FACTS Reports

Field Actions Science Reports

Special Issue 3 (2011)
Brazil

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Electronic reference
Andréa Cardoso Ventura and José Célio Silveira Andrade, « Polyculture in the semi-arid regions of Brazil », *Field Actions Science Reports* [Online], Special Issue 3 | 2011, Online since 19 April 2013, connection on 11 June 2013. URL : http://factsreports.revues.org/2557

Publisher: Institut Veolia Environnement
http://factsreports.revues.org
http://www.revues.org

Document available online on: http://factsreports.revues.org/2557
This PDF document was generated by the journal.

http://factsreports.revues.org/2557
Published 19 April 2013

FACTS Reports

POLYCULTURE IN THE SEMI-ARID REGIONS OF BRAZIL

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ABSTRACT. The previsions say that the semiarid regions in the world are between the most impacted by the global climate change. In Brazil, among the environmental (lost of biodiversity, extreme droughts), social (migrations, diseases exposition) and economics (reduction on income generation, in employment rates, and in the Gross Domestic Product) of global warming, it is affirmed strong pressures specially over the agriculture and livestock, the mainly subsistence resource in Brazilian semiarid region, because of the increase of the rain irregularity and increase of evaporation. However, it is possible to believe that the many projects that are being developed by the social movement of convivial with the semiarid could play an important act in the climate change mitigation and adaptation, and also in the region development. In this paper, one of this initiatives is presented, the Policultura no Semiárido (multiple cultivation in semiarid), developed by Instituto de Permacultura da Bahia that used simple technologies, evolving the local and the experts knowledge, contribute to Human Development in 65 rural communities in four municipalities in semiarid region at Bahia state, bringing new ways to adapt to the climate reality, with less green house emission, and with the improvement of life conditions.

Key Words. Multiple cultivations, climate changes, semi-arid regions, human development, Bahia-Brazil

1. Introduction

In 2012, the year of Rio+20, another United Nations conference on sustainable development, in Brazil, global environmental management continues to face challenges that are remarkably similar to those faced at the first United Nations Conference on the Human Environment (UNCHE) in Stockholm, Sweden in 1972. The main current challenges of vital importance to human development include climate change (UNDP 2007). Humanity as a whole is looking at medium and long term risks but it is clear that the risks and vulnerabilities created by climate change are primarily faced by the poorest people in the world, creating an obvious threat to the advances made towards meeting millennium development goals or MDGs (UNDP, 2000).

Most solutions so far presented and supported at global and national level for the reduction of climate change and its impact involve mainly financial measures, such as the proposals developed within the Kyoto Protocol, which have created the carbon credit market. However, many studies around the world have shown that the projects associated with these proposals are failing in their double aim of cutting greenhouse gases while also promoting sustainable development (Sutter and Parreño, 2007; Guijarro et al, 2008; Boyd et. al., 2009a), meaning that significant change is needed in future development policies and practices to include climate change scenarios (Boyd et al., 2009b).

Given the need to identify principles to guide the management strategies that will ensure the future sustainable development of the planet - including not just environmental questions but also human and planet development and the eradication of poverty and fairness *inter alia* (UN, 2012) - and the absence of clear definitions of how climate is to be environmentally managed in future in terms of both mitigating climate change and adapting to it, current instruments must clearly be redefined to ensure that in future they provide real and measurable co-benefits (additional to sustainable development and emission reductions) to the countries hosting projects.

When talking of social and environmental problems connected with climate change and the need to ensure sustainable development in Brazil, it is impossible not to think about the semi-arid region of the country. Studies indicate that this ecosystem will be one of those most strongly affected by climate change, which will impact not just existing biodiversity but also food production and the quality of life of local populations (IPCC 2007; Marengo 2007) and could result in disease, hunger and starvation in what is already an area suffering from poverty, social inequality and major migration.

