivian Amazon and, more widely, conservation and development efforts in Amazonia and the role of agricultural/NRM innovations in rural development.

6 Discussion and conclusions

6.1 Introduction

In the last decade there has been renewed interest in agricultural and NRM innovations and their role in poverty reduction and economic growth in developing countries (CGIAR, 2005; DFID, 2005; World Bank, 2007). However, there is limited consensus about the role that small farms must play in this development (see Byerlee et al., 2009; Hazell et al., 2010; Lipton, 2006; Sumberg, 2006; Wiggins et al., 2010 for reviews of the debates surrounding the role of agriculture in development and the future of small farms). As discussed in Chapter 2, for some authors the positive link between smallholder development and poverty reduction has been considerably weakened by changes in local and global conditions, including: increased liberalization of international trade; livelihoods diversification away from farming in rural areas; the retreat of state intervention in agricultural R&D; the rise of supermarkets in many developing countries; and new environmental constraints such as climate change (Byerlee et al., 2009; Collier, 2008; Dorward et al., 2004a; Dorward et al., 2004b; Ellis, 2005, 2006). The relevance of agricultural/NRM innovations for poverty reduction is likely to vary according to each region and the structure of poverty and importance of agriculture in that region (Byerlee et al., 2009); the location and proximity to urban markets and access to natural resources (Wiggins and Proctor, 2001) and the socioeconomic characteristics of individual farmers (Ruben and Pender, 2004; Sumberg et al., 2004). The challenge will be to find ways of developing useful innovations for small-scale producers with increasingly diverse livelihoods working in diverse environments and in a changing world where the prospects for small farmers are deteriorating.

In light of these debates, the thesis has explored the case of aquaculture development in the Bolivian Amazon and its contribution to poverty reduction, with particular emphasis to indigenous territories. In relation to the research questions posed in section 2.3 of the thesis, the answers to those questions provided by the fieldwork investigations are set out briefly below, with a fuller summary of findings, conclusions and recommendations following in subsequent sections of this chapter:

A. The thesis examines the institutional context of aquaculture as a new innovation and the poverty effects of the R&D process using an Innovation Systems framework and graph theoretic techniques. It is concluded that the institutional context in the Bolivian Amazon limits aquaculture's contribution to smallholder development in LFAs. The Amazon Aquaculture Innovation System is weakly connected and polarised between public and private sector actors; Innovation networks are particularly weak among the former. Support has been fragmented and weak, with key missing elements and linkages (e.g. credit, extension services), limiting producers' access to information and other inputs. These weaknesses are especially disadvantageous to aquaculture success for poorer farmers and remote communities. Commercial adopters of aquaculture have partly overcome these obstacles by developing direct ties with private suppliers of inputs and services, who are beginning to step in to fill the gap arising from the absence of public provision. In time, the expansion of commercial farms could help overcome some of the institutional deficiencies that limit aquaculture's direct contribution to smallholder development at present, by encouraging the consolidation of input/output markets and increasing poorer farmers' access to information and aquaculture services. Improving marketing systems will also require strengthening producer organisations for bulk marketing.

B. Data and budgetary analysis is provided which demonstrates that aquaculture can represent a positive net addition to rural livelihoods, but the extent to which this applies depends on (a) initial livelihood conditions, and (b) the type of aquaculture being practised. When taken together (a) and (b) mean that aquaculture works much better for households whose farm production is more market oriented and who adopt more commercial and capital intensive forms of fish farming. The activity is least appropriate where production is wholly used for subsistence consumption, since capital costs and labour inputs are too high to justify a purely subsistence orientation; and other activities make better use of scarce capital resources and labour availability in subsistence communities. Labour requirements can represent a particular burden for women. Furthermore, low-external-input aquaculture systems, often integrated with agriculture, are considerably information intensive, whilst know-how and access to information in the Bolivian Amazon are very limited.

C. A valuable finding of the thesis which arises in part from the other components is that organisation of production makes a considerable difference to the likelihood of sustainability of aquaculture beyond the initial introduction of the technology, in the case of indigenous and campesino communities usually stimulated by an external agency like an NGO or aid donor. In particular, private, commercial adopters were found to have the greatest likelihood of sustaining production in the long term, linked also to location (access to markets), size of operation, and the dominance of sales in their production strategies. Communal production (for example, by all members of an indigenous community) was least likely to succeed in these ways, but interestingly it was found that sometimes communal production evolved towards a kinship model i.e. eventually ponds were run by an extended family rather than the whole community, and in this case, greater likelihood of success was observed.

Overall, aquaculture has significant potential, but weaknesses in paths of innovation need to be overcome and sequencing between different types of potential adopter needs to be considered. In particular, the absence of a coherent public sector approach to aquaculture means that perhaps the growth of commercial aquaculture in areas with access to the emergent input/output markets should be prioritised in order to ensure that institutional support systems come into existence. The private sector will provide these services if demand is sufficient from commercial adopters. Once these conditions are in place, and access to information and other key inputs becomes easier and cheaper, it could become more viable for poorer farmers and communities to take up aquaculture as an additional livelihood activity.

The results of the thesis and their relevance to wider debates surrounding agricultural/NRM innovations and sustainable development in Amazonia are discussed in further detail in this final chapter. It explores the links and interconnections between the innovation process at the farm and community level in Moxos and the wider processes within Bolivia's Amazon Aquaculture Innovation System (BAAIS), and attempts to draw some conclusions that might be of practical value to rural development workers and policymakers.

6.2 An actor oriented approach to development

The conceptual and methodological frameworks adopted in this study and described in Chapter 3 are grounded in an actor-oriented approach to development (Long and Long, 1992). The approach acknowledges the role of both structural forces and human agency in shaping social change and the need to account for multiple realities, history and context. In the field of rural development and NRM innovations, it recognises that different alternatives exist for different people in different places and times, and that this requires a very context-specific analysis and an understanding of local environments, peoples' livelihoods and institutional settings. Local level analysis is here aided by the Knowledge Engineering Approach (Reece et al., 2003; Sumberg and Reece, 2004) and Livelihoods perspectives. The former is particularly useful in helping define and characterise often poorly understood innovations and increase the effectiveness of poverty focused technology development and extension efforts. Livelihoods analysis provides a valuable framework for understanding farmers' diverse 'rural worlds', including their possible interest in and access to proposed innovations. Chapter 5 explored the case of a pro-poor aquaculture development project in two indigenous territories in Beni. The answers to the initial research questions are, necessarily, context-specific: Who can afford and/or is willing to adopt aquaculture and why - in this setting and at this time?

However, addressing who might afford and/or might be willing to adopt aquaculture and why - in other settings and/or at other times in the future – requires cutting across scales and looking at the links between the innovation process at the farm level and the wider national context. Aquaculture development and extension in indigenous territories in Moxos cannot be understood in isolation. The innovation process at the farm or community levels is inextricably linked to developments in the wider sector, within input/output markets, government bodies, research organisations, NGOs, fish farmers in other regions etc. As Thompson and Scoones highlight, "While individual farmers in particular places may be our empirical focus, their options and opportunities must be understood in relation to processes interacting across scales, from the very local to the global" (2009: 394). Thus, Chapter 4 analysed the development of Amazon aquaculture and its role in poverty reduction at a national scale: What does Bolivia's Amazon Aquaculture Innovation System look like? How effective is it in producing and diffusing aquaculture technologies? Is it pro-poor? How do small farmers integrate into BAAIS? How is it likely to evolve under different scenarios? What policies might increase the odds of desired outcomes within BAAIS?

The actor-oriented paradigm offers a different approach to the study of how societies produce, exchange and use knowledge from the classical Diffusion of Innovations Theory (Rogers, 1983). The Innovation Systems approach adopted in this study sees knowledge development as a social process, the result of interactions between different actors and networks through which information is created, communicated and negotiated. Although some actors have more influence than others, no single actor or group can control the process entirely. Actors define and redefine their strategies in relation to interactions with others and a changing environment and, in turn, attempt to modify the environment in ways that might further their own agendas (Spielman et al., 2009). Behaviour patterns are difficult to 'manage' or predict, often resulting from unintended processes; the nature and characteristics of an innovation system cannot be understood by analysing individual actors as separate entities. The study of Bolivia's Amazon Aquaculture Innovation System is aided by graph theory techniques to map relationship dynamics and information networks (Temel, 2006, 2007), to help uncover the system's workings (and non-workings) and devise ways to strengthen it and support more effective information flow.

6.3 Pro-poor aquaculture development in context

The study of pro-poor aquaculture development in Moxos has shown that: (i) the average value of a day's labour in pacú farming in the TIM and TIMI indigenous territories is significantly higher than what could be earned by a day's work in the local labour market and (ii) several groups of farmers show considerable interest in this activity, despite its seasonal nature. However, the development of aquaculture under any form in Moxos has only been possible because of efforts by local NGOs and external assistance organisations to increase small producers' access to information, credit and the markets for aquaculture inputs and associated services. The sustainability of pacú farming in indigenous communities in the future will depend on fish farmers' ability to ensure their continued access to information and input/output markets. Here the role of ASOPIM, the local producer association, in helping to pool resources and increase small farmers’ access to aquaculture will be fundamental. Nevertheless, the sustainability of pacú farming in TIM and TIMI will also be influenced by changes in the priorities of local government and NGOs, the consolidation and decentralisation of input/output markets in Moxos and Beni, particularly for fry and feed, and developments in the wider sector, i.e. the direction taken by Bolivia’s Amazon Aquaculture Innovation System and the priority that is assigned to poverty reduction in BAAIS.

6.4 Subsistence fish farming for the poorest of the poor in the Bolivian Amazon: limitations of the approach

As discussed in Chapter 2, in recent years there has been growing interest in the role of aquaculture as an instrument for poverty reduction and economic growth in developing countries. In the Bolivian Amazon, the last decade has seen a rise in pro-poor aquaculture development projects aimed at increasing rural food security and economic development (for example Canal, 2007; Castañón et al., 2002; IAS, 2003; Pascual, 2005a; PRODISA-Belga, 2005; Sakamoto and Suárez, 2005; SIBTA, 2006; UTB, 2004, 2005; Viruez, 2005). However, as interviews with NGOs, farmers and other actors that were involved in these initiatives have shown, many of the positive impacts of the projects were short lived and ended once subsidies and external support were withdrawn (section 4.7). A frequent mistake has been to try and involve a whole community in managing small, multi-functional fish ponds for low external-input subsistence fish farming that has limited growth potential but requires significant investment in time, know-how and organizational capacity.

Low-external-input subsistence aquaculture systems for the poorest of the poor in the Bolivian Amazon are, at present, neither possible nor desirable. On the one hand, they are not viable within a small and weak sector that has yet to be consolidated; where even the wealthier farmers with greater access to urban markets face difficulties in accessing information and other inputs and where there is little tradition and know-how of input-extensive but information-intensive integrated systems. On the other hand, low-external-input subsistence aquaculture systems are not attractive to many farmers. In the Bolivian Amazon, as in other regions (Brummett et al., 2008), returns from these small-scale systems are often so low that even among resource-poor farmers there is little interest in adoption.

6.4.1 The Innovation System is weak and input markets are underdeveloped

There is evidence that small scale, subsistence, integrated aquaculture systems have contributed to food security and livelihoods enhancement in countries where there is a long tradition of fish farming, particularly in Asia (Ahmed and Lorica, 2002; Demaine and Halwart, 2001; Edwards, 1999, 2000; Roos et al., 2002). Nevertheless, the same has not always been true in other regions, such as in Africa or Latin America, where fish farming is a relatively recent development (Brummett et al., 2008; FAO, 1997; Martínez-Espinosa, 1999a; Moehl et al., 2006). In these regions the market for aquaculture inputs and services is limited and often centralised in and around major cities; few people in government, research centres or the private sector have experience or training in aquaculture and the role of the public sector in research and extension is small and decreasing. In the African context, Moehl *et al.* came to the conclusion that "aquaculture is tough business" (Moehl et al., 2006: vii). The same can be said of the Bolivian Amazon.

The study of the aquaculture sector in the Amazon region of Bolivia and the survey of fish farmers presented in sections 4.3 and 4.4 showed that aquaculture production based on indigenous species is significantly higher than official estimates and that there has been important progress in the introduction and development of generic technologies and input markets. Although this trend offers hope for the sector, producers still find it difficult to access the information and many of the inputs they need to adopt aquaculture. The study also shows that fish farmers in the Bolivian Amazon do not live by fish farming alone, but rather aquaculture is a supplement to agriculture, cattle ranching or the catering and tourism industries.

The analysis of BAAIS portrays a weak innovation system with very limited participation of the public sector components, hardly any extension services and no financing mechanisms. The analysis of pro-poor aquaculture development has shown that no indigenous or *campesino* farmer has set up a fish farm without external assistance and that most resource-poor farmers rely on a single source of information and aquaculture inputs: a local NGO. While larger producers have established important direct ties with input and service providers in BAAIS and often have more than one source of fry, feed and information, small farmers tend to access input/output markets and providers with the local NGO acting as a go-between. This shows that pro-poor aquaculture is fragile and particularly susceptible to any change in the structure or dynamics of the innovation system. If a group of farmers in a given area is relying on a single source of information and inputs for aquaculture and that source stops operating or moves away, as often happens, then production in the whole area is compromised.

Because of the characteristics of the aquaculture sector in the Bolivian Amazon at this early stage of its development, pro-poor fish farming will not be sustainable over time if introduced to favour food security in remote areas where input/output markets and support services are absent and the costs of accessing information and other inputs high – even if there is local demand for pacú, and great agro-ecological potential and natural ponds are available. Pro-poor aquaculture development projects targeting the poorest of the poor in remote areas of lowland Bolivia will benefit from taking into account the distinction made by Sumberg (2005b) between "constraints" and "pre-requisite conditions" for the adoption of innovations. If wider context elements are not favourable, it is very unlikely that aquaculture technologies will be adopted by resource-poor farmers or be sustainable in the long run (Sumberg, 2005a).

6.4.2 Integrated low-external-input systems are information intensive

In Bolivia there is no national extension agency designed to promote the fisheries and aquaculture sector (see section 4.4.4). The private sector is the main disseminator of information and knowledge about aquaculture innovations to farmers, occasionally via expert consultants, but more frequently via fry and feed providers who act indirectly as 'extension agents' whilst marketing their products. Lack of 'know-how' is still an important drawback to the adoption of aquaculture technologies. This is particularly so in the case of poorer farmers, who often cannot afford the high transaction costs associated with information acquisition.

Pro-poor aquaculture development projects in the Bolivian Amazon have tended to favour the development and extension of integrated agriculture-aquaculture, low-external-input technologies, as these have been seen as more accessible and suitable for resource-poor farmers. It has been argued that integrated systems make more efficient use of the farm's overall resources when compared with stand-alone enterprises (Pant et al., 2005; Prein, 2002) and that they are more accessible to resource poor farmers as they are less capital intensive and susceptible to risk from diseases or price fluctuations. Some authors have also argued that integrated systems are less information intensive than stand-alone enterprises (Prein, 2002).

However, it could be questioned whether the management of a multi-enterprise system, which requires planning the production calendar so that the outputs of one subsystem required as inputs for another are available at the right time and in the right amount, does not require a fair amount of know-how too (!). In fact, the case study of aquaculture development in Moxos in Chapter 5 suggests that, contrary to what might be expected, integrated low-external-input technologies, such as those grouped under the "Chaco system," are more information intensive than technologies with greater reliance on external inputs, such as those grouped under the "Commercial system" (see Table 5-10). Therefore, the Chaco system technologies tend to be more prone to technical problems and failure in a context where there is little experience in fish farming and access to information is limited (see for example the four communities with negative returns from fish farming in Table 5-5).

All the fish farms examined in the Moxos case study were integrated with agriculture to some extent and all of them were relatively extensive in terms of stocking densities and energy inputs. However, under the Chaco system, farmers use foodstuffs from their Chaco (slash and burn agriculture) as supplementary feed for pacú farming, whilst under the Commercial system, the bulk of the supplementary feed is purchased. All fish farmers share some common risks (e.g., predators, periods of drought, poor water quality), but under the Chaco system, home-made feed is an additional source of potential problems. Home-made supplementary feed tends to be poorer in protein (see section 5.3.1), substantially slowing down growth and making fish more susceptible to disease. Furthermore, experience in the field shows that home-made feed is not always 'mechanically fit', in which case it either dissolves so rapidly in water or precipitates so rapidly to the bottom of the pond that a lot of it goes uneaten, contaminating the water and reducing oxygen availability. The success of fish farming under the Chaco system depends largely on the quality of the home-made feed, which varies in relation to the producer's experience and annual access to high protein crops, such as soya and frijol. This is reflected in the wide range of results obtained by different farmers and communities using the Chaco system. Some communities, such as Retiro and San José del Cavitu, obtained substantial net returns (Table 5-5) and were greatly encouraged. However, this was not the norm, yields were often small and, in some cases, such as in Bella Brisa and Argentina (2), net returns after cash and labour costs were negative. Obviously, there were also differences in the returns obtained by producers using the Commercial system, but in general, outputs were more homogeneous and in all cases a net benefit was obtained after cash and labour costs. The disparity of results obtained under the Chaco system and the Commercial system is represented in the Figure 6-1. The graph illustrates the normalised variations in output (in terms of net returns after total costs) of all fish farms under the Chaco and the Commercial systems with respect to the best performers (those fish farmers who obtained the highest net returns under each system).

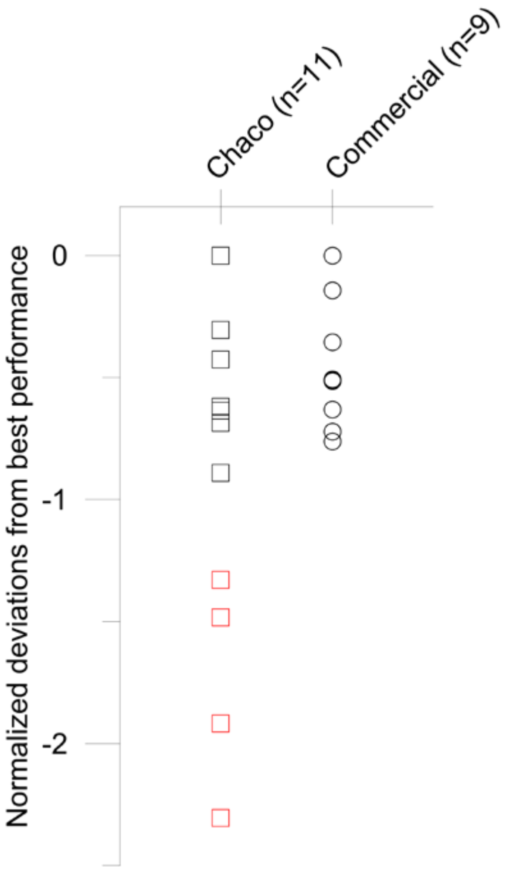


Figure 6-1 Variability of outputs obtained by farmers under the Chaco and Commercial systems. Y axis: Normalised differences in 'outputs' of fish farmers in relation to best performers. 'Outputs' = net returns per hectare after total costs. Y = (Performer N – Best Performer) / Best performer. Red squares correspond to those fish farms under the Chaco system where net returns after cash and labour costs were negative.

The sample studied is small, and some differences can be the result of chance, such as a caiman or a nutria getting in a pond. Nevertheless, the experience in Moxos suggests that integrated low-external-input technologies are not the 'easiest' option, with regards to information requirements, for people trying out pacú farming for the first time in their lives.

At the centre of the move towards greater participation in agricultural research and extension that emerged in the 1980s (Chambers, 1994; Chambers et al., 1989) was the recognition that farmers are active partners in technology development processes and not just passive recipients of externally derived innovations. This view stresses the importance of local knowledge and the idea of farming as a skilled and knowledgeable activity and not an automatic, routine procedure. This is probably even more the case for "low-external-input agroecological systems, where knowledge and labour serve as a substitute for external inputs" (Thompson and Scoones, 2009: 392). Research shows that there are significant similarities between the methods of formal research and those of farmers (Clark et al., 2003; Sumberg and Okali, 1997) and that the latter can play a significant role in fine-tuning techniques to suit individual circumstances. It has been argued that the R&D process could benefit from handing over technologies to farmers before their full specification (Reece and Sumberg, 2003; Sumberg et al., 2003). However, some technologies might leave more room than others for end-user fine-tuning. The 'partial substitutability principle' (Sumberg et al., 2003) might be particularly useful when an innovation implies the modification of an activity that farmers are already practicing. However, when the innovation being promoted is completely new to a region or group of farmers, such as aquaculture in the Bolivian Amazon, then releasing the technology too soon can place heavy demands on farmers. The promotion of integrated low-external-input pacú farming that requires the orchestration of the production calendar in a way that agricultural outputs are available at the right time and in the right amount to ensure a regular supply of supplementary fish feed in a region with no fish farming tradition is a major challenge. Perhaps, the development of more fully specified aquaculture technologies based on commercial feeds needs to precede the development of more information-intensive integrated systems. Fish farmers (and extension workers!) will need time and experience to better adapt technologies to individual circumstances, to find ways to reduce costs by building new synergies between aquaculture, chaco and livestock production and, if appropriate, develop increasingly cost-effective home-made feeds.

In a recent review examining the impact of rural development projects promoting low-external-input technologies in Africa, Asia and Latin America, Tripp (2006) concludes that although these types of technologies can contribute to improved farm productivity and environmental conservation, there is no evidence to support the idea that they are particularly suited to poor, diversified farmers. The case studies suggest that wealthier farmers with better links to markets tend to be more able to take advantage of low-external-input technologies, as is also the case with other types of innovations (Tripp, 2006). This may also be true for fish farmers in lowland Bolivia. Fish farmers, both large and small, could benefit from the development of innovations that increase the overall efficiency of their farms and reduce reliance on external inputs. However, at present and in the context of Bolivia's Amazon Aquaculture Innovation System, poorer farmers may find integrated low-external-input technologies as difficult to adopt as more input-intensive ones.

6.4.3 Integrated low-external-input systems provide low returns on labour

Low-external-input technologies, often promoted by pro-poor aquaculture development projects, have not always received as much interest from farmers as might have been expected. Brummett et al. (2008) report that in Africa, even with project subsidies, the returns from these types of small-scale fish farming operations have sometimes been so low that they have attracted limited attention even among resource-poor farmers. This has also been a problem in the short history of pro-poor aquaculture development initiatives in the Bolivian Amazon (see sections 4.7.2 and 4.7.3). Building on the premise that more intensive and market oriented farming technologies require inputs and resources that the poor do not have, projects have generally promoted small-scale subsistence farming. But what these projects have often overlooked is the fact that low-external-input 'affordable' technologies do not necessarily provide high returns on labour. On the contrary, not only do they require skills (as discussed in the previous section), but they can also be very labour intensive, with household labour being used as a substitute for external inputs. It has been argued that poor households with diversified livelihoods might find it hard to adopt these kinds of technologies due to labour constraints (Tripp, 2001). In defining technologies that could be accessible and attractive for poorer households it is fundamental to take into account the dynamics of the local labour market and alternative employment opportunities in other areas, including migration (ADB, 2004). As the percentage of non-farm income and employment opportunities increase, the gains expected from adopting a new agricultural/NRM innovation will have to be higher (Sumberg et al., 2004).

In the case of rural Moxos, labour migration to urban areas or employment opportunities in timber mills or cattle ranches compete with on-farm activities and reduce the availability of on-farm labour. Farmers will only adopt NRM innovations if they represent a more profitable use of their labour. The value of labour in fish farming in Moxos varies considerably among the different communities and farms analysed in section 5.3. On average, the amount of work needed to produce 1 kilo of gutted fish in TIM and TIMI is 3.5 times higher under the Chaco system than under the Commercial system, because of the extra labour needed to harvest and prepare supplementary home-made feed. For those using the low-external-input technologies of the Chaco system, the value of labour is 2.96 US$/day, about the same as in the local market for hired labour at the time of the interviews. However, fish farming returns are seasonal and many poorer household may have urgent needs that require more immediate income. Furthermore, in low-external-input systems, fish harvested at the end of the production cycle are often too small to fetch a good price. This is particularly a problem in Beni, where the market is accustomed to large specimens of wild pacú (*Colossoma* spp.), tambaquí (*Piaractus* spp.) or surubí (*Pseudoplatystoma* spp.). If the end result is limited to fish for household consumption, the Chaco system might represent too high an investment in time to justify adoption, particularly if the household has other sources of animal protein such as fishing, hunting or the raising of fowl. Furthermore, under the Chaco system the growth potential for aquaculture is limited, as the surface area that a household can manage will always be conditioned by the availability of household labour and the size of their Chaco.

Some authors have stressed the important contribution that fish farming can make to improve the situation of rural women in particular. The fact that ponds tend to be close to households means that women, who are often less mobile, can play a central role in husbandry (Boll and Garádi, 1995; Bouis, 2000; Setboonsarng, 2002; Wetengere, 2009). The data from TIM and TIMI presented in section 5.4.2 reinforces the idea that women play a central role in pond management. Women do most of the work, preparing supplementary feed, feeding the fish and harvesting. However, this may be a heavy burden for the women if the type of aquaculture practiced involves technologies that are extensive with regards to external-inputs but intensive with regards to labour requirements.

The survey of fish farmers presented in Chapter 4 reveals that the majority of indigenous and campesino farmers involved in pro-poor aquaculture projects are interested in fish farming so that they can sell at least a part of the harvest and have a new source of cash income. Many farmers consider that these fish farming projects are too small and their growth potential too limited to have any substantial impact on their livelihoods (see sections 4.7.2 and 4.7.3). Some pro-poor aquaculture development initiatives have realised this and their focus is beginning to shift towards more commercial forms of aquaculture, for example in Moxos, or the Alternative Development programme in the coca-growing region of Chapare.

The development of pro-poor aquaculture technologies must take into consideration the costs of labour, particularly in areas where the opportunity costs of labour might be rising due to rapid economic development and the growth of the markets for hired labour. In fact, low-external-input technologies are in many aspects no different to any other technology with different inputs (Thompson and Scoones, 2009). According to these authors, the practically 'universal acceptance' of this type of technology by rural development NGOs and their focus on diffusion and expansion may mean they overlook the diversity of farming communities and their often rapidly changing environments. Thus, the NGOs have not engaged in the wider debate: how to favour the development of agricultural innovation systems able to respond to this diversity of needs and expectations and deliver a wider range of technology choice (ibid). Projects aimed at encouraging changes in farming systems among shifting cultivators have often failed to acknowledge that farmers will not change their traditional practices unless alternatives represent a better use of their time (Brown and Schreckenberg, 1998).

6.5 Subsistence and communal fish farming in indigenous territories: limitations of the approach

The ‘integrated conservation and development approach’ (Hall, 2000a) is at the centre of most projects involving indigenous communities in the Bolivian Amazon. The idea behind integrated conservation and development projects is that indigenous peoples’ standards of living can be improved whilst meeting conservation objectives by providing incentives for people to move away from environmentally destructive practices in favour of more benign alternatives. These projects aim to reinforce traditional indigenous ‘values’ and land-use practices (Brown and Schreckenberg, 1998; Posey, 2000) and favour low impact patterns of resource use, such as extraction of non-timber forest products, agro-forestry, low-impact logging etc. (Allegretti, 1994; Azevedo-Ramos et al., 2006; Gockel and Gray, 2009; Hoch et al., 2009; Panayotou and Ashton, 1992; Peters et al., 1989; Schwartzman et al., 2000). Fish farming projects in indigenous territories have often taken this approach too. Fish farming has often been presented as a low-impact technology, easily integrated with traditional agricultural and extractive economies, one reason being pacú and tambaquí’s variable diets and preference for fruits and seeds (Araujo-Lima and Goulding, 1997; Gram et al., 2001; Smith, 2000). In practice, this has meant the promotion of low-external-input systems that tend to have limited growth potential.

By putting forest dwellers at the centre of sustainable development efforts in Amazonia, there is no doubt that productive conservation has played a pivotal role in securing land rights and empowering indigenous peoples. Access to land and forest resources is particularly important to poorer households and serves as a safety net in times of crisis (Arnold and Pérez, 2001; Coomes et al., 2010; López-Feldman and Edward, 2009). Nevertheless, conservation and development projects have sometimes been unrealistic about the livelihoods and expectations of indigenous communities (Redford and Stearman, 1993). Many forest product activities are labour intensive and generate low returns. These activities are likely to be abandoned if more rewarding alternatives become available and household labour becomes scarce (Arnold and Townson, 1998; Byron and Arnold, 1999; Novotny, 2010). Indeed, although access to forest resources and traditional livelihoods is important in mitigating poverty, it has been argued that the path out of poverty might not involve the use of non-timber forest products or other low-impact traditional land use systems (Wunder, 2005) and that their contribution to conservation and development objectives has been overstated (Arnold and Pérez, 2001; Clough et al., 2009; Coomes et al., 2004; Ezebilo and Mattsson, 2010; Homma, 1994; Manzi and Coomes, 2009; Ndangalasi et al., 2007; Pokorny et al., In press; Redford, 1992; Wunder, 2001).

Ultimately, sustainable development in Amazonia is likely to require a combination of strategies and approaches: productive conservation, protected areas, paying for environmental services and 'debt-for-nature swaps' (Börner et al., 2010; Edwards et al., 2010; Fearnside, 1997; Hall, 2008); innovations in agriculture and NRM systems among small farmers (Dorward et al., 2004a; Dorward et al., 2004b; Renkow, 2000), stimulating regional development around existing settlements in frontier areas and investing in institutional reform and human capital (Carvalho et al., 2001; Illukpitiya and Yanagida, 2010; Lovejoy, 2000; Southgate, 1998) and expanding the market for rural non-farm jobs (Ellis, 2004, 2006). Perhaps what should be of greatest concern, from a policy perspective, is how indigenous peoples' livelihoods, expectations and relationships with their natural environment are changing over time in particular territories and socio-political contexts. One-size-fits-all solutions will not do. Different alternatives will exist for different peoples in different territories and generalisations are bound to be, at best, unhelpful.

6.5.1 Changing livelihoods and expectations in indigenous territories

Indigenous territories and communities in the Bolivian Amazon are many and diverse. Indigenous peoples' needs and expectations will be influenced by differences in their livelihoods, the physical characteristics of their territory, their production environment and degree of market integration, not to mention cultural and ethnic background. In the case of the Mojeño Ignaciano (TIMI) and Multiétnico (TIM) indigenous territories, livelihoods analysis suggests that, to some extent, all communities are experiencing changes due to growing pressure on resources and new expectations and economic needs created by increased access to markets, education, health care centres etc. (see section 5.5.1). Changes are only likely to increase, particularly in TIM, if the project goes ahead to build a road through TIM linking San Ignacio to Cochabamba (Lorenzo, 2011). These changes have already brought about high rates of migration among the young and a gradual diversification of sources of income, as has been documented in many other parts of rural Amazonia (Salisbury and Schmink, 2007; Steward, 2007). Although slash and burn agriculture and extraction are still the most important sources of income for the Moxos communities, the sale of labour in cattle ranches and timber mills is the most important source of cash income.

It has been claimed that diversification among poor households tends to have a negative impact on the effectiveness and benefits of NRM R&D and the adoption of innovations (Renkow, 2000; Sumberg et al., 2004; Tripp, 2001). However, diversification varies in relation to causes and outcomes, for example as a response to shocks, or as a risk management strategy (Ellis, 2000), within the agricultural sector, or outside of it (Reardon, 1997). The degree and 'nature' of livelihoods diversification influences farmers' interest in and access to new agricultural technologies and innovations. In the case of Moxos, results suggest a positive link between intra-sectoral diversification (within the agricultural sector) and adoption of aquaculture. The livelihoods survey of TIM and TIMI indicates that those households that take up fish farming are proportionally more dependent on agricultural and livestock activities than non fish farmers and their farm production is more market oriented. Farmers who experiment with aquaculture are also often involved in other NRM innovations, trying to diversify their on-farm production and steer it towards more commercial activities (see section 5.5). Hartwich et al. (2007) also found a positive link between adoption rates of aquaculture technologies and farmers with a positive attitude toward change and interest in experimenting in their study of local innovation processes in four communities in Bolivia exposed to aquaculture development and extension efforts.

Clearly differences also exist among communities in TIM and TIMI with regards to sources of income and production environments. Nevertheless, on the whole, in TIMI and North-East TIM, increasing access to markets is creating a stronger logic for intensification. And the logic for intensification is likely to increase even among those communities in the more remote South-West TIM if the road to Cochabamba is completed (Figure 5-1). Communities report that fishing and hunting is today harder than in the past. However, those interested in aquaculture do not see this innovation as an alternative to falling returns from these traditional activities. Most households, 90% of those interviewed, are primarily interested in aquaculture as a potential source of cash income, in other words, as an alternative or a supplement to the sale of labour and other cash generating activities. The aquaculture project in Moxos has shown that the functionality threshold[59] for aquaculture in TIM and TIMI is often higher than was initially expected.

Low-external-input subsistence fish farming operations with little growth potential are not appropriate for the indigenous territories of TIM and TIMI for the same reasons that they are not appropriate for campesino farmers in Chapare or small-farmers in other parts of the Bolivian Amazon: they are not sustainable or financially feasible within BAAIS today, there isn't the know-how and for many indigenous households the effort required is just not worth their while.

6.5.2 Community versus kinship ties

Integrated conservation and development projects in Amazonia, such as the extraction of non-timber forest products, low-impact logging or ecotourism, often require the involvement of the entire community and favour collective action. Pro-poor aquaculture development initiatives in indigenous territories in lowland Bolivia have also tended to favour community-based farming (see section 4.7.2). The benefits of targeting the community as a whole are many: pooling capital for the 'set up' phase, sharing risks, reducing the costs of accessing markets and information, channelling municipal and NGO resources and credits and ensuring that the benefits of the project are distributed equitably among community members. It has also been suggested that this type of project and the institutional arrangements that are required can help strengthen cooperative capacity in other areas of community life (Pretty and Ward, 2001; Sultana and Thompson, 2004). Nevertheless, cooperation is not cost-free. It entails negotiating collective agreements, monitoring and enforcing them (Aggarwal, 2000). In community based projects involving NRM innovations, such as aquaculture in lowland Bolivia, where there is limited understanding of the innovation in question and limited knowledge about the potential payoffs of cooperation, farmers' willingness to participate will be greatly conditioned by their feelings for and trust in group members (Cárdenas and Ostrom, 2004). It has often been assumed that this willingness to participate in collective action will be greater in indigenous communities in Amazonia

[59] The minimum objective performance (independent of price) that a given technology must deliver in order to interest a farmer (Levinthal, 2001: 615 quoted in Sumberg and Reece, 2004)

than within other communities and social groups, because social capital in the former is thought to be high. However, as already stressed in the previous section, indigenous territories and communities in Amazonia are many and diverse, and although there is considerable evidence of forest peoples with a strong tradition of collective action there is just as much evidence of the opposite (Redford and Stearman, 1993). In the case of TIM and TIMI in Moxos, many communities were founded only recently (during the last pilgrimage in search of the Loma Santa[60], which took place in 1984) and they comprise families of diverse ethnic backgrounds (see section 2.2.4). It is not uncommon for families to move from one community to another, looking for greater access to markets and schools or pastures, timber and other natural resources. Furthermore, a history of cultural and economic colonisation has seriously eroded traditional institutions (Albó, 1994). However, new organisational forms and institutions are being built among indigenous peoples in Beni (Ávila-Montaño, 2006) within a growing movement that started in the 1990s with the first national protest march demanding rights for indigenous peoples over their traditional lands (Ávila-Montaño, 2003). The author's personal experience with rural development projects in this region suggests that some communities have more cooperative capacity than others and have been more successful than others in implementing community-based initiatives such as purchasing communal cattle, setting up a brick kiln or low-impact logging operations. These communities are often more isolated, for example, some of the communities in South-West TIM, or smaller and more homogeneous with regards to kinship ties, for example, Villa Esperanza in TIMI, where nine out of the ten households are related. But many variables affect incentives, patterns of interaction and outcomes associated with self-organisation and common-property regimes. Agrawal in his study of common property institutions described more than thirty (Agrawal, 2001). Identifying what characteristics of the rules governing Common Pool Resource settings, or design principles (Ostrom, 1990), will favour sustainable results and long-enduring resource governance is far from straightforward; there are no simple predictive models or panaceas (Ostrom, 2007). Perhaps in some communities in Moxos there is a place for communal management of aquaculture ponds. But the

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[60] La *Loma Santa,* or Sacred Land, is thought to be a place that never floods, rich in game and pastures and 'free of evil' (Jordà, 2003)

study of fish farming groups presented in sections 5.4 and 5.6.3 suggests that, on the whole, ‘farming all together’ has posed too heavy a burden on community institutions, particularly within low-external-input subsistence farming systems that require harvesting and preparing supplementary fish feed. As predicted by Common Pool Resource Theory, the bigger and more heterogeneous the community/group of farmers is, the more complex the organisational task becomes (Agrawal, 2001). Nevertheless, few households are able to incur the costs of setting up a fish farm on their own, particularly if it entails the construction of a pond. In TIM and TIMI, over time, fish farming groups have tended to evolve in two ways: they have become smaller, with an average of 5 or 6 households per farm and they have become more homogeneous in terms of kinship (section 5.4.3). Drawing from this experience, aquaculture development and extension in the region in the future might benefit from favouring small ‘family groups’ to set up and manage fish farms.

Encouraging the management of fish ponds by individual households or ‘family groups’ (rather than community based aquaculture) should go hand in hand with efforts to strengthen producer organisations at the community, regional and national levels. Experiences in other parts of the country have highlighted the potential for indigenous and campesino federations to contribute to the sustainable intensification of rural livelihood opportunities (Bebbington, 1996), by helping secure rights, improve access to existing and new markets, increase small farmers’ bargaining power and attract support and services from the government and external assistance organisations.