This study forms part of research into new opportunities that could be incorporated into technological decisions relating to the "green economy", a concept adopted as the main pillar of discussion at Rio+20 and in global strategies for the future development of humanity. These are not "new solutions" "transferred" from developed countries for application in semi-arid regions but are instead developed and/or implemented together with the local population and are appropriate for it - they are Social Technologies (ST). This study presents an example of ST developed to help people live with the climate in the semi-arid region of Brazil: Polyculture in the Semi-Arid Regions of Brazil. It focuses in particular on how this technology contributes to Human Development (HD) in the communities in which it has been implemented. The ST could be applied in other locations with similar environments.

2. METHODOLOGY

The methodology applied in this investigation involves three stages. Firstly, ST is characterised by identifying its main concepts from the literature (theses, dissertations, scientific books and articles) and Science and Technology (S&T) institutes. This stage, which used Vantage Point software, revealed that the concept most widely applied in Brazil to characterise ST experiments and projects is that developed by the Social Technology Network (STN) which understands how "replicable products, techniques and methodologies developed together with the community are effective social transformation solutions" (STN, 2010). This stage also identified the main characteristics of an ST: (i) low financial investment; (ii) use of local resources; (iii) community involvement; and (iv) replicability.

The next step was to identify - from public notices, awards and S&T certificates and from social transformation projects - the ST characteristics included in the requirements specified in the relevant regulations and procedures. This revealed 20 awards, public notices and support programmes in Brazil and South America that were directly or indirectly connected with ST and included among their award/certification requirements the above characteristics.

The second stage of the methodology was documentary analysis (ST lists on the websites of relevant institutions and sent to the researchers, specialist reviews, scientific publications mentioning ST, books) of all STs identified in the above prizes and public notices, showing place of implementation, number of replications, type of ST (e.g. education, health, environment, water), managing organisation and main partners. The data was then organised into an Excel worksheet and analysed. The 20 prizes and public notices analysed revealed 130 STs in the State of Bahia. While all were recognised as STs, very few received an award. The list of municipalities with an ST was then compared with the list of 265 municipalities[1] in the semi-arid region of the State provided by the Ministry of Regional Integration (2005). This revealed 60 different types of ST in 95 municipalities (37%) in the semi-arid region of Bahia. 29% of the municipalities in the semi-arid region with an ST had more than one technology.

We then checked which STs located in the semi-arid region contribute to mitigating climate change problems. This was done by applying the Ventura, Andrade and Almeida (2011) analytical model which presents indicators of contribution to the mitigation of climate change (e.g. the use of renewable raw materials or of less intensive technologies to reduce greenhouse gases) and of adaption to it (e.g. the development of crops that are more resistant to climate change and the increased availability or more rational use of water and energy). This revealed 19 STs, after which we moved on to field work.

In-depth visits were made to 9 (nine) of the ST projects, which were selected on the basis of their accessibility. The aim of this stage was to carry out a physical inspection of whether there were any indicators of contribution to the mitigation of climate change and the promotion of human development. Each visit, which lasted 1-3 days depending on the distance between locations, involved semi-structured interviews with the ST managers and at least three members of the communities involved. An observation chart was used. The interviews and the observation chart were based on the Sustainability & Empowerment Framework model developed to measure the co-benefits of Kyoto Protocol clean development mechanisms (CDM) in the communities that implement them (Fernández et al, 2011). This model analyses in particular the possible collaboration that climate change projects might contribute to human development the locations hosting them.

Use of this tool to measure the contribution of social technologies to HD was first validated by Ventura et al (2011) based on the results obtained by three STs in the semi-arid region of Bahia. This study presents the results of the Polyculture in Semi-Arid Regions ST, which was selected because of its striking contribution to the mitigation of climate change and adaptation to it and also because of its part in improving the quality of life in the communities in which it was run.

1 Sixty-three per cent (63%) of the municipalities in Bahia are in the semi-arid region.

3. POLYCULTURE IN SEMI-ARID REGIONS: REVIVAL OF TRADITIONS AND INTRODUCTION OF