6.6 Pro –poor commercial aquaculture - for the less poor and better organised?

The previous sections have highlighted how low-external-input subsistence aquaculture for small farmers in remote areas is not sustainable or financially feasible in the context of Bolivia’s Amazon Aquaculture Innovation System at present. On the other hand, in areas closer to markets where the costs of accessing information, fry and other inputs are lower and the production environment favours technologies with a stronger logic of intensification, producers are often not interested in low-external-input subsistence aquaculture with limited growth potential. These conclusions seem to support the thesis of those authors who argue that ‘pro-poor aquaculture’ is a contradiction in terms and that promoting aquaculture to alleviate poverty is thus promoting a rich man's technology for a poor man's problem (Chapman and Abedin, 2002; Gupta et al., 2002). The evidence of lowland Bolivia does suggest that aquaculture's direct contribution to livelihoods enhancement and food security among the poorest of the poor will be limited in the context of BAAIS, with limited public sector investment, small, centralised associated markets, expensive inputs and human capital in short supply. Nevertheless, as Edwards et al. note, in some situations small farmers might benefit from operating higher input and higher cost aquaculture systems (Edwards et al., 2002a). The financial feasibility analysis of aquaculture in Moxos has shown how pacú farming in rain-fed earthen ponds using commercial feeds to supplement part or all of the fish's diet has important growth potential. In Moxos the commercial pellets used were not of the best quality, they were not extruded and were produced using only soy, maize, rice bran and wheat. Nevertheless, average net returns after total costs under these systems in the indigenous communities were around 2,500 US$/Ha and reached 5,000 US$/Ha in the Mausa experimental station, suggesting that there is still considerable room for improvement. Perhaps 'the less poor' living closer to aquaculture input/output markets could directly benefit from the adoption of this type of aquaculture technology. One could argue that it is precisely access to 'the rich man's technology' and activities with growth potential that will allow for the accumulation of capital that 'the poor man' needs to escape poverty.

6.6.1 Aquaculture as a business

These results are in line with recent developments in several countries in Asia and Africa that have seen the emergence of small and medium-scale enterprises with a more commercial orientation (Beveridge et al., 2010). There is now a growing consensus that past efforts to involve the poorest of the poor in subsistence or artisanal aquaculture systems have been disappointing and that rural development and poverty reduction objectives might be better met by favouring more capital intensive and commercial forms of aquaculture (Allison, 2011; Belton et al., 2012; Beveridge et al., 2010; Brummett et al., 2008; Moehl et al., 2006; Stevenson and Irz, 2009). In the case of Africa, Moehl et al. conclude: "There is now a clear need to move beyond subsistence aquaculture and to deal with aquaculture as a business; be it a micro-, small-, medium-, or industrial-scale enterprises" (2006: 7). Whilst it is acknowledged that subsistence or artisanal aquaculture can be an important poverty prevention measure by helping small farmers recover from shocks and reduce their vulnerability, it is argued that more commercially-oriented aquaculture can contribute to poverty reduction by facilitating accumulation of capital, generating economic growth and employment in value chains (Belton et al., 2012; Béné et al., 2010). The key difference between what Brummett et al. call ‘artisanal farmer’ and ‘commercial enterprises’ is not in size and stocking densities, the main difference is that while the former seek food security and farm diversification, the latter understand the concept of cash-flow and are seeking a new source of cash income in fish farming (Brummett et al., 2005).

In Bolivian Amazon aquaculture, ‘intensification’ is mainly a function of the amount and/or quality of feed supplied, as metabolic waste removal through pumping is expensive and difficult to employ. As a result, as in many African countries, production systems are normally most profitable at some intermediate level of intensification (Brummett et al., 2008). ‘Commercial’ systems do not necessarily involve large-scale ‘industrial’ farming at high stocking densities and open (i.e. high water exchange) pond, tank or cage-based systems. In some countries in Latin America it is these kinds of large-scale, export-oriented operations that are taking the lead in aquaculture, such as shrimp farming in Ecuador and salmon farming in Chile (FAO, 2006). However, in the Bolivian Amazon, where land and water are cheap and energy is expensive, ‘industrial’ aquaculture does not exist. The aquaculture survey carried out for this thesis has shown that average yields per unit area are 3.18 t/ha/yr. The bulk of aquaculture production in the region comes from entrepreneurs engaged in agribusiness and/or the catering industry and tends to be a sideline business. Even in the most ‘intensive’, stand-alone fish farms in the area of Trinidad, yields per hectare are relatively small, below 6 t/ha/yr (section 4.3).

Some authors have suggested that rural development and poverty reduction objectives can be better met by favouring the development of a greater number of smaller and medium-scale commercial fish farms (Brummett et al., 2008). The potential contribution of large-scale industrial aquaculture to foreign exchange earnings and employment is acknowledged (Hishamunda and Ridler, 2006; Hishamunda et al., 2009; Muir, 2005). However, it is argued that large-scale aquaculture businesses will tend to concentrate wealth much more than a greater number of smaller commercial investments. "Getting people out of poverty is a function of income growth. However, the distribution of wealth is crucial to the rate at which income growth by investors is translated into national poverty reduction" (Brummett et al., 2008: 383).

Constraints on the development of commercial enterprises in the Bolivian lowlands are many: poor infrastructure, unreliable energy supply, poor market development, limited access to credit, lack of investment in R&D, political instability, etc. In the case of commercial aquaculture, producers are faced with additional problems: the supply of fingerlings, feed and information is centralised and expensive, and marketing infrastructures are limited. Fish farming with a commercial focus, be it small, medium or large, will be more likely to succeed in areas with easy access to the emerging aquaculture input/output market. Moehl et al. (2006) call these areas 'high potential zones' able to house 'clusters' of aquaculture activity, and argue that efforts to develop the sector should focus on these clusters. IFPRI's study of local innovation processes in four communities in Bolivia exposed to aquaculture development and extension efforts shows how those farmers with better access to markets are more likely to adopt aquaculture technologies (Hartwich et al., 2007).

In the Bolivian Amazon at present the largest cluster of aquaculture activity is in Santa Cruz de la Sierra, a major agro-industrial centre. Six of the nine hatcheries operating in the region at the time of the interviews were in Santa Cruz, as were three of the four fish feed factories. Furthermore, Santa Cruz has the university-linked research station and hatchery 'El Prado', which, despite the problems with its *modus operandi* highlighted in section 4.4.2, is an important actor in BAAIS. Other 'high potential zones' might include the area around the input markets of Trinidad and San Ignacio, with relatively good access to fry, feed and information, as well as particularly favourable impermeable clay soils (Boixadera et al., 2003) and a warm climate. However, in comparison with Santa Cruz, the local market for farmed fish is smaller and buyers are more exacting about fish size. The region of Chapare, in the humid tropics of Cochabamba, has great potential for commercial aquaculture: pond construction is cheaper than in other regions because of the unevenness of the terrain, which allows secondary rivers and streams to be dammed; it is near the Cochabamba market where buyers are not so concerned about fish size as in Trinidad and will pay up to 100% more. Furthermore, Chapare hosts Pirahiba, one of the best equipped hatcheries and experimental stations in the region and administered by the state university Mayor San Simón. The main problem facing Chapare at the time of the study was that Pirahiba could not ensure a regular supply of seed and there was no regional supply of feed. At the time of the interviews, both were being imported from Santa Cruz de la Sierra or from neighbouring countries, significantly increasing production costs. The area of Yungas in La Paz and Rurrenabaque and San Borja (south-west of Beni) could potentially target consumers in the city of La Paz, but at present the market for aquaculture inputs and services in the area is too small and unreliable and experience is limited (section 4.4.5). No data are available for the department of Pando and the region of north Beni, as due to time limitations they were not included in the study of BAAIS.

6.6.2 Producer associations

Concentrating efforts to develop aquaculture in high potential zones that can host clusters of aquaculture activity and input/output markets will also facilitate greater association among producers. In regions with little aquaculture tradition, small- and medium-scale fish farmers cannot "go it alone" (Moehl et al., 2006: 49). Growing attention is being given to rural producer organisations as a strategy to increase small farmers' access to markets and contribute to agricultural development and poverty reduction worldwide (Kassam et al., 2011; World Bank, 2003, 2007). Although the role of these types of organisations and cooperatives in promoting smallholder commercialization and poverty reduction is far from straightforward (Bernard and Spielman, 2009; Chirwa et al., 2005), it would seem that association is crucial for small farmers to access aquaculture in the context of BAAIS. This is likely to be the case in most regions where the aquaculture sector is only beginning to develop. In studies on Asia and Africa, researchers agree that poorer farmers often lack the means to access aquaculture on their own and producer associations are a key to the development of pro-poor commercial aquaculture (ADB, 2004; Moehl et al., 2006). Association is needed to pool resources together, reduce costs and risks and gain lobbying power to pull down support and services from the government and external assistance organisations. It may be necessary for the consolidation of many medium and larger producers as well as small farmers. An interesting experience in lowland Bolivia was that of Beni's Aquaculture Association, CABE, which negotiated a loan with the 'Los Andes' Bank for several of its members at a relatively low interest rate (see section 4.4.7). Similarly, the agricultural cooperative CAISY played an important role in Yapacaní, securing producers' access to fry, feed and tractors for pond construction and improvements. These findings are reinforced by IFPRI's study of local innovation processes in four communities in Bolivia, where they found that producer associations played important roles in information exchange and technology diffusion, particularly in those cases where there was no external assistance organization involved in promoting aquaculture (Hartwich et al., 2007)

In the longer term, efforts to develop and strengthen commercial aquaculture in the Bolivian Amazon could trickle down and benefit poorer subsistence farmers around high potential zones by increasing their access to markets, information and services and reducing overall costs of adoption. The development of the sector could also help reduce the pressure on natural stocks (Petrere et al., 2004; Reinert and Winter, 2002; Ruffino, 2005) and indirectly benefit poorer families in rural Amazonia whose livelihoods often rely heavily on artisanal fishing (Coomes et al., 2010).

6.7 Strengthening the aquaculture sector in the Bolivian Amazon: an Innovation System perspective

Fish farming based on indigenous species in the Bolivian Amazon is, to a considerable extent, the result of what Belton and Little call 'immanent aquaculture development' (Belton and Little, 2011). It has developed despite limited support from governments and donors and is largely unplanned and undirected. The survey of fish farmers undertaken as part of this thesis showed that only about 30% of the region's total production at the time of the interviews was the result of project-based interventions in indigenous and campesino communities. Given the nascent stage of the sector and the limited participation of public sector organisations in its development, private producers, input/service providers and external assistance organisations have had to cover an important part of the costs of research and development activities (Chapter 4). There is very little data on aquaculture production in the region and a poor understanding of the sector's driving forces and ways to strengthen it.

Behaviour patterns in the context of this kind of 'immanent aquaculture development' are particularly difficult to predict or manage. Diverse actors participate in the innovation process, interacting among each other within a changing environment subject to institutional, market, technological and socioeconomic forces. There is no underlying plan and policy makers have little control or direct influence over the system. Nevertheless, interventions can be devised to try and steer the process in one direction or another, increase the chances of desired outcomes and reduce the chances of negative or unwanted results (Spielman et al., 2009: 400).

The following section re-examines, in light of the research, the role of innovation systems in strengthening agricultural R&D in developing countries and the thesis' contribution to the approach. Finally, taking an innovation systems perspective, the last sections of this chapter explore possible interventions that could help strengthen the aquaculture sector in the Bolivian Amazon and its contribution to poverty reduction, as well as the research's implications for wider debates regarding conservation and development strategies for Amazonia

6.7.1 Applying Innovation Systems frameworks to agricultural R&D in developing countries

Although most of the work on innovation systems has focused on industrial economies in developed countries, there is growing interest in using systems of innovation theory to inform the processes of agricultural R&D in developing countries (for example Biggs, 2007; Furtado et al., 2011; Spielman et al., 2008; Sumberg, 2005b; World Bank, 2006). Nevertheless, the approach is still relatively new in the study of developing country agriculture and it has been suggested that research to date has often been of limited application in the design of strategies to strengthen R&D (Spielman, 2006), and that when applied to the South there should be a greater focus on system building (Lundvall et al., 2002). Spielman et al. (2009) highlight three methodological limitations in the application of IS frameworks to agricultural R&D in developing countries: 1) the limited use that has been made of the diverse and rigorous analytical tools developed for IS research in industrialised countries, 2) the few links that have been made between empirical analysis and practical policy recommendations and 3) the limited focus that has been given to the poverty-related effects of innovation processes (Spielman et al, 2009: 402).

In the BAAIS study presented in Chapter 4, an effort was made to move beyond the descriptive *ex post* analysis of Amazon aquaculture R&D and address some of the issues highlighted by these authors. Drawing from social network analysis (Freeman, 2000, 2005) and graph-theoretic concepts (Richardson, 1999), interaction matrixes have been used to systematize qualitative data and identify key actors and information pathways, as well as isolated actors or mismatches that might be hindering the innovation process. This method can help to identify key areas for policy design as well as incentives and new institutions that might improve the flow of knowledge. The BAAIS analysis is based on the approach used by Temel *et al*. in their ISNAR study of Azerbaijan's agricultural innovation system (Temel, 2004a, 2004b, 2006, 2007; Temel et al., 2003). Here actors are organized within 'components' that supposedly share objectives and roles in the system, and network analysis is primarily used to study relationships and information flow among components (policy, research, education, extension, national and international input firms, credit, external assistance organizations and producers). There is nothing inherently 'pro-poor' in this approach, but it can be very useful to study the distributional and poverty effects of innovation processes if used for this purpose. Innovation Systems approaches are particularly relevant for pro-poor innovation analysis as they put particular emphasis on identifying and understanding innovation processes that are already leading to positive outcomes and building on those positive situations (Biggs, 2007: 161). In the BAAIS analysis, the components used to organise the actors in the ISNAR study have been adapted to allow for a distributional or poverty analysis, and the 'Producers component' has been divided into two categories, medium/large entrepreneurs and resource-poor farmers. This poverty analysis highlights the changes experienced in the system's structure and dynamics when resource-poor farmers are specifically targeted; it identifies situations where pro-poor innovations are already taking place, the key actors and key networks involved and critical areas for pro-poor policy design.

The analysis of BAAIS also differs from ISNAR's study of Azerbaijan's agricultural innovation system in that it goes beyond mapping the information structure underlying the innovation system and maps the flow of other key inputs for the sector's development, such as fry and feed. This is particularly relevant given the incipient nature of the market for aquaculture inputs and services and the fact that limited access to inputs represents a bottleneck for the sector's development in many areas (section 4.6.1). The analysis of BAAIS was considerably data intensive, as it was built on interviews with nearly 400 fish farmers in Beni, Santa Cruz, la Paz and Cochabamba, as well as the interviews with the actors who made up the system's different 'components' (N=90). The survey of fish farmers was conducted in order to gain an idea of the size and nature of the sector given the total absence of official data and provided considerable depth to the analysis. However, the approach would still have been relevant had this wealth of data not been available.

Finally, it is important to note that in a small, new system like BAAIS, roles are not very clearly defined and everybody seems to be doing a bit of everything: fish farmers are often also input/service providers, public researchers are also university teachers, private producers and consultants etc. In this context the use of interaction matrixes where actors are organised within components or groups of actors with shared roles in the system (such as Policy, Research, Producers etc.) can be misleading if not supported and triangulated with other methods. Too much focus on inter-component dynamics might overlook the significance of intra-component dynamics and the versatility and multifunctional nature of many actors within 'immature' systems such as Amazon aquaculture in Bolivia. Although the study of BAAIS adopts cross-component linkage matrixes to help organize and analyse the data, the nature of intra-component dynamics and the behaviour of 'multifunctional actors' was also explored in the descriptive analysis of the system.

In the following sections, an attempt is made to link the results of the empirical analysis of BAAIS to practical recommendations that could help strengthen the aquaculture sector. Institutional change can be favoured by specific reforms within organisations and components in the system (strengthening the system's individual components) and at a system level, by stimulating the formation of active innovation networks among organisations and components (strengthening the system as a whole).

6.7.2 Strengthening the individual components of Bolivia's Amazon Aquaculture Innovation System (BAAIS)

The analysis of BAAIS has revealed an inefficient and weakly connected system. There is severe polarisation between private and public sector components. Lack of information networks are particularly evident among public sector organizations under the policy, education and extension components, which operate in relative isolation and on the whole have very little influence over the system.

Policy component

It is not clear who in the national and regional governments is in charge of formulating and implementing fisheries and aquaculture policies or what it is these policies should be regulating or promoting. Before entering any discussion about appropriate policies, technologies or investment strategies to strengthen the aquaculture sector in the Bolivia Amazon it is important to define what the goals of the sector should be and clarify the roles of the different organizations involved. There is a need for a national development strategy for aquaculture, agreed upon by as many of BAAIS' actors as possible. The research suggest that efforts might be best spent on strengthening aquaculture as a new source of cash income for farmers, both large and small, in areas able to host the expanding markets for aquaculture inputs and services. The policy component should realign the mandates of the different policy areas accordingly: education policy, environmental policy, science and technology policy etc.

Extension & Education components

The participation of public extension services in BAAIS is very limited. The main sources of information for farmers are input/service providers, both national and from neighbouring Amazon countries, NGOs and farmer-to-farmer contacts. The education component in the innovation system is also very weak. Efforts to strengthen the human capital base might be best met by increasing learning opportunities that respond to the specific needs of the different actors in the innovation system, rather than in response to the priorities and standards set by public service and academia alone (Spielman et al., 2008). These could include short-term training courses as well as longer-term degrees and research programs, work practice on private fish farms and experimental stations run by universities and NGOs, exchanges with centres in Peru and Brazil etc.

However, given the limited financial and human resources in the public sector and its weak participation in BAAIS to date, it is not realistic to think that the government will be taking on a leadership role in promoting Amazon aquaculture development in the near future. It might be more cost-effective to focus on those actors and components that are shaping BAAIS at present and build on positive processes that are already taking place (Biggs, 2007). Many of the dominant actors in BAAIS are operating within the private sector and emphasis should be given to strengthen their individual and collective capacity to access, adapt and develop innovations.

Research component

The only actors within the public sector components that play an important role in BAAIS are the national fisheries and aquaculture research centers. Despite their weaknesses due to lack of financial support and human resources, some organisations have managed to establish important ties with producers, input/service providers and the external assistance component. The need to ensure economic resources to cover operating costs has turned key research centers into 'production centers', competing with private sector organizations in the market for aquaculture inputs. Furthermore, key individuals within national research organizations are, in some cases, privately engaged in joint ventures with large producers, private hatcheries or fry traders and importers. This market-oriented focus has contributed to the growth of associated markets for Amazon aquaculture, particularly in Santa Cruz. Nevertheless, it has also led to the somewhat monopolistic position of some actors within the Research component and a disincentive to the flow of knowledge. It is important to consider ways of limiting the negative consequences of this *modus operandi*, while supporting these key actors in order to increase their positive impact in BAAIS. Professional and financial incentives could be linked to development objectives and targets aimed at increasing human capital formation and information diffusion.

Input & service providers

Accessing information, fry, feed and other resources still represents a bottleneck for fish farming in many areas. The unfulfilled demand for inputs is often satisfied by importing fingerlings and feed from Brazil or Peru via large producers and national suppliers. These links with neighbouring countries are of critical importance for BAAIS. Nevertheless, the sector in Bolivia needs to agree to a common strategy and establish some form of legal framework for importing aquaculture inputs and live organisms. In relation to importing seed from other countries, it is important to consider the potentially negative impact that the introduction of non-native species or subspecies might have on the region's native fish populations (CBD, 1992; Gozlan et al., 2010; Loebmann et al., 2010; Zambrano et al., 2007).

Fish farmers - large and small

Problems faced by fish farmers in the region include lack of capital and credit to invest in pond construction and farm improvements, lack of information dissemination channels and absence of government support for the sector. The aquaculture sector in the Amazon region is small and producer associations have limited influence on the government. Greater association among Amazon fish farmers should be encouraged and local-level organisations should be linked to regional and national networks to gain greater political voice (Moehl et al., 2006). This could help channelize resources from public sector components and external assistance organizations, as well as help pool resources together, increase farmer-to-farmer information flow and increase their access to input/output markets. As highlighted in previous sections, this is particularly important for smaller farmers, who face greater obstacles to integrate into navigable networks in BAAIS and access information and other inputs.

External assistance component

The analysis of the BAAIS information structure shows that the external assistance component is the main source of information for national research organizations. This entry point of new technologies and knowledge is very important, as the research component is well-connected via commercial ties and, in turn, an important source of information for large producers and input/service providers. Hence these networks need to be strengthened and further developed.

External assistance organizations are also key players in pro-poor aquaculture development (see sections 4.4.9 and 4.7). In a pro-poor BAAIS (a BAAIS that specifically targets resource-poor farmers) the External Assistance component is the dominant component, displacing research organizations and national and foreign input and service providers to secondary roles. Unfortunately, pro-poor aquaculture projects have often been small and taken a short term approach, overlooking the importance of linking farmers directly to input/output markets and failing to ensure continuity. There is a tendency among NGOs to shy away from others and work in relative isolation. This leads to weak self-evaluation and institutional learning within the external assistance component as a whole.

Existing networks and positive processes should be strengthened, but the component's overall focus should change: 1) external assistance organisations should actively seek greater coordination among themselves and with actors in other components and realign and unify their objectives; 2) they should put greater emphasis on evaluation and abandon those technologies or strategies that have proven unsuccessful, such as subsistence farming for the poorest of the poor in remote areas; 3) they should focus on areas able to congregate groups of farmers and input/service providers and on helping small farmers access markets and integrate into navigable networks in BAAIS; 4) in light of the problems faced by the education component in BAAIS, they should put greater emphasis on training and developing the sector's human capital and 5) they should consider further options for financing aquaculture investments among small farmers and increasing their access to credit.

Financing the sector

An important setback faced by farmers in Bolivia, and fish farmers in particular, is the lack of a strategic plan to finance the sector. In light of the weak public sector components in BAAIS and the problems faced by policy organizations, it is not likely that the sector will be able to benefit from government credit schemes in the near future. Nevertheless other alternatives could be considered. In BAAIS several interesting arrangements have been documented that could be promoted among other groups of farmers: 1) Partnerships are very common among medium-large entrepreneurs setting up fish farms, particularly in Trinidad where nearly half of the farms are run in joint-venture. This practice brings together investors and people with some experience in Amazon aquaculture, including researchers linked to national universities and research institutes. Similarly, several of the BAAIS private hatcheries, as well as fish feed factories and import and marketing enterprises are the result of joint ventures between investors and research staff or people with experience in aquaculture. As discussed in previous sections, when research staff are involved, these types of arrangements bring both advantages and disadvantages. 2) Another possible source of financing and resource pooling in BAAIS is via the recently established aquaculture associations. These could help negotiate credits for their members, as we have seen in Trinidad (section 4.4.7), or help reduce overall costs of pond construction and access to inputs by sharing resources among members (such as tractors, nets and other equipment). 3) Credits from input/service providers also exist in BAAIS, particularly in the context of pro-poor aquaculture development projects that give credit in kind (fry, feed). 4) Finally, as discussed above, another important funding mechanism for BAAIS, and its research component in particular, has been the development of joint projects with external assistance organizations. The latter have contributed to build and equip Amazon aquaculture research centers in the country.

6.7.3 Strengthening the system as a whole – increasing BAAIS' navigability

Beyond specific reforms within organisations and components, efforts to strengthen BAAIS also need to favour institutional change at the system level. The development of personal and professional networks among actors is a key to effective innovation systems (Biggs and Smith, 1998; Clark, 2002; Clark et al., 2003; Edquist and Hommen, 1999; Ekboir, 2003; Lundy and Gottret, 2006). Strengthening BAAIS requires increasing its 'navigability'. The system's navigability, or network effectiveness, is its "collective capacity to facilitate exchanges of information and resources" (Spielman et al., 2009: 401). Navigability depends on the existence of well-connected actors, their ability to access, use, adapt and develop information and the context in which they function. In recent years increasing attention has been given to the role of interactive learning and cooperation in agricultural R&D in developing countries, particularly with regards to public-private partnerships (Hall, 2006; Hartwich et al., 2005; Hartwich and Tola, 2007; Spielman et al., 2007). Public-private partnerships are seen as a new source of funding for public sector research and a way of conducting research that neither sector would have attempted separately, increasing the relevance of R&D and making its results more widely available. Promoting partnerships and coalitions of partners, however, has proved more difficult than many predicted (Hall, 2006; Hartwich et al., 2005). Obstacles to collaboration are often institutional in nature, relating to patterns of trust, habits and organisational cultures (Hall, 2006). Hall suggests that the formation of effective partnerships might be best achieved at the system level, by developing the social capital within the innovation system to build trust among actors and a sense of common purpose – rather than promoting institutional change within individual organisations and components. Interventions that intensify interaction among potential partners have important process outcomes as well as product outcomes, as over time sustained interactions *per se* can help build trust and better communication patterns (ibid).

The development of social capital in BAAIS could be favoured by a strategic plan that prioritizes aquaculture production in areas close to markets that host 'clusters of activity', such as Santa Cruz or Trinidad, by bringing producers, input/service providers and other actors physically closer together and making interactions logistically easier (Moehl et al., 2006). As discussed in previous sections, this approach could also benefit smaller farmers in these areas by facilitating their access to information and other inputs at lower costs. The following section highlights possible interventions that could favour the exchange of information and greater collaboration among specific actors in BAAIS. Again one must consider whether to prioritise building those links that are absent in BAAIS or whether it might be more cost-effective, given the limited resources available, to focus on dominant components and existing innovation networks.

Links that are non-existent or very weak in BAAIS include those within and among public sector organisations and those between the public sector and the private sector (with the exception of the research component). Greater cohesion among actors within the policy component could be favoured via cross-ministerial consultations and information exchange meetings among the national government and the Amazon regions in Bolivia. The construction of a strategic plan for aquaculture development in the region that was supported by a wide range of actors and developed via consultative processes could bring actors, from both the public and private sectors, closer together. Also, the creation of some form of 'unifying entity' at a national level that could pull together national research organisations, technical schools and universities under a common goal could help strengthen the weak education component in BAAIS and build up the sector's human resource base. Furthermore, the system could benefit from bringing students and educators closer to producers, NGOs and input suppliers through work placements or apprenticeships in private farms and centres, etc. The education component could also make greater use of the existing university-linked aquaculture stations in Santa Cruz and Cochabamba for work experience. In Beni, *Mausa*, the experimental farm and hatchery run by a national NGO could play a greater role in training students and farmers, as *CIRA*, the university-linked research centre, does not have the necessary aquaculture installations.

But perhaps more can be gained in the short term by focusing on the dominant components in BAAIS and strengthening existing links among fish farmer organisations, private input/service providers (national and from neighbouring countries), the external assistance component and those national research centres that are important providers of fry and advisory services. These are the actors that are shaping the aquaculture sector in the Bolivian Amazon at present.

An activity that could help bring together private sector actors that might not always be interested in sharing information and skills with potential competitors is to organise meetings around the commercialisation of aquaculture products and services, such as stands in agricultural or food fairs, for example the famous Expocruz in Santa Cruz. Information exchange among fish farmers can also be favoured via producer associations, with information exchange meetings, farmer to farmer visits etc., and by linking local-level associations to regional and national networks. Greater collaboration among national research centres and between these and the private sector will require incentives. Organisational cultures, mistrust and, in some cases, overlapping roles and hidden agendas hinder the effectiveness of innovation networks among these actors. Interventions to promote collaboration should find ways of making the benefits from teamwork more attractive than existing disincentives to sharing knowledge. This might be the case when partnerships represent new financing opportunities and/or when dealing with 'complex information'[61] and team building across disciplines is required. There are both positive and negative examples of partnerships and projects carried out

[61] "The Complexity of information is measured by the variety of complementary units of information used to generate a new unit. Complex information cultivates the will for cooperation in information exchange" (Temel, 2007: 192).

jointly among national research centres, international research centres and NGOs (Chapter 4). Clearly this formula is not always straightforward. However, in the context of BAAIS and the public sector components' lack of resources, this type of arrangement will remain important. Participatory research programmes could also be developed to increase the links between the research component and farmers and input/service providers.

Perhaps BAAIS' 'foreign' actors represent one of the most important potential sources of information and this potential has hardly been exploited. Brazilian and Peruvian companies and research centres, with more resources and experience in Amazon aquaculture, already provide valuable information to large producers, input/service providers and national research stations in Bolivia. These links are usually informal, and often an indirect 'side effect' of commercial transactions, but they could be actively targeted and further developed. Here, perhaps, the external assistance component could help finance some activities, such as international meetings, courses and aquaculture fairs at the Amazon level, apprenticeships for Bolivian students and/or farmers in Brazilian/Peruvian companies and research stations etc.

Greater cohesion and information exchange among actors in Bolivia and other Amazon countries could also be favoured via the internet. Internet is increasingly common in towns and villages in the Amazon region. Although it is often inaccessible to poorer farmers, many actors in BAAIS do use the web: researchers, students, large producers and input/service providers, NGO and government staff etc. These could be brought closer together via some kind of interactive blog-like webpage where information can be published, practical questions asked, problems discussed and products and services advertised. An interactive site like this could also help build links among national actors and foreign experts, students and producers from other Amazon countries and further abroad. It could use a free service such as Blogspot and would be cheap to set up. The 'Amazon aquaculture blog' would have to be managed by an organization or actor with experience in the field, well connected within BAAIS and respected by other actors.

However, a note of caution is in order here. Too much emphasis on interactive learning and cooperation may sometimes overlook the power aspects of development and the fact that opportunities for interactive learning may be truncated for political reasons related to the distribution of power and hidden agendas (Lundvall et al., 2002: 226).

Obstacles to collaboration highlighted by actors in BAAIS, such as lack of human and financial resources and lack of a unifying entity could clearly benefit from an approach that actively seeks to develop innovation networks. But other problems highlighted by interviewees would appear more difficult to overcome, such as the market-oriented focus and secretiveness of some research organizations, political tensions between regions (such as Beni and Cochabamba fighting over the Isiboro Sécure Territory) or political antagonism between the central government in La Paz and regional governments in the lowlands governed by rival parties.

6.8 Summing up: aquaculture, conservation and development in the Bolivian Amazon

The thesis hopes to contribute to the debates surrounding rural development and livelihoods in Lowland Amazonia and the role of agricultural/NRM innovations in poverty reduction efforts. The research has focused on rural aquaculture development initiatives in the Bolivian Amazon, with particular reference to pacú farming in two Indigenous Reserves in the province of Moxos, Beni. This final section summarises the thesis' key findings and recommendations:

Indigenous species aquaculture is an attractive strategy to integrate development and conservation efforts in the Bolivian Amazon. It can contribute to economic development whilst conserving fisheries resources, and represents an alternative to other more extensive land-use practices that require the clearing of vast areas of forest, such as cattle ranching. But the sector is new and, as the thesis has shown, it faces many challenges. Access to information and input/output markets is limited and expensive, few people have experience or training in the field and the role of the public sector in research and extension is small and decreasing. In this context, aquaculture's direct contribution to livelihoods enhancement and food security among subsistence farmers in remote areas will be small. Fish farming operations need to be able to recover the costs of accessing information and fry, and building or adapting ponds. Low-external-input integrated aquaculture systems have limited growth potential whilst requiring considerable skills and labour, both of which tend to be in short supply in Amazonia. Subsistence-oriented fish farming for the poorest of the poor is not viable in Bolivia today, the sector is too young and the innovation system too weak, there isn't the know-how and, for many farmers, the effort required is just not worth their while. Nevertheless, more capital intensive and commercial forms of pacú and tambaquí farming have proven considerably lucrative and could represent and attractive investment for farmers closer to urban centres and that are more integrated into markets. In a region like the Bolivian Amazon, where land and water tend to be cheap and energy is expensive, the most profitable systems are likely to be those with an intermediate level of intensification. Development and poverty reduction objectives might be best met by supporting the development of small and medium-scale commercial fish farms in areas with access to the growing markets for aquaculture inputs and services. Concentrating efforts in areas able to congregate clusters of aquaculture activity can also facilitate greater association among producers and increase small and medium-scale farmers' access to aquaculture by pooling resources and reducing costs and risks.

These results reinforce the idea supported by an increasing number of authors working in agriculture and poverty reduction in developing countries, who suggest that, in light of limited resources, priority should be given to agricultural/NRM technology development in those areas where the potential for productivity gains and links to the wider economy are highest (DFID, 2005; Poulton et al., 2006). It is suggested that although smallholder development in less favoured areas may play an important role in ensuring food security, it is unlikely to be a trigger of growth and economic development (Poulton et al., 2006). This may be particularly the case in contemporary agriculture, where changes in local and global conditions and the policy environment have brought about new threats and challenges to small farms (Hazell et al., 2010; Wiggins et al., 2010). Perhaps, in this context, efforts to support those families who continue to practice largely subsistence farming and are unable to move into more productive agriculture or the non-farm sector, should prioritize the development of safety nets and social protection strategies (Sumberg, 2006).

Indigenous communities or families in the Bolivian Amazon who already have access to markets and links to the wider economy could also benefit from fish farming with an intermediate level of intensification and a more commercial approach. Indigenous territories and communities vary considerably with regards to their livelihoods, production environment and degree of market integration, needs and expectation; hence what might benefit some will not suit others. One should not assume that indigenous peoples' engagement in farming only seeks to meet household subsistence needs. Conservation and development efforts must take into account how indigenous peoples' livelihoods and relationship with their natural environment change over time in particular places (Bebbington, 1994). The thesis has shown that for many families in the *Mojeño Ignaciano* indigenous territory (TIMI) and the *Multiétnico* territory (TIM), growing pressure on resources and increased access to markets, education, health care etc. has brought about new needs and aspirations, many of which require increased income. Aquaculture is seen by some as a potential new source of cash. But interest in and access to fish farming within these territories is influenced, among other things, by people's income portfolio and degree and type of livelihoods diversification. Households who engage in aquaculture activities tend to be more dependent on agricultural and livestock farming than those households who do not, and their farm production tends to be more market oriented. They also tend to innovate in other areas within the farm. Many would prefer to adopt fish farming at the household level, as group farming requires a good deal of negotiating collective agreements and monitoring and enforcing them; nevertheless, limited access to capital often requires pooling resources together and associating with other households. Group farming is less problematic if association is among households that share kinship ties and if groups are kept relatively small.

In light of the increasing diversity in rural livelihoods in many countries (Ellis, 2000, 2001, 2004, 2005; Ruben and Pender, 2004; Sumberg et al., 2004) and contexts in which agriculture is practiced (Wiggins and Proctor, 2001), the links between agricultural/NRM technology development and poverty reduction are likely to be increasingly complex and contingent in nature (Sumberg, 2006). In this context, efforts to develop useful innovations for the rural poor will be faced by ever more challenges. The thesis has stressed how technology development needs to go hand in hand with an understanding of the combination of factors that will influence people's interest in and access to agricultural innovations, including: location (access to markets and quality of natural resources), livelihoods type, access to inputs and information, sources of non-farm income and/or remittances and the presence of extension services or external assistance (Sumberg, 2006). The thesis has used key concepts of the Knowledge Engineering Approach for agricultural research management (Reece et al., 2003) to study aquaculture development and the adoption of innovations at a local level in Moxos. It has stressed that agricultural R&D in general could benefit from making greater use of the theory and experience in the field of industrial and commercial 'new product development' (Sumberg and Reece, 2004).

The development and adoption of innovations at the local and farm level will be influenced by processes in the wider sector and economy. Pro-poor aquaculture development in Moxos or in any other part of Bolivia's Amazon region cannot be understood in isolation. Indigenous and campesino farmers' access to fish farming will be conditioned by wider developments in the country's Amazon Aquaculture Innovation System and the role that is assigned to poverty reduction. The thesis has adopted Innovation Systems theory and graph theoretic concepts to study BAAIS and explore possible interventions that could help strengthen the sector and its contribution to poverty reduction. BAAIS is small, weakly connected and polarised between public sector and private sector actors. Information networks are particularly weak among the former. Institutional change can be favoured by strengthening individual components and organisations and, at the system level, by increasing its overall navigability. Given the weakness of the public sector components in BAAIS, it is not realistic to think that the government will be taking a leadership role in the sector's development in the near future. Perhaps efforts to strengthen the I.S. would be best spent by focusing on positive processes that are already taking place among producers, input/service providers from Bolivia and abroad, the external assistance component and those national research centres that have developed ties with the private sector. The thesis places emphasis on interactive learning and building innovation networks in BAAIS, nevertheless, it must be acknowledged that opportunities for interactive learning can be undermined by existing organisational cultures, hidden agendas or political reasons related to the distribution of power.

As discussed in the introduction of this concluding chapter, changes in the local and global conditions in which agriculture is practiced pose new challenges to smallholder development around the globe (Byerlee et al., 2009; Collier, 2008; Dorward et al., 2004a; Dorward et al., 2004b; Ellis, 2005, 2006; Ellis and Harris, 2004; Sumberg, 2006). Hazell et al. (2010) stress how the retreat of the state in agricultural R&D and the concentration of buying power and increasing use of demanding standards in many countries affect small producers disproportionately. As we have seen in the case of aquaculture in the Bolivian Amazon, the provision of inputs, information, credit and extension services are increasingly in the hands of private actors, leaving many smaller producers at a disadvantage, as they tend to face higher transaction costs in the markets. Similarly, small farmers will encounter greater difficulties in accessing markets for outputs with increasingly strict standards for the quality and timelines of supply. In this context, if small producers are to survive they will need to find ways of obtaining inputs, information and credit at the same price paid by larger producers and meet the growing demands of supply chains (Hazell et al., 2010). Changes in the context in which agriculture is performed need to be accompanied with changes in policy. Particular emphasis should be given to increase small farmers' access to input/output markets and their capacity to meet new demands in supply chains. This will require greater collaboration among farmers, private input/service providers, buyers, NGOs and public agencies, and the development of institutional innovations in the provision of inputs and services that will favour the private coordination of complementary markets (ibid). Improving marketing systems so that small farmers can compete with larger producers will also require building stronger farmer associations for bulk marketing (Hazell et al., 2010; Kassam et al., 2011; Poulton et al., 2010; Sumberg, 2006).

Indigenous peoples in the Bolivian Amazon should not be excluded from these efforts by default. It is important to avoid the preconception that indigenous peoples' engagement in farming in Amazonia only seeks a food security agenda. Indigenous communities are many and diverse; there is considerable evidence of indigenous households in Moxos diversifying their production to include more commercially oriented farming, as well as activities in the non-farm sector and wage labor. Integrated Conservation and Development Projects in Amazonia should not overlook this reality. It would be safe to say that some indigenous households in some indigenous communities in Amazonia will benefit from efforts to promote farm productivity enhancement and greater market integration.

6.9 Table of recommendations

Aquaculture development in the Bolivian Amazon and its contribution to poverty reduction: Bolivia's Amazon Aquaculture Innovation System - BAAIS *(Innovation Systems and graph theory)*	
KEY FINDINGS	**RECOMMENDATIONS**
*Indigenous species aquaculture is significantly higher than official estimates. The bulk comes from medium/large entrepreneurs. About a quarter comes from resource-poor farmers via project-based interventions. The former manage larger farms, but the type of farming practiced by all is similar: extensive/semi-intensive farming of pacú or tambaquí in earthen ponds. Nobody lives by aquaculture alone	*IS approaches are particularly useful for studying innovation processes in the context of BAAIS, where development is largely unplanned. Institutional change in BAAIS can be favoured by strengthening key individual organisations and by increasing the system's overall navigability. Graph-theoretic concepts can help identify important areas for policy design and institutional arrangements that will favour interactive learning
*** There is limited know-how and access to markets and information is expensive. The I.S. is weakly connected and polarised between private and public actors. Information networks are particularly weak among public components**	***Given limited resources and the weakness of public sector actors, efforts to strengthen BAAIS should focus on existing innovation networks within the private sector**
*The private sector is the main disseminator of information and inputs, including some national public research organisations that also compete in private markets for aquaculture inputs	* It is important to consider ways of limiting the negative consequences of the market-oriented focus of key national research organisations, while not undermining their contribution to the growth of the associated markets for aquaculture
***In the context of BAAIS, aquaculture's direct contribution to food security among subsistence farmers in LFA is, and will be, limited** ***On the other hand, more capital intensive and commercial forms of fish farming with an intermediate level of intensification can represent a lucrative investment for farmers (large and small) with access to input/output markets**	***The development of small and medium commercial farms around centres of aquaculture activity should be prioritised** ***Efforts should focus on increasing small farmers' access to input/output markets; the development of institutional innovations in the provision of inputs and credit; and the development of producer associations for bulk marketing.**
*External assistance organisations are important actors in BAAIS and pro-poor BAAIS. But aquaculture projects have often overlooked the need to link producers with markets and failed to ensure continuity. There is little coordination among actors, leading to weak self-evaluation and institutional learning within the external assistance component	*External assistance orgs. need to actively seek greater coordination and unify objectives; they should put greater emphasis on evaluation and abandon those strategies that have proven unsuccessful; they should favour small farmers' access to navigable networks in BAAIS; put greater emphasis on building the sector's human capital; and assess further options for financing aquaculture investments among small farmers
Aquaculture technology development in indigenous communities in Moxos *(Knowledge Engineering and livelihoods approaches)*	
KEY FINDINGS	**RECOMMENDATIONS**
*Indigenous communities in Moxos are diversifying their production. Farming and extraction are still the most important source of gross income, but the sale of labour is the main source of cash	* Projects should take into account the increasing diversity in rural livelihoods and how this diversity influences farmers' interest in and access to a given technology
*Interest in and access to aquaculture is influenced by location, income portfolio and type of livelihoods diversification. In Moxos those households who engage in aquaculture are more dependent on farming and their farm production is more diversified and market oriented	*Knowledge Engineering can help characterise innovations in terms of inputs and benefits that are relevant to particular groups of farmers and identify critical performance targets. Livelihoods analysis can aid the identification of potential 'end users' of a given technology

***Most of the farmers initiating aquaculture are interested in it as a source of cash** ***The value of a day's labour in pacú farming in rain-fed earthen ponds with an intermediate level of intensification can be up to 4 times higher than the value of labour in the local labour market** ***Low-external-input integrated aquaculture systems, often promoted as 'pro-poor', are information and labour intensive and have limited growth potential - whilst labour and know-how are often in short supply. The labour requirements can represent a particular burden for women**	***Aquaculture development efforts in Moxos should stop the promotion of subsistence farming in remote parts of S-W TIM** ***Efforts should prioritise more commercial forms of aquaculture among indigenous farmers in TIMI and N-E TIM that are already producing for the market** ***ASOPIM, the Moxos indigenous fish farmers' assoc., should be strengthened and linked to regional and national networks to increase access to markets and political weight**
*Communal and group farming poses serious strains on community institutions, particularly if low-external-input farming is promoted.	*Projects should prioritise farming at the household level when possible and, if association is necessary, group farming should prioritise cooperation among a small number of households with kinship ties
Implications for wider debates: Integrated Conservation and Development Projects and agricultural innovations in Amazonia	
KEY FINDINGS	RECOMMENDATIONS
*Forest dwellers in Amazonia vary with regards to livelihoods and degree of market integration; still the majority are being increasingly exposed to modern industrial societies, bringing about changes in land use practices, livelihoods, needs and expectations * Still, in most of rural Amazonia, farming continues to represent a vital part of the livelihoods of indigenous and campesino communities	*ICDPs that do not acknowledge these changes are likely to fail in both their conservation and development objectives. *Sustainable development in Amazonia is likely to require a mixture of strategies; but **smallholder development and agricultural/NRM innovations will remain of paramount importance as long as farming continues to represent a key source of income in rural areas**
*Integrated low-external-input technologies, often promoted within the ICDP agenda, where knowledge and labour are a substitute for inputs, are not necessarily affordable and suited to poor and diversified farmers in Amazonia * In conditions of land surplus and/or new opportunities in the local labour market, farmers will be interested in innovations able to increase the productivity of labour *** In indigenous communities, the functionality threshold for a given NRM innovation is often higher than what some advocates of productive conservation assume. New needs and expectations require new sources of cash**	*Approaches to development that build on 'traditional' and/or 'subsistence' land use practices alone have limited capacity to improve the economic situation of forest dwellers *Understanding the nature and diversity or forest dwellers' livelihoods and the dynamics of the local labour market is essential for the effective targeting of pro-poor technology development ***Efforts aimed at farm productivity enhancement and greater market integration should not exclude indigenous farmers by default**
*ICDPs often require involvement at a community level, but cooperation is not cost free and social capital is not inherent to all indigenous communities alike	* Strengthening collective action among forest dwellers is essential to safeguard social equity and land rights. Nevertheless, the promotion of innovations at a community level is not a panacea for all indigenous communities in Amazonia.

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Appendix 1

Analysis of BAAIS: sample

Table A-1 List of actors in BAAIS interviewed, organised by component

COMPONENTS	INSTITUTIONS INTERVIEWED	NUM. PEOPLE INTERVIEWED
A **POLICY COMPONENT** Units operating under the Cabinet of Ministers and Commissions performing specific tasks to support the formulation and/or enforcement of fisheries and aquaculture policy	- Unidad Pesca y Piscicultura, Ministerio Asuntos Campesinos y Agropecuarios, La Paz	2
	- Dirección General de Biodiversidad, Ministerio Desarrollo Sostenible, La Paz	1
	- Dirección Recursos Naturales y Biodiversidad, Prefectura Beni	1
	- Servicio Departamental Agropecuario, Prefectura Beni	1
	- Dirección Desarrollo Productivo, Prefectura Beni	1
	- Dirección Desarrollo Social, Prefectura Beni	2
	- Servicio Nacional Sanidad Agropecuaria e Inocuidad Alimentaria, Prefectura Beni	1
	- Honorable Alcaldía Municipal de San Andrés, Beni	1
	- Dirección Recursos Naturales y Biodiversidad, Prefectura Santa Cruz	1
	- Servicio Departamental Agropecuario, Prefectura Santa Cruz	1
	- Servicio Departamental Agropecuario, Prefectura Cochabamba	1
	- Honorable Alcaldía Municipal de Ivirgarzama, Cochabamba	1
	- Honorable Alcaldía Municipal de San Buena Ventura, Beni	1
SUBTOTAL		15
B **RESEARCH COMPONENT** National Research Institutes & Universities engaged in Amazon aquaculture R&D	- Estación Piscícola El Prado, Universidad A. Gabriel René Moreno, Santa Cruz	1
	- Estación de Limnología y Acuicultura Pirahíba, Univ. M. San Simón, Cochabamba	2
	- Centro de Investigación de Recursos Acuáticos, Universidad A. del Beni, Beni	1
	- Unidad Académica Carmen Pampa, Universidad Católica de Bolivia, La Paz	1
	- Colección Boliviana de Fauna MNHN, Universidad M. San Andrés, La Paz	2
SUBTOTAL		7
C **EDUCATION COMPONENT** State and private Universities/Colleges that offer courses/degrees in fisheries/aquaculture	- Facultad de Ciencias Veterinarias y Zootecnia, UAGRM, Santa Cruz	1
	- Unidad de Limnología y Recursos Acuáticos, UMSS, Cochabamba	1
	- Dirección de Investigación Científica, UAB, Beni	1
	- Universidad Católica de Bolivia, UCB, La Paz	1
	- Universidad Evangélica Boliviana, UEB, Santa Cruz	1
SUBTOTAL		5
D **INFORMATION & EXTENSION COMPONENT** Public centres promoting the dissemination of research results & extension services	- UCPSA, Sistema Boliviano de Tecnología Agropecuaria (SIBTA), La Paz	2
	- Fundación para el Desarrollo Tecnológico Agropecuario del Trópico Húmedo, SIBTA Santa Cruz y Beni	2
	- EMFOPESBE, Empresa de Fomento Pesquero del Beni, Beni	1
SUBTOTAL		5
E_n **MARKETS: NATIONAL** INPUT/OUTPUT SUPPLY, PROCESSING, MARKETING COMPONENT	Input suppliers, marketing & processing firms in Santa Cruz and Beni:	
	- SEED Suppliers (producers, importers, traders)	6
	- FEED Suppliers (producers, importers, traders)	6
	- INFORMATION Suppliers (private consultancy firms)	3
	- PROCESSING / MARKETING enterprises	2
SUBTOTAL		17
E_a **MARKETS: ABROAD** INPUT/OUTPUT SUPPLY, PROCESSING, MARKETING COMPONENT	- Proyecto Pacú, Campo Grande, Matto Grosso, Brasil - ABRACOA Asoc. Brasilera de Criadores de Organismos Acuáticos, Brasil - EMBRAPA Empresa Brasileira de Pesquisas Agropecuária, Brasil - CEPTA Centro de Pesquisa e Treinamento em Acuicultura, Brasil - IIAP Instituto de Investigaciones de la Amazonia Peruana, Perú - INPA Instituto Nacional de Pesquisas da Amazônia, Manaus, Brasil	X

SUBTOTAL		
F **CREDIT COMPONENT** The banking systems, government credit schemes for public and private enterprises engaged in Amazon aquaculture/agriculture	- Centro de Investigación y Promoción del Campesinado (Specialist micro credit), Beni - CACTRI Cooperativa de ahorro y crédito abierta Trinidad, Beni	1 1
SUBTOTAL		2
G_e **PRODUCERS: MEDIUM/LARGE ENTREPRENEURS** PRIVATE FISH-FARM COMPONENT Cooperatives, Producer Organizations	- CAOR Cámara de Acuicultores del Oriente, Santa Cruz - CABE Cámara de Acuicultores del Beni, Beni - CAISY Cooperativa Agropecuaria Integral San Juan de Yapacaní, Santa Cruz	1 1 1
SUBTOTAL		3
G_f **PRODUCERS: RESOURCE POOR FARMERS** PRIVATE FISH-FARM COMPONENT Cooperatives, Producer Organizations	- ASOPIM Asociación de Piscicultores Indígenas de Moxos, Beni - TAMBAQUÍ Asociación de piscicultores de Ivirgarzama, Cochabamba - AIPANE Asociación Integral de Productores Agropecuarios Nueva Estrella, Carrasco, Cochabamba - Asociación de pescadores Río Mamoré, Beni - Agrupación de piscicultores Loma Suárez, Beni - Gran Consejo Chimán, Beni - Organizaciones de base del pueblo Takana, San Buena Ventura, Beni	2 1 2 1 1 1 3
SUBTOTAL		11
H **EXTERNAL ASSISTANCE COMPONENT** Donors, International Research Institutes, NGOs etc. involved in Amazon aquaculture activities in Bolivia	- JICA Japanese International Cooperation Agency, La Paz - PRODISA Belga. Programa de Desarrollo Rural Integral de las Provincias Ichilo y Sara. Bilateral development programme Bolivia – Belgium, Santa Cruz - PRAEDAC Programa de Apoyo a la Estrategia de Desarrollo Alternativo en el Chapare. Bilateral development programme Bolivia - European Union, Cochabamba - IRD Institut de Recherche pour le Développement (Ex-Orstom, France), La Paz - EPM Estación Piscícola Mausa, Centro de Estudios Hoya Amazónica, Beni **NGOs** - HOYAM Moxos. Centro de Estudios Hoya Amazónica, Beni - CIPCA Beni. Centro de Investigación y Promoción del Campesinado, Beni - EPARU. Equipo Pastoral Rural, Trinidad, Beni - MANB Caranavi. Misión Alianza Noruega en Bolivia, La Paz - VSF Rurrenabaque. Vétérinaires Sans Frontières – Francia, Beni - PRODESIB San Borja. Unidad Gerencial Territorio Chimán, Beni - QHANA Caranavi, La Paz - CARITAS Caranavi y Coroico, La Paz - PDA Taipiplaya, Caranavi y Coroico. Programa de Desarrollo Alternativo. La Paz - Escuela Técnica PATAGC Caranavi y Coroico, La Paz - Instituto técnico ISTAIC Caranavi, La Paz - CARE-Bolivia Caranavi, La Paz - Ex proyecto MINACHI Coroico. FAO y CORDEPAZ. La Paz	2 2 2 1 1 1 1 1 1 1 1 1 2 3 2 1 1 1
SUBTOTAL		25
TOTAL		**90**

Table A-2 Sample of fish farmers interviewed in the Bolivian Amazon, organised by regions

COMPONENTS	PRODUCERS INTERVIEWED PER REGION	NUM.
FISH FARMERS	MEDIUM/LARGE ENTREPRENEURS	
	Santa Cruz	77
(**G_e**) MEDIUM/LARGE ENTREPRENEURS	Beni (Trinidad)	34
&	Beni (San Ignacio de Moxos)	6
(**G_f**) RESOURCE POOR FARMERS	Beni (San Borja, Yucumo, Rurrenabaque)	11
	La Paz (Yungas)	3
	Cochabamba (Chapare)	4
	RESOURCE POOR FARMERS	
	Santa Cruz	3
	Beni (Trinidad)	5
	Beni (San Ignacio de Moxos)	79
	Beni (San Borja, Yucumo, Rurrenabaque)	92
	La Paz (Yungas)	66
	Cochabamba (Chapare)	4
TOTAL		**384**

Appendix 2

Analysis of BAAIS: questionnaire for actors

LA ACUICULTURA AMAZÓNICA EN BOLIVIA:
UN ANÁLISIS DEL SISTEMA DE INNOVACIÓN TECNOLÓGICO

Cuestionario 'Actores'

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Reino Unido

Julio/Diciembre 2005

OBJETIVOS DE LA INVESTIGACIÓN

Objetivo general
Profundizar nuestro conocimiento sobre las características y dinámicas del sistema de innovación tecnológico del rubro piscícola en la región amazónica de Bolivia

Objetivos específicos
* Identificar los principales actores en el desarrollo de la acuicultura, sus funciones, actividades e interacciones con demás agentes del proceso de innovación tecnológica
* Identificar los principales retos que enfrenta el sector y que inhiben el proceso de innovación tecnológica
* Identificar posibles estrategias para fortalecer el sector y mejorar el proceso de innovación tecnológica

Toda la información recopilada para esta investigación será publicada en una tesis doctoral (PhD) accesible a todos los interesados a través de la Facultad de Desarrollo de la Universidad de *East Anglia* del Reino Unido. También se depositarán copias de la tesis, una vez terminada, en las sedes de las principales instituciones bolivianas vinculadas al rubro piscícola. Paralelamente, se prevé utilizar los resultados de la investigación para fortalecer iniciativas dirigidas al desarrollo y la extensión de la acuicultura y canalizar recursos para la región amazónica.

La información proporcionada por personas entrevistadas será del todo confidencial.

Para mayor información por favor contactar con la Lic. Elisa Canal Beeby a través del correo electrónico: E.Beeby@uea.ac.uk ó elisa_canal@hotmail.com

Formato del cuestionario adaptado de:
T. Temel, W. Janssen, F. Karimov (2002) 'The Agricultural Innovation System of Azerbaijan: An Assessment of Institutional Linkages'. ISNAR Country Report 64

I. PERFIL DE LA ORGANIZACIÓN

I.I. INFORMACIÓN SOBRE EL/LA ENTREVISTADO/A

Nombre del entrevistado____
Cargo____
Nombre de la organización/ente____
Dirección sede____
Teléfono_____________ Fax_____________ Correo electrónico____
Lugar y fecha de la entrevista____

I.II. CLASIFICACIÓN DE LA ORGANIZACIÓN/ENTE

Carácter legal de la organización:
Privada____. Pública____. Semi-pública____. Otros_____________.
Nombre legal de la organización____________________________________.
Área de influencia:
Internacional____. Nacional____. Amazónica____. Departamental___. Local____.
Tipo de organización:
Gubernamental____. Empresarial____. ONGSL____. Coop. Internacional____.
Nº de trabajadores: Profesionales_______. Otros_______. Total:_______.
Objetivo/Mandato____
Actividad/es principal/es:
Formulación políticas para el sector____. Financiamiento____. Crédito____. Investigación____. Extensión/divulgación____. Formación____. Producción____. Proveedor/distribuidor insumos____. Procesamiento____. Marketing____. Cooperación Internacional______.
Año de fundación/creación____________________________________.

I.III. PROPORCIONAR UN ESQUEMA DE LA ESTRUCTURA DE LA ORGANIZACIÓN/ENTE (Mostrar la relación entre los diferentes departamentos o secciones de la organización y sus funciones)
I.IV. PROPORCIONAR UN ESQUEMA DE LAS RELACIONES QUE LA ORGANIZACIÓN MANTIENE CON OTROS ACTORES EN EL RUBRO PISCÍCOLA (Identificar los vínculos que existen con otras organizaciones involucradas en la acuicultura amazónica. Por ejemplo: productores, ONGs, la administración pública, Universidades, etc.)

II. EL PAPEL DE LA INNOVACIÓN EN SU ORGANIZACIÓN

Por INNOVACIÓN entendemos todas aquellos procesos dirigidos al desarrollo y la difusión de nuevas tecnologías y/o viejas tecnologías mejoradas o adaptadas a nuevos entornos. Bajo esta definición incluimos nuevos productos o procesos productivos, nuevas formas organizativas, la aplicación de viejas tecnologías en áreas nuevas, el descubrimiento de nuevos recursos y la apertura de nuevos mercados.
Si la organización está involucrada en actividades de innovación en el campo de la acuicultura amazónica, completar la sección II.

II.I. TIPO DE ACTIVIDADES RELACIONADAS CON EL PROCESO DE INNOVACIÓN EN LAS QUE PARTICIPA SU ORGANIZACIÓN

Actividad	Principal	Secundaria	Nunca
Formulación políticas para el sector			
Financiamiento actividades de innovación			
Desarrollo nuevas tecnologías			
Demostración/Evaluación nuevas tecnologías			
Introducción (venta) nuevas tecnologías			
Difusión nuevas tecnologías			
Adquisición/Incorporación nuevas tecnologías			
Uso nuevas tecnologías			
Otras (especificar)			

Narrar con mayor detalle el tipo de actividades/proyectos en las que participa la organización

II.II. OBJETIVO DE LAS PRINCIPALES ACTIVIDADES

Objetivo	Principal	Secundario	Nunca
Introducir nuevos productos y/o procesos			
Abrir nuevos mercados			
Incrementar la producción			
Mejorar la calidad del producto			
Reducir costos de producción			
Reducir impacto ambiental			
Cumplir con políticas/standards del sector			
Difundir información/conocimiento			
Generar ingresos propios			
Reducción de la pobreza			
Otros (especificar)			

II.III. FUENTES DE INFORMACIÓN/CONOCIMIENTO SOBRE INNOVACIONES PARA SU ORGANIZACIÓN

Componentes del S.I.	**Fuentes de información** Indicar organizaciones o personas que representan importantes fuentes de información/conocimiento	P	S	N
Formulación políticas Ej.: Ministerios	- - -			
Investigación Ej.: el Prado, Pirahiba	- - -			
Educación Ej.: UAGRM, escuelas técnicas	- - -			
Crédito/Sistema bancario Ej.: Coop. agrícolas	- - -			
Extensión Ej.: Consultorías	- - -			
Input/output Servicios asociados Ej.: proveedores alevines	- - -			
Productores Ej.: C.A.O.	- - -			
Coop. Internacional Ej.: ONGDs, IRD	- - -			
Otros Ej.: Internet	- -			

P = Principal, S = Secundario, N = Nunca

II.IV. FUENTES DE FINANCIACIÓN DE ACTIVIDADES RELACIONADAS CON EL PROCESO DE INNOVACIÓN EN EL RUBRO PISCÍCOLA

Tipo de financiación	**Fuentes de financiación** Especificar organizaciones o entes que representan importantes fuentes de financiación	P	S	N
Recursos propios Ej.: ventas	- - -			
Contratos/Subcontratos de clientes Ej.: productores	- - -			
Subvenciones sujetas a concurso público	- - -			
Subvenciones no sujetas a concurso	- - -			
Crédito/Préstamos	- - -			
Cooperación Internacional	- - -			
Otros	- -			

P = Principal, S = Secundario, N = Nunca

II.V. RECURSOS DESTINADOS A ACTIVIDADES RELACIONADAS CON EL PROCESO DE INNOVACIÓN EN EL RUBRO DE LA PISCICULTURA AMAZÓNICA

¿Cuántos recursos destinó su organización a actividades relacionadas con el proceso de innovación en el rubro de la piscicultura?	En Dólares Americanos ($)
En la gestión 2004-2005	
En la gestión 2003-2004	
En los últimos 5 años	
Desde su creación (Total)	

II.VI. PRINCIPALES LOGROS DE SU ORGANIZACIÓN

¿Cuáles considera qua han sido los mayores logros de su organización en el proceso de Innovación?

II.VII. PRINCIPALES RETOS PARA EL PROCESO DE INNOVACIÓN EN EL QUE PARTICIPA SU ORGANIZACIÓN

Factores	**Especificar principales problemas**
INTERNOS Mandato y objetivos poco claros Administración interna poco eficiente Naturaleza y estructura de la organización Poca coordinación con demás actores Falta personal cualificado Falta información Falta recursos económicos Otros	
EXTERNOS Infraestructura insuficiente (Ej. mercados, caminos) Servicios insuficientes (Ej. limitado acceso a alevines) Inexistencia de marco legal Inexistencia marco político Inestabilidad social Elevado riesgo económico El comercio internacional Otros	

III. DINÁMICA DEL SISTEMA DE INNOVACIÓN: RELACIÓN ENTRE SUS COMPONENTES

III.I. GRADO/TIPO DE COLABORACIÓN CON OTRAS ORGANIZACIONES DEL SI

Componentes del SI	**Actores** Indicar principales organizaciones o personas con las que su organización está vinculada, se relaciona y/o colabora	**Grado de colaboración**				**CÓDIGOS tipo de vínculo***			
		M	R	P	N				
Formulación políticas Ej.: Ministerios									
Investigación Ej.: el Prado, Pirahiba									
Educación Ej.: UAGRM, escuelas técnicas									
Crédito Ej.: Cooperativas agrícolas									
Extensión Ej.: Consultorías									
Input/output Servicios asociados Ej.: proveedores alevines									
Productores Ej.: C.A.O.									
Cooperación Internacional Ej.: ONGDs, IRD									
Otros									

M = Mucha, R = Regular, P = Poca, N = Ninguna

*CÓDIGOS: TIPO DE VÍNCULOS/MECANISMOS DE COLABORACIÓN

Tipo de vínculo	**Mecanismos de colaboración**	**Código**
A. Planificación y evaluación	Diagnosis conjunto de problemas	1
	Identificación conjunta de prioridades y objetivos	2
	Evaluación y reflexión conjunta	3
B. Actividades, implementación proyectos	Desarrollo conjunto de innovaciones	4
	Evaluación conjunta de innovaciones	5
	Demostración/difusión conjunta de innovaciones	6

C. Uso de recursos	Intercambio de personal	7
	Uso compartido de infraestructuras y equipos	8
	Uso compartido de financiación	9
D. Información	Intercambio de información	10
	Publicación conjunta	11
	Participación conjunta en seminarios/talleres	12
E. Formación	Formación conjunta de estudiantes	13
	Formación conjunta de técnicos	14
F. Otros	*Relación comercial, proceso de compra-venta de insumos y servicios para la piscicultura*	15
		16
		17

III.II. ESPECIFICAR ACTIVIDADES/PROYECTOS DE COLABORACIÓN

En el caso de que su organización colabore con otras instituciones en el proceso de innovación tecnológico, especificar las actividades o proyectos en los cuales dicha colaboración se manifiesta:

III.III. PRINCIPALES RETOS PARA LA COLABORACIÓN CON OTRAS INSTITUCIONES DEL S.I.

Especificar cuáles son los principales factores que impiden que exista mayor coordinación y colaboración con otras organizaciones o personas del S.I.. Por ejemplo: con la administración pública, las universidades, las ONGs, los productores etc.

IV. POLÍTICAS DEL SECTOR AGROPECUARIO

(*Solamente para actores involucrados en la formulación e implementación de políticas para el sector)*

IV.I. CIENCIA Y TECNOLOGÍA EN EL SECTOR AGROPECUARIO

¿Cuáles son las prioridades del gobierno para el sector agropecuario en el TH?

¿Existen políticas nacionales sobre ciencia y tecnología en el sector agropecuario?

Sí___. No___. No sé___.

¿Quién las formula? Dibujar organigrama de principales actores en la formulación e implementación de políticas para el sector agropecuario

Describa las políticas nacionales sobre ciencia y tecnología del sector agropecuario

¿Qué mecanismos usa el gobierno para promover la innovación en el sector agropecuario?

Mecanismos	Principal	Secundario	Nunca
Reducción impuestos para inversiones en innovación			
Fondos especiales para inversiones en innovación			
Servicios de apoyo técnico			
Préstamos a bajo interés para empresas			
Subvenciones estatales para compra equipos			
Reducción aranceles para importación			
Incentivos para exportación			
Otros			

IV.II CIENCIA Y TECNOLOGÍA EN EL SUBSECTOR PESCA Y ACUICULTURA

¿Existen políticas nacionales sobre ciencia y tecnología para el subsector de Pesca y Acuicultura?
Sí___. No___. No sé___.

¿Quién las formula? Dibujar organigrama de principales actores en la formulación e implementación de políticas para el subsector Pesca y Acuicultura

Describa brevemente las políticas nacionales sobre ciencia y tecnología del subsector de Pesca y Acuicultura

¿Qué mecanismos usa el gobierno para promover la innovación en el subsector de Pesca y Acuicultura?

Mecanismos	Principal	Secundario	Nunca
Reducción impuestos para inversiones en innovación			
Fondos especiales para inversiones en innovación			
Servicios de apoyo técnico			
Préstamos a bajo interés para empresas			
Subvenciones estatales para compra equipos			
Reducción aranceles para importación			
Incentivos para exportación			
Otros			

Appendix 3

Analysis of BAAIS: questionnaire for producers

PRODUCCIÓN Y ACCESO A INSUMOS

NOMBRE..
E-MAIL...
TELÉFONO...

UBICACIÓN CRIADERO..
LUGAR Y FECHA DE LA ENTREVISTA..
OBSERVACIONES..

I. PAPEL DE LA ACUICULTURA

¿En qué año inició usted la actividad de producción acuícola ?__________
Indicar los años en los que ha sembrado alevines y la cantidad

¿Qué le motivó a iniciar la actividad de producción acuícola?

MOTIVACIONES	**Principal**	**Secundario**	**Nunca**
Es rentable la cría			
Hay mucha demanda de pescado			
Para pesque y pague / complejo turístico			
Dificultad de conseguir pescado (me gusta el pescado)			
Para mejorar la dieta (seguridad alimentaria)			
Dar utilidad a aguadas existentes			
Hobby/pasatiempo			
Recomendación vecinos/amigos			
Recomendación ONGs			
Otras			

¿Qué importancia tiene la acuicultura en términos de su contribución a la economía familiar? *(en comparación con las demás actividades económicas/productivas en las que participa)*
Muy importante____. Importante____. Regular____. Poco importante____.
Nada importante____.

II. CARACTERÍSTICAS DE LA ACTIVIDAD

¿En qué consiste su producción actual? Peces_____. Camarones_____. Otros_______.

Especies exóticas	Unidades	Especies nativas	Unidades
-	-	-	-
-	-	-	-
-	-	-	-

Nº	SUPERFICIE DE CRÍA (m^2)	< 500	500-2.000	2.000-5.000	5.000-20.000	> 20.000
	Estanque tierra					
	Estanque cemento					
	Atajado					
	Jaulas					
	Otros					

ALIMENTACIÓN	Solo casero (producción propia)	Solo balanceado comercial	Alimento casero y comercial
Tipo de alimentación *(Especificar principales insumos usados y/o marca del balanceado)*			

FERTILIZACIÓN	Orgánico (Ej. gallinaza)	Inorgánico (comercial)	Ninguno
Tipo de abono *(Especificar)*			

DESTINO PRODUCCIÓN	Todo consumo familiar	Casi todo consumo familiar	Consumo familiar y venta	Casi todo venta	Todo venta
(Epecificar mercados y forma de venta)					

¿Cuánto es la producción *potencial* de su criadero? ______________________ Kg./año

¿Cuánto fue su producción *real* en el 2004?___________________________ Kg./año

¿Cuánta gente trabaja en su piscigranja?	De la familia (dedicación parcial)	Personal contratado
Trabajadores piscigranja (Nº)		

III. ACCESO A INSUMOS Y SERVICIOS

Insumos/servicios	**Principales proveedores**
Alevines	
Alimento balanceado	

Construcción aguadas	
Subvenciones y/o crédito	
Apoyo técnico / información *(Mencionar personas u organizaciones que le proporcionen asesoramiento técnico. Indicar si se les paga por el servicio)*	
Equipos *(mallas, fertilizantes, motobombas oxigenadores etc.)*	
Otros	

IV. EVALUACIÓN DE LA CRÍA

¿Está satisfecho/a con los resultados de la actividad acuícola?
Mucho____. Bastante____. Regular____. Poco____. Nada_____.

Especificar por qué:

Identifique los principales problemas que afectan la actividad acuícola

Factores	**Especificar principales problemas**
INTERNOS Poca coordinación con otros productores Falta personal cualificado Falta información Falta recursos económicos Otros	
EXTERNOS Infraestructura insuficiente (Ej. mercados, caminos) Servicios insuficientes (Ej. limitado acceso a alevines) Inexistencia de marco político/legal Inestabilidad social Elevado riesgo económico El comercio internacional Otros	

¿Qué planes de futuro tiene con respecto a su criadero?

Ampliar____. Mejorar infraestructuras existentes_____. Mantener igual____.
Abandonar parcialmente____. Abandonar totalmente____. Otros__________________.

¿Conoce usted a alguien que viva de la acuicultura en Bolivia? Sí____. No____.
En caso afirmativo especificar quién

Appendix 4

The Moxos project: questionnaire used for group interviews with fish farmers in the indigenous territories

ENTREVISTA GRUPAL PISCICULTORES TIM Y TIMI:

REFLEXIÓN SOBRE LA EXPERIENCIA DE CRÍA DE PECES

PROCEDIMIENTO

Visitamos aquellas comunidades que tienen más de un año de experiencia en cría de peces y han completado un ciclo entero de cultivo. Nos reunimos con cada grupo de piscicultores por separado y revisamos conjuntamente su experiencia. Es importante que participen tanto el hombre como la mujer de cada familia de socios.

Este ejercicio tiene los siguientes objetivos:

- *Identificar qué motivó a los comunarios para que se decidieran a iniciar la cría de peces. ¿Qué objetivos y expectativas tenían con respecto a la piscicultura antes de empezar? ¿a qué necesidades y/o oportunidades responde?*
- *Completar los datos existentes de rentabilidad económica, incluyendo aquellas inversiones que no fueron registradas durante el seguimiento por parte de los técnicos de Hoyam y de la comunidad (ej. costo de la inversión en mano de obra). Evaluar el sistema de producción que ha sido utilizado, en función de 'inputs' (productos del chaco, dinero, mano de obra etc.), 'outputs' (cantidad/tipo de beneficios obtenidos) y estrategia organizativa adoptada para la realización del trabajo.*
- *Rescatar la opinión de los piscicultores con respecto al proceso vivido y los resultados obtenidos, incluyendo aquellos elementos 'no cuantificables' que influyen en el rendimiento de los módulos y la motivación de los piscicultores. ¿Se ajustan los resultados a las expectativas iniciales (a)?*
- *Identificar los principales problemas con los que han tropezado y consensuar posibles estrategias para resolverlos*
- *Identificar los objetivos y expectativas que tienen los piscicultores para el futuro.*

Para complementar y triangular la información obtenida en este proceso de reflexión, el moderador/a debe llevar consigo los registros de seguimiento de los módulos que fueron elaborados por los técnicos de Hoyam y de las comunidades durante los meses de engorde (tasas de crecimiento, inversiones en alimento e insumos, productividad de los módulos, % de carne de pescado vendida y cambios en la composición del grupo)
IMPORTANTE: Identificar a las personas que iniciaron la cría de peces pero se retiraron de la actividad en una fase posterior. Éstas personas serán entrevistadas posteriormente de forma individual.

FORMATO DE LA ENTREVISTA
(Completar una ficha paara cada ciclo productivo concluido)

Fecha.. Durada del taller (horas)....................................
Moderador/a...

COMUNIDAD	GRUPO	MÓDULOS			PERIODO DE CRÍA

Aguada existente	
Estanque construido por el proyecto	

SISTEMA DE CULTIVO	Extensivo	Semi-intensivo
Familiar		
Grupal		

LISTA DE ASISTENTES A LA ENTREVISTA: Nombre y apellidos, cargo y firma
SOCIOS DEL GRUPO DE PISCICULTORES INSCRITOS AL INICIO DEL CICLO (COMPLETAR PARA CADA CILCO PRODUCTIVO)
ESPECIFICAR PARA CADAFAMILIA SOCIA: Nombre y apellidos de hombre y mujer. Edades. Indicar si se han retirado del grupo y en caso afirmativo qué explicación dan el resto de socios de por qué decidieron retirarse. Indicar el vínculo de parentesco con las demás familias. Indicar si participan en alguna otra actividad productiva grupal/comunal y con qué familias.

A. OBJETIVO DE LA ACTIVIDAD DE PRODUCCIÓN PISCÍCOLA

¿Qué metas o expectativas tenían con respecto a la piscicultura antes de empezar? ¿Qué razones les animó a iniciar la cría de peces? ¿A qué necesidades y/o oportunidades pretendían responder con esta actividad?

Para identificar posibles diferencias de opiniones y prioridades por cuestiones de género, dividimos el grupo entre hombres y mujeres y les damos 5 minutos para debatir este punto por separado. Luego pedimos a cada grupo que anote en una hoja sus principales conclusiones.

Una vez completa la lista de 'factores' que les motivó a iniciar la cría de peces, pedimos que les den una puntuación (1 = factor más importante; n = factor menos importante).

Algunos ejemplos: * La mejora de nuestra alimentación, * La generación de ingresos, * Una fuente de agua en época seca etc.
Observar también si se manifiestan diferencias de opinión/prioridades por una cuestión generacional

Mujeres	Nº	Hombres	Nº
Observaciones			

B. CARACTERIZACIÓN DEL SISTEMA PRODUCTIVO

En este apartado nos interesa completar y triangular los datos de seguimiento de los módulos productivos recopilados por los técnicos de Hoyam y de la comuna durante el periodo de cría. Así mismo nos interesa comprender y evaluar la estrategia organizativa que tiene cada comunidad para la realización del trabajo.

B.1. REVISIÓN CONJUNTA DE LOS REGISTROS DE SEGUIMIENTO DE LOS MÓDULOS
Llevamos los siguientes registros:

- Tablas de crecimiento
- Registro alimentación
- Registro cosechas y ventas

Revisamos la información y completamos aquellos datos que faltan

B.2. EVALUACIÓN INVERSIÓN MANO DE OBRA PARA LA ACTIVIDAD PISCÍCOLA

B.2.1. INVERSIÓN INICIAL

Actividad	Nº Jornales
Comprobación del terreno (hoyos)	
Limpieza del terreno para construcción aguada	
Limpieza y encalada poza (en caso de préstamo)	
Construcción cerco	
Sembrado de pasto	
TOTAL	

B.2.2. ELABORACIÓN ALIMENTO BALANCEADO

En base a los datos del registro de alimentación de los peces elaborado por los técnicos de la comunidad a lo largo del periodo de engorde, calculamos el costo en mano de obra para la producción de 1 QQ de balanceado:

Insumo	%	Kg. inicial	Procesamiento (horas)	Kg. final (pellet)	Mezcla y peletizd.	Secado (horas)	
TOTAL				46 Kg.			h

¿Quién realiza este trabajo?

Sólo mujeres	Más mujeres	Mujeres y Hombres	Más hombres	Sólo Hombres

¿Participan los niños en esta actividad?

Mucho	Un poco	Nada

INVERSIÓN TOTAL MANO DE OBRA PRODUCCIÓN ALIMENTO PARA TODO EL CICLO
................................h / QQ x ....QQ =.................................... h total
................................h total / 8 h/jornal = ...Jornales

B.2.3. ALIMENTACIÓN

Echada de alimento	Horas/día
Mañana	
Medio día	
Tarde	
TOTAL	

INVERSIÓN TOTAL MANO DE OBRA ALIMENTACIÓN
(.....................h / día x ....días / semana x ....semanas / año) / 8 h / jornal = ...TOTAL Jornales

¿Quién realiza este trabajo?

Sólo mujeres	Más mujeres	Mujeres y Hombres	Más Hombres	Sólo Hombres

¿Participan los niños en esta actividad?

Mucho	Un poco	Nada

B.2.4. MUESTREOS

Jornales necesarios para un muestreo	Nº de muestreos por ciclo	TOTAL jornales

¿Quién realiza este trabajo?

Sólo mujeres	Más mujeres	Mujeres y Hombres	Más Hombres	Sólo Hombres

¿Participan los niños en esta actividad?

Mucho	Un poco	Nada

B.2.5. MANTENIMIENTO DE LOS ESTANQUES

Jornales/día	Nº de días invertidos en mantenimiento por ciclo	TOTAL jornales

¿Quién realiza este trabajo?

Sólo mujeres	Más mujeres	Mujeres y Hombres	Más Hombres	Sólo Hombres

¿Participan los niños en esta actividad?

Mucho	Un poco	Nada

B.3. VALOR PRODUCTOS DEL CHACO APROVECHADOS EN LA ALIMENTACIÓN

Insumo	Unidad	¿Se vende?	Mercado	Bs./unidad (bruto)	Costo flete (Bs./unidad)	Bs./unidad (neto)
Plátano						
Maduro						
Yuca						
Maíz duro						
Maíz blando						
Arroz						
Afrecho arroz						
Trigo						
Guineo						
Papaya						
Manga						
Joco						
Palmito						
Frejol						
Soya						
Sorgo						
Arveja						
H. hueso						
H. carne						
Frutos varios						

B.4. ORGANIZACIÓN

¿Cómo se han organizado el trabajo de la cría de peces?

ALIMENTACIÓN

Actividades	Estrategia organizativa
Aportación insumos o dinero	
Compra o hechura de alimento	
Alimentación	
Registros de seguimiento	

MANTENIMIENTO DEL VIVERO

COSECHAS Y DISTRIBUCIÓN DE LOS BENEFICIOS

¿Está su reglamento de trabajo por escrito? Sí______ No______
¿Cómo se acordó?
¿Es una normativa clara y comprendida por todos los socios del grupo?

Ejercicio. Por separado, que cada persona escriba en un papel cómo respondería el grupo frente a las siguientes situaciones (Si no estamos seguros de la respuesta anotamos 'no se'):

- Un socio del grupo se ausenta 2 meses para trabajar en una estancia
- Un socio del grupo pierde parte de sus cultivos del chaco y no puede aportar la totalidad de productos ó dinero que le toca
- Un socio del grupo es de muy escasos recursos y su aportación a la cría es siempre menor que la de los demás
- Un socio del grupo aporta todos los productos y dinero correspondientes pero nunca se aparece para el trabajo de la hechura del alimento o el mantenimiento de los estanques

Socialización de los resultados

¿Cuántas veces se reúnen para trabajar o hablar del trabajo?
¿Quién convoca las reuniones?
¿Cuesta que se junten? Que cada persona escriba la respuesta en un papel por separado

Cuesta mucho	Cuesta bastante	Cuesta un poco	No cuesta mucho	No cuesta nada

Socialización de los resultados

C. EVALUACIÓN DEL PROCESO DE CRÍA Y LOS RESULTADOS OBTENIDOS

C.1. EVALUACIÓN DEL PROCESO DE CRÍA

Aspectos positivos y negativos del proceso de cría de peces
Dividimos al grupo entre hombres y mujeres y pedimos que identifiquen 1 aspecto de su experiencia en piscicultura que les haya gustado y 1 aspecto que no les haya gustado:

Mujeres		Hombres	
Sobre el trabajo			
Sí nos gustó	*No nos gustó*	*Sí nos gustó*	*No nos gustó*
Sobre los resultados obtenidos			
Sí nos gustó	*No nos gustó*	*Sí nos gustó*	*No nos gustó*
Socialización			

Ventajas e inconvenientes de trabajar en grupo

Ventajas	Inconvenientes

Impacto de la experiencia sobre la relación entre socios piscicultores. ¿Se ha fortalecido la relación entre socios? ¿Se han profundizado conflictos existentes? ¿Se han creado nuevos conflictos a raíz del trabajo grupal?

Impacto de la experiencia sobre las relaciones entre socios y el resto de la comunidad. ¿Se ha fortalecido el aspecto organizativo en la comunidad? ¿Se han profundizado conflictos existentes? ¿Se han creado nuevos conflictos a raíz del trabajo grupal?

C.2. RESULTADOS OBTENIDOS

Hagan una lista de beneficios obtenidos de la cría de peces y ordénenlos por orden de importancia. Compárenlos con las expectativas iniciales que tenían (A) ¿Qué hemos logrado? ¿Se ajustan los resultados a las expectativas iniciales? ¿Por qué?
Para identificar posibles diferencias de opiniones y prioridades por cuestiones de género, dividimos al grupo entre hombres y mujeres.

Mujeres	Nº	Hombres	Nº
Socialización			

Destino de la cosecha

Año	Total Unid	Total Kg.	Consumido Unid.	Consumido Kg.	% sobre total Kg.	Vendido Unid.	Vendido Kg.	% sobre el total Kg.	Bs./Kg.

	Mujeres	Hombres
Estuve de acuerdo con lo que consumimos y lo que se vendió		
Hubiera preferido consumir más		
Hubiera preferido consumir todo		
Hubiera preferido vender más		
Hubiera preferido vender todo		
Observaciones		

¿Qué utilidad hemos dado a las ganancias?

Familia	¿Qué hizo con las ganancias de la venta?
Observaciones	

Piensan que esta actividad puede contribuir sustancialmente a mejorar su nivel de vida? ¿Cómo?

Mujeres	Hombres
Mucho____ Bastante____ Algo____ Nada_____	Mucho____ Bastante____ Algo____ Nada_____

D. PRINCIPALES PROBLEMAS Y POSIBLES SOLUCIONES

¿Cuáles han sido los principales problemas con los que se han topado? ¿Qué estrategias se han adoptado para intentar resolverlos?

PROBLEMAS INTERNOS
ASPECTOS TÉCNICOS
(Tipo de suelos, el estanque, abastecimiento y calidad del agua, la alimentación de los peces, enfermedades, falta de información/conocimiento sobre el manejo etc.)

PROBLEMA	INTERVENCIÓN
Observaciones	

ASPECTOS ORGANIZATIVOS (Internos al grupo de piscicultores)

PROBLEMA	INTERVENCIÓN
Observaciones	

¿Cuál sería el tamaño del grupo ideal para trabajar en esta actividad? ¿Por qué?

¿Cómo podríamos organizarnos para que el trabajo grupal fuera equitativo? ¿Desarrollar mecanismos para asegurar que todos aporten igual? ¿Implementar un sistema de redistribución en función de la aportación de cada socio?

PROBLEMAS CON EL RESTO DE LA COMUNIDAD
¿Hemos tenido problemas con el resto de la comunidad? ¿Con algunas familias que no son socios del grupos de piscicultores? ¿Con las autoridades comunales?

PROBLEMA	INTERVENCIÓN
Observaciones	

¿Hay alguien del grupo que sea o haya sido recientemente autoridad comunal?

¿Han recibido apoyo de las autoridades comunales para llevar a cabo el trabajo? Ejemplos.

PROBLEMAS EXTERNOS

(Caminos, estacionalidad del mercado, exigencias del mercado, Hoyam, el rol del municipio etc.)

PROBLEMA	INTERVENCIÓN
Observaciones	

E. PROYECCIONES PARA EL FUTURO

¿Tienen la intención de ampliar su superficie de cría?

Sí	No	Mantener igual

¿Cuál sería la producción que les gustaría tener?

Que cada familia socio anote en un papel por separado cuántos peces le gustaría criar si tuviera las infraestructuras necesarias

Socio	Peces / familia
Observaciones	

En el caso de que tuvieran varias pozas y la posibilidad de tener una producción mucho mayor: ¿Sería una limitante la falta de mano de obra? ¿y el tamaño de sus chacos? ¿Qué otros aspectos podrían limitar su capacidad de incrementar su producción considerablemente?

Con el sistema de cultivo que manejan ustedes ahora, ¿Cuál sería la cantidad máxima de pescado que podría cultivar una familias? ¿Por qué? ¿Y la cantidad mínima? ¿Por qué?

Si quisieran ampliar considerablemente su producción de pescado, ¿usarían el mismo sistema de cultivo que usan ahora? ¿Qué harían diferente? ¿Por qué?

Si dependiera de ustedes, ¿Cuál de las siguientes opciones escogerían? ¿Por qué?:

Poza de 200 peces familiar (a 200 peces por familia)	
Poza de 1250 peces entre 5 familias (a 250 peces por familia)	
Poza para 3000 peces entre 10 familias (a 300 peces por familia)	

Que cada socio anote en un papel su respuesta sin consultar con los demás. Posteriormente se comentan los resultados con el resto del grupo. Posteriormente se procede a la socialización de los resultados

¿Deberíamos establecer una asociación de piscicultores de Moxos? ¿Qué función debería tener? ¿Cómo debería organizarse? ¿Que ventajas/inconvenientes podría tener? ¿Cómo ven la coordinación entre comunidades de su TCO? ¿Y de la otra TCO? ¿Creen que hay gente de las comunidades que, después de ser capacitados en administración, podrían llevar la gestión de la asociación? ¿Quiénes? ¿Creen que una vez la planta de acopio y de producción de balanceado esté funcionando bajo su gestión haría falta la presencia de Hoyam? Discusión:

Appendix 5

The Moxos project: questionnaire used for the livelihoods household survey in the indigenous territories

FORMATO ENCUESTA FAMILIAR (TCOs TIM Y TIMI)

Fecha de la entrevista (día/mes/año):
Nombre del/la entrevistador/a:

Comunidad y TCO:
Nombre y apellidos del/la entrevistado/a:
Cargo:
Grupo étnico:
Años de residencia en la comunidad (si nació ahí anotar como 'siempre'):

Lugar de procedencia:

Código de la familia *(número / comunidad / piscicultor)*:

Socio de la cooperativa de piscicultores	
Piscicultor a nivel familiar	
Ha solicitado participar en el proyecto de cría de peces en el futuro	
Era socio de la cooperativa de piscicultores pero se ha retirado	
No le interesa la actividad de producción piscícola	

¿Participa en alguno de los proyectos productivos de CIPCA o alguna otra ONG? Sí_____ No______

Especificar actividad	Familiar	Grupal (Nº)	Comunal (Nº)

APARTADO A
DATOS GENERALES

MIEMBROS DE LA FAMILIA QUE VIVEN CON USTED (incluyendo al / la entrevistado / a)

Nº	Nombre y apellidos	Edad	Sexo	Roles	Años escolaridad	Principal actividad	Movilidad	Motivos	Época	Cuando se fue	Residencia actual	Le envían dinero	Cada cuánto tiempo	Qué cantidad	Total año
			1 =F 2 =M	1 = padre 2 = madre 3 = hijo/a 4 = nieto/a 5 = abuelo/a 6 = sobrino/a 7 = Otros	1 = ninguno 2 = 1 - 3 3 = 4 - 6 4 = 7 - 8 5 = > 8 6 = bachiller	1 = niño/a 2 = estudiante 3 = chaco 4 = caza, pesca 5 = ganadería 6 = jornalero estancia 7 = extrac. madera 8 = trabajos hogar 9 = empl. doméstica 10 = empl. público 11 = empl. Empresa 12 = otros	Se ausenta de la comunidad 1 = nunca 2 = 1 sem./año 3 = 2 sem./año 4 = 1 mes/año 5 = 2 meses/año 6 = más de 2 meses/año	1 = trab. estancia 2 = trab. pueblo 3 = Salud 4 = Educación 5 = Fiestas 6 = compra / venta productos 7 = asuntos familiares 8 = otros	1= ene. 12= dic.	Año	Comunidad/Ciudad, Dpto, País	1 = Sí 2 = No	1=cada mes 2=varias veces al año 3=ocasionalmente	Cantidad Bs. cada vez que manda	total Bs. por año
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															

APARTADO B
BIENES Y RECURSOS

B.1. VIVIENDA

Tipo de vivienda	Observaciones sobre su estado (Comparar con casas vecinas)
Con material = 1 De adobe = 2 De barro y tacuara = 3 De madera/tacuara = 4 Otros = 5	
Puede evaluar el valor de su casa	

B.2. GANADO Y AVES DE CORRAL

	Cantidad hoy (num)	Cantidad en el 2003	Valor unidad (Bs/u)	Valor total (Bs)
Vaca de carne				
Vaca lechera				
Caballo				
Buey				
Burro				
Chancho				
Oveja de pelo				
Chivo				
Gallina				
Pato				
			TOTAL	

B.3. BIENES Y AHORROS

Inventario de bienes

Bienes	Cantidad	(Bs./u)	Bs. Total
Bicicleta			
Motocicleta			
Carretón			
Movilidad			
Canoa			
Motosierra			
Cama / Catre			
Radio			
Telar			
	Cantidad	(Bs./u)	Bs. Total
Terreno en			
Terreno en			
Terreno en			
Casa en			
Casa en			
Casa en			
		TOTAL	

Ahorros y créditos

¿Algún miembro de la familia que viva en la comunidad iene una cuenta en el banco o cooperativa de ahorros? (e.g. como Cactri o Prodem) Sí = 1; No = 2 ________

En caso afirmativo, ¿quiénes?

En caso afirmativo, ¿cuánto dinero tiene ahorrado en el banco o cooperativa de ahorro?

¿Algún miembro de esta casa tiene un crédito con alguna institución, banco o persona? (e.g. en Prodemo o Cactri) Sí = 1; No = 2 ____

En caso afirmativo ¿quiénes?

En caso afirmativo, ¿cuánto dinero se ha sacado prestado?

¿Qué institución le ha hecho el préstamo?

¿Por qué se ha prestado dinero?

¿Cuál es la tasa de interés de su préstamo?

En el caso que ningún miembro de la familia tenga créditos o préstamos en instituciones financieras, ¿por qué no se ha sacado ningún crédito? (e.g. no hay quien preste, la tasa de interés es muy alta, no hace falta etc.)

APARTADO C
CAPITAL SOCIAL

C.1. PARTICIPACIÓN EN ACTIVIDADES PRODUCTIVAS COMUNALES/GRUPALES

¿Participa su familia en alguna actividad productiva conjuntamente con otras personas? Sí = 1 / No = 2 _____

Ej. aserradero, ganado al partido, cría de ovejas en potrero compartido, rozada y tumbada de chaco etc.

Especificar actividad	Total familias	Parientes Todos = 1; Casi todos = 2 Algunos = 3; Pocos = 4	Desde cuándo	Problemas / beneficios

C. 2. SOLIDARIDAD Y CONFIANZA ENTRE COMUNARIOS

Cuándo la familia pasa por un apuro grave (enfermedad, pérdida de la cosecha etc.) ¿recibe apoyo de la comunidad?
Sí = 1 / No = 2 / Muy poco = 3 ________
En caso afirmativo ¿Qué tipo de apoyo es más común? (dinero, comida, medicamentos, ayuda en el chaco)

Cuándo la familia pasa por un apuro grave (enfermedad, pérdida de la cosecha etc.) ¿recibe apoyo de sus parientes (hermanos/as tíos/as etc.)? Sí = 1 / No = 2 / Muy poco = 3 ________
En caso afirmativo ¿Qué tipo de apoyo es más común? (dinero, comida, medicamentos, ayuda en el chaco)

Si usted pudiera escoger entre tener 10 vacas solo ó 25 vacas al partido con un comunario ¿Qué preferiría?

Opciones	Observaciones		
10 solo = 1 25 al partido = 2	Homb.		
	Mujer		

C. 3. PERCEPCIONES SOBRE LA VIDA EN COMUNIDAD

Imagine que un comunario tiene bastantes cabezas de ganado y quiere hacer potreros en una área donde otra familia tiene plantaciones. ¿De quién cree usted que es la responsabilidad de solucionar el problema?

Opciones	Observaciones		
Los afectados = 1 Las autoridades comunales = 2 Toda la comunidad = 3 La Subcentral = 4	Homb.		
	Mujer		

En el caso de que haya algunos niños dañinos que causen problemas en la comunidad ¿De quién cree usted que es la responsabilidad de llamarles la atención y corregirlos?

Opciones	Observaciones		
Sus padres = 1 Las autoridades comunales = 2 Toda la comunidad = 3 El profesor = 4	Homb.		
	Mujer		

¿Creen que las autoridades comunales y los dirigentes trabajan para el bien de todos los comunarios ó utilizan su posición para beneficiarse personalmente?

Opciones	Corregidor, Caciques		Dirigentes Subcentrales	
Trabajan para el bien de todos = 1	Hombre	Mujer	Hombre	Mujer
Trabajan para el bien de todos pero a veces se aprovechan = 2				
Se aprovechan bastante = 3				
Solo están ahí para el beneficio personal = 4				
Ejemplos:				

APARTADO D

ACTIVIDADES ECONÓMICAS

Actividades	Las más importantes para el sustento familiar (seguridad alimentaria)	Las más importantes para la generación de ingresos (plata)
Producción agrícola = 1; Producción ganado mayor = 2; Producción ganando menor = 3; Aves de corral = 4; Caza / pesca = 5; Extracción madera = 6; Tejería = 7 Artesanías = 8; Venta fuerza de trabajo = 9; Pulpería = 10		

D.1. AGRICULTURA

SUPERFICIE DE CULTIVO

Periodo	Superficie de cultivo (tareas) (x10 = 1 ha)	¿Por qué no se ha cultivado una superficie mayor? (enumerar razones)
En el 2003		
En el 2004		
Este año (2005)		
Promedio		

PRODUCCIÓN AGRÍCOLA 2005

Cultivos anuales

Cultivos anuales (oct. 2004 – oct. 2005)	Cuándo sembró 1=enero 12=dic.	Cuándo cosechó 1=enero 12=dic	Cosechas Al año	Unidad	Tot. Cantidad Consumido A Cantidad	B %	Tot. Cantidad Vendido C Cantidad	D %	Total producido / año E = A+C

Cultivos perennes

Cultivos perennes (oct. 2004 – oct. 2005)	Mes de siembra 1=enero 12=dic.	Mes de cosecha 1=enero 12=dic	Cosechas al año	Unidad	Cantidad Consumido A Cantidad	B %	Cantidad Vendido C Cantidad	D %	Total producido / año E = A+C

COMERCIALIZACIÓN

Cultivos (oct. 2004 – oct. 2005)	Donde venden los productos	Cómo transporta los productos	Precio venta (Bs./u)	Cuanto cuesta la flete (Bs./u)
(Solamente para cultivos destinados total o parcialmente para el mercado)	1 = entre comunarios 2 = acopiadores sobre crrtra. 3 = comunidad vecina 4 = estancias cercanas 5 = San Ignacio 6 = Trinidad; 8 = otros	1 = a pie; 2 = bicicleta 3 = carretón; 4 = moto propia 5 = moto alquiler; 6 = movilidad propia; 7 = movilidad transportista 8 = expreso (flete)		

D.2. PRODUCCIÓN PECUARIA & AVES DE CORRAL

Producción (oct. 2004 – oct. 2005)	Unidad	Cantidad Consumido A Cantidad	B %	Cantidad Vendido C Cantidad	D %	Total producido / año E = A+C
Vacas para carne	Kg. carne / año					
Vacas lecheras	Litros leche / semana					
Chanchos	Kg. carne / año					
Gallinas criollas	Huevos / semana					
Gallinas criollas	Kg. pollo / año					
Gallinas ponedoras	Huevos / semana					
Gallinas ponedoras	Kg. pollo / año					
Patos	Huevos / semana					
Patos	Kg. carne / año					
Ovejas de pelo	Litros leche / semana					
Ovejas de pelo	Kg. carne / año					
Abejas	*Litros miel / año*					

COMERCIALIZACIÓN

Producción 2005	Donde venden los productos	Cómo transporta los productos	Precio venta (Bs./u)	Cuanto cuesta la flete (Bs./u)
Solo cultivos destinados total o parcialmente para la venta	Mismos códigos que para agricultura	Mismos códigos que para agricultura		

D.3. ACTIVIDADES EXTRACTIVAS
CANTIDADES EXTRAÍDAS en el 2005

Recurso	Especie	Época aprovech. Seca = 1; Lluvias = 2 Siempre = 3	Unidad	Cantidad Consumido A Cantidad	B %	Cantidad Vendido C Cantidad	D %	Total / año E = A+C
Madera								
							TOTAL	
Caza								
							TOTAL	
Pesca								
							TOTAL	
Recolección								
							TOTAL	

COMERCIALIZACIÓN

Productos (2005)	Donde venden los productos	Cómo transporta los productos	Precio venta (Bs./u)	Cuanto cuesta la flete (Bs./u)
Solo los destinados total o parcialmente a la venta	Mismos códigos que para agricultura	Mismos códigos que para agricultura		

D.4. ACTIVIDADES ECONÓMICAS NO AGROPECUARIAS

Actividad (Ej. Tejería, Pulpería, Artesanía etc.)	Época Producción Seca = 1; Lluvia = 2; Siempre = 3	Unidad	Cantidad Consumido A Cantidad	B %	Cantidad Vendido C Cantidad	D %	Total / año E = A+C

COMERCIALIZACIÓN

Actividad (2005)	Donde venden los productos	Cómo transporta los productos	Precio venta (Bs./u)	Cuanto cuesta la flete (Bs./u)
Solo las destinados total o parcialmente a la venta	Mismos códigos que para agricultura	Mismos códigos que para agricultura		

D.5. VENTA FUERZA DE TRABAJO 2005

Miembro familia	Lugar Comunidad =1; Comunidad Vecina=2; Haciendas =3; S.I.=4; Trinidad =5; otros=6	Activ. Desempeñadas 1=chaco; 2=Vaquero 3=jornalero estancia; 4=extrac. Madera; 5=empl. doméstica 6=empl. Público; 7=empl. Empresa 8=Ayud. Albañil; 12=otros	Nº días	Bs/Jornal (con comida)	Total ganancias 2005	Época meses (1-12)

D.6. COMPRA FUERZA DE TRABAJO

¿En el 2005 pagó a alguien para que le ayudara con el trabajo? Sí = 1, No = 2 ________

Actividad (2005)	Meses (1-12)	Nº jornales	Forma de pago 1= Contado 2= Por obra 3= productos	Valor Bs./jornal	Bs. Total

APARTADO E

CAMBIOS EN EL SISTEMA DE VIDA / EXPECTATIVAS

Actualmente la familia vive de:

1		2		3	

¿De qué vivían hace 10 años?

¿De qué vivían los abuelos?

Cuando se vivía mejor

1 = Ahora 2 = Hace 10 años 3 = En época de los abuelos 4= Ninguno	¿Por qué?

¿En los últimos 10 años han iniciado una actividad agropecuaria o extractiva nueva? Sí = 1 / No = 2 ______

¿Cuál/es? ¿Por qué/objetivo?

En los últimos 5 años, su situación económica ha:

Mejorado	Empeorado	Sigue igual

¿Por qué?

Si pudiera escoger ¿Cuál de las siguientes situaciones preferiría? (*Preguntar al hombre y a la mujer por separado)***

Estar ganando:

35 Bs. / jornal en Santa Cruz = 1	*Hombre*__________ ¿Por qué?	*Mujer*__________ ¿Por qué?
25 Bs. / jornal en el pueblo (S.I. ó TDD) = 2		
20 Bs. / jornal en estancia cercana o caminos = 3		
10 Bs. / jornal en su propio chaco =4		

Si dispusiera de 1000 Dólares (8000 Bs.) ¿Qué haría c on la plata?

Si pudiera escoger entre tener los siguientes bienes ¿Qué preferiría?

2 vacas preñadas y 1 hectárea de terreno 2 vacas lecheras y 1 hectárea de terreno 1 poza de 20X50 con 500 pacuses 150 gallinas con su gallinero incluido 5 ovejas 1 ovejo y 1 hectárea de terreno 1 motosierra y 200 dólares de combustible		¿Por qué?

APARTADO F

EVALUACIÓN PISCICULTURA

SOLAMENTE PARA AQUELLAS COMUNIDADES CON MÁS DE 1 AÑO DE EXPERIENCIA EN PISCICULTURA

F.1. EVALUACIÓN PISCICULTORES

Hombre

¿Para usted cuál es el principal interés que tiene la piscicultura?

Principalmente el consumo = 1 El consumo y la venta = 2 Principalmente la venta = 3		¿Por qué?

Si dependiera de usted, ¿Cuál de las siguientes opciones escogería?

Poza de 200 peces familiar (a 200 peces por familia) = 1		¿Por qué?
Poza de 1250 peces entre 5 familias (a 250 peces por familia) = 2		
Poza para 3000 peces entre 10 familias (a 300 peces por familia) = 3		

Mujer

¿Para usted cuál es el principal interés que tiene la piscicultura?

Principalmente el consumo = 1 El consumo y la venta = 2 Principalmente la venta = 3		¿Por qué?

Si dependiera de usted, ¿Cuál de las siguientes opciones escogería?

Poza de 200 peces familiar (a 200 peces por familia) = 1		¿Por qué?
Poza de 1250 peces entre 5 familias (a 250 peces por familia) = 2		
Poza para 3000 peces entre 10 familias (a 300 peces por familia) = 3		

F.2. EVALUACIÓN PERSONAS NO INVOLUCRADAS EN LA ACTIVIDAD PISCÍCOLA

¿Usted cree que la crianza de peces ha sido buena para la comunidad? Si = 1 / No = 2 / Regular = 3 ¿Por qué?

¿Le gustaría que hubiese más crianza de peces en su comunidad? Si = 1 / No = 2 / Igual = 3 ¿Por qué?

¿Se ha generado algún conflicto por el uso de aguadas comunales para la crianza de peces? Si = 1 / No = 2 ¿Por qué?

¿Por qué no participa usted en la actividad piscícola a nivel familiar?

Es muy arriesgado / No creo que salga a cuenta = 1 Es muy costoso hacer la poza = 2 Hay harto pescado en el río/laguna = 3 Aquí es difícil sacar el producto / no hay donde vender = 4 No tengo tiempo = 5; No tengo chaco para alimentarlos = 6 No me gusta el pescado = 7; No se = 8		Observaciones

¿Por qué no se ha juntado con alguno de los grupos de piscicultores existentes?

Yo trabajaría en grupo, pero no me interesa la actividad = 1 Prefiero trabajar solo = 2 Hay ciertas personas del grupo con la que no me llevo = 3 El grupo de piscicultores nunca me ha invitado, no dejan entrar = 4		Observaciones

F.3. EVALUACIÓN PERSONAS QUE HAN SIDO PISCICULTORAS PERO SE HAN RETIRADO

Tenía poza familiar	
Participaba en poza grupal	

¿Por qué abandonó la actividad piscícola?

Problemas técnicos = 1 No salía rentable = 2 No tenía tiempo = 3 Problemas con el grupo = 4 Tuve que ausentarme = 5		Especificar

¿Tiene intención de retomarla en algún momento? Si = 1 / No = 2 / No se = 3 ¿Bajo qué condiciones?

Construcción poza / aguada
Sistema organizativo
Tipo de alimentación
Destino de la producción

Appendix 6

Pro-poor aquaculture development and extension projects in the Bolivian Amazon (up until 2006)

Project & organisation	Location & beneficiaries	Project characteristics	Sources of funding	Budget (US $)
		BENI		**1,723,000**
1996-2001 *Proyecto Yucumo* *Proyecto Pilón Lajas* NGO VSF – France	TCO Pilón Lajas: indigenous communities Rurrenabaque – Yucumo: campesino settlements	- Construction of experimental farm and Hatchery 'Piedras Blancas' - Training in artificial reproduction and farming of fish - Extension: ponds & small dams, family based farming, tambacú (hybrid) & carp, food security & income generation	DFID EU DGIS TCA	500,000
1997-2000 *Piscicultura Doméstica e Institucional* UG TICH - PRODESIB	TCO Chimán: indigenous communities San Borja	- Construction of experimental farm 'Horeb' - Training in fish farming - Extension: ponds & cages, family based farming, tilapia & pacú, food security	FIDA FONAMA CAF CIDA	100,000
2004-2005 *Reactivación del Proyecto Chimán* UG TICH - PRODESIB	TCO Chimán: indigenous communities San Borja	(Reactivation of the project *Piscicultura Doméstica e Institucional* PRODESIB) - Training in fish farming - Extension: ponds, family/community based farming, pacú	FIDA	10,000
(1997-1998 research) **2001-** *Desarrollo de la Piscicultura rural en los Llanos de Moxos* NGO HOYAM - Moxos	TCOs TIM & TIMI: Indigenous communities S. I. de Moxos & Trinidad: campesino settlements & fishing communities along the river Mamoré	- Construction of experimental farm and Hatchery 'Mausa', fish feed factory and fish storing & processing facilities - Research and training in artificial reproduction and farming of native fish species. - Extension: ponds, family/group based farming, pacú, tambaquí, sábalo & boga, food security & income generation - Establishment of regional producer association ASOPIM	AECI ACCD Spain Local councils of *BCN, St. Cugat, Masnou, Gavà* Catalunya	500,000

2001-2003 *Piscicultura en Centros Multiuso* NGO EPARU	TCO TIPNIS: indigenous communities	- Training in fish farming - Extension: ponds, community based farming, pacú, food security & income generation	Autonomous government Basque Country	25,000
2002- *Cría de pacú en TIM y TIMI* NGO CIPCA - Beni	TCOs TIM & TIMI: indigenous communities	- Extension: pond construction, family/group based farming - Extension: agricultural crop diversification for local fish feed production	UNITAS NOVIB EED	50,000
2003-2005 *Unidades Modelo de Producción Piscícola San. Andrés* Humid Tropics Found., SIBTA CIRA - UAB	San Andrés & Trinidad: indigenous & campesino communities, fishing communities along the river Mamoré	- Design of business plan for aquaculture development in Beni - Training in fish farming - Extension: ponds, group based farming, pacú & tambacú (hybrid), - Establishment of regional producer association 'San Andrés'	IDB FOCAS Local council Prefectura	165,000
2004- *Piscicultura rural TIPNIS* DDS Prefectura Beni	TCO TIPNIS: indigenous communities	- Training in fish farming - Extension: ponds, group based farming, pacú, food security	Prefectura Local councils benef., JICA	50,000
2005- *Programa de desarrollo de la Piscicultura en San Andrés* H. Alcaldía San Andrés	San Andrés: indigenous & campesino communities	- Construction of a hatchery, fish feed factory and fish storing & processing facilities - Training in artificial reproduction and farming of fish - Extension: ponds & cages, family/group based farming.	JICA, FPS PUMA SDC Local council	323,000
SANTA CRUZ DE LA SIERRA				**180,000+**
1989 – *Programa de Desarrollo Piscícola* UAGRM Santa Cruz	Santa Cruz: small/medium producers, university students	- Construction of experimental farm and Hatchery 'El Prado' - Research and training in artificial reproduction and farming of fish - Extension: tilapia, carp, tambaquí, surubí	CORDECRUZ FAO IRD, UAGRM	-
2003- *Unidades modelo de producción piscícola* PRODISA - Belga	Provinces Ichilo & Sara: indigenous and campesino communities	- Training in fish farming - Extension: ponds, family/group based farming, pacú & carp, food security & income generation	DGCD PLANE Prefectura	30,000
2004 - NGO GATHER – Bolivia	San Julián: campesino communities	- Training in fish farming - Extension: ponds, family based farming, tilapia	-	-
2005- *Repoblamiento y cría de peces en embalses.* El Prado - UAGRM Instituto D. Champagnat	Comarapa: fishermen and campesino communities	- Training in fish farming - Restocking program, carp - Pond construction, carp	Prefectura Local council Comarapa	120,000

Proposal for evaluation *Piscicultura comunal en Pailón* El Prado - UAGRM	Pailón: compensation for riverine communities affected by the construction of a bridge over the Río Grande.	- Training in fish farming - Extension: ponds, group based farming, carp	Prefectura Local council Pailón	30,000
		COCHABAMBA		**1,000,000**
1988- *Programa de Desarrollo Piscícola integral* ULRA - UMSS	Chapare: indigenous and campesino communities, university students	- Construction of experimental farm and Hatchery 'Pirahiba' - Research and training in artificial reproduction and farming of fish - Extension: ponds, family and community based farming, tilapia, carp, tambaquí, food security & income generation	USAID, PDAR UMSS, VLIR ADEPESCA PRAEDAC	700,000
2001-2003 *PRAEDAC* Natural Resources Department	Chapare: campesino communities	- Training in fish farming - Extension: ponds, community based farming, tambaquí, food security	EU VMDA	160,000
2003-2006 *PRAEDAC (Stage II)* Natural Resources Department	Chapare: campesino communities	- Extension: family based farming, tambaquí, income generation - Construction of feed factory and fish storing & processing facilities - Establishment of regional producer association 'tambaquí'	EU, VMDA Local council Ivirgarzama	100,000
2004-2006 *Piscicultura familiar N. Estrella* Producer Asoc. AIPANE UAPAC	Chapare: campesino communities	- Extension: family based farming, tambaquí, income generation - Establishment of regional producer association 'Nueva Estrella'	USAID	40,000
2006- *Programa ARCO*	Chapare: campesino communities	- Extension: family based farming, tambaquí, income generation	USAID	-
		LA PAZ		**599,000+**
1980-1992 *Programa de Desarrollo Piscícola integral* CORDEPAZ	Coroico: campesino communities	- Construction of experimental farm and Hatchery 'Minachi' - Research and training in artificial reproduction and farming of fish - Extension: ponds, family and community based farming, tilapia, food security	CORDEPAZ UNDP	500,000
1997- ? ISTAIC. Instituto Superior Técnico	Caranavi: ISTAIC students	- Research and training in fish farming - Experimental farm: tilapia, carp, pacú	Ministry of Education	-
1996- 2002 *Proyecto MIRNA.* NGO CARE	Caranavi and Larecaja: campesino communities	- Training in fish farming - Extension: ponds, community based farming, tilapia, carp, food security	DANIDA	50,000

2000-2003 *Ecopiscicultura en el Trópico Húmedo* NGO MAN-B & BIDECA	Caranavi: campesino communities	- Training in fish farming - Extension: ponds, family based farming, tilapia, carp, pacú, food security	MAN-B	11,000
2000-2002 NGO QHANA	Caranavi: campesino communities	- Extension: ponds, family based farming, carp, food security	Ayuda en Acción USA	10,000
2003- PDA Taipiplaya	Caranavi: women, campesino communities	- Extension: ponds, family based farming, carp, food security	World Vision USA	-
2003- *PATAGC* Boarding school Martín Cárdenas	Coroico: students of Martín Cárdenas	- Training in fish farming - Extension: ponds, family based farming, carp, food security	CATIE USAID	8,000
2004- NGO CARITAS Coroico	Coroico: women, campesino communities	- Extension: ponds, family based farming, carp, food security	CARITAS	-
Proposal for evaluation PDA Coroico	Coroico: women, campesino communities	- Extension: ponds, family based farming, carp, food security	World Vision USA	-
2004- NGO CARITAS Caranavi	Caranavi: women, campesino communities	- Extension: ponds, family based farming, carp, food security	CARITAS	20,000
2005- PDA Caranavi	Caranavi: women, campesino communities	- Extension: ponds, family based farming, carp, food security	World Vision USA	-
INVESTMENT IN PRO-POOR AMAZON AQUACULTURE EXTENSION (Minimum)				**3,502,000**

Appendix 7

Map of the indigenous communities in TIM and TIMI

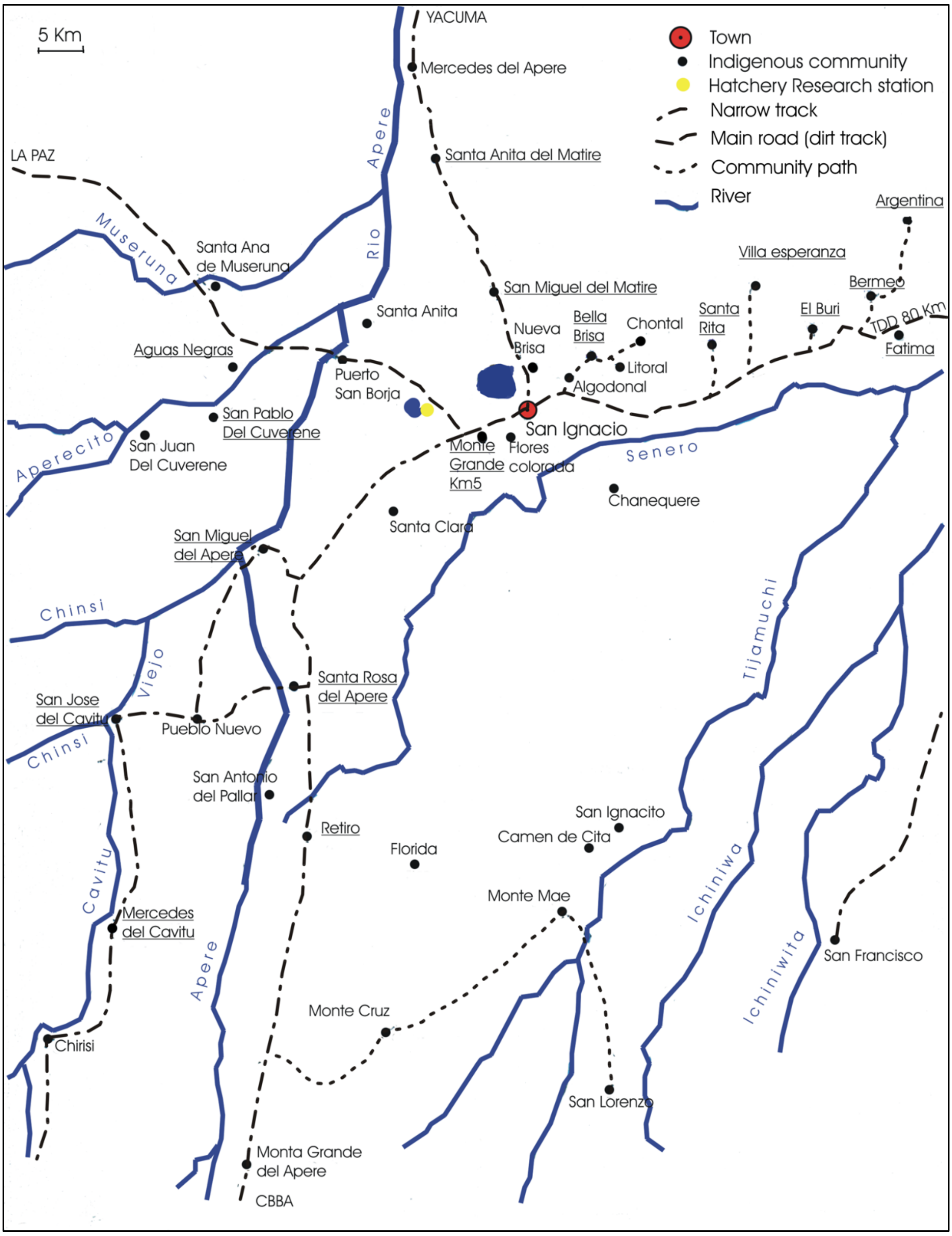

Figure A- 1. Indigenous communities in TIM and TIMI, province of Moxos. Underlined: communities engaged in aquaculture activities in 2006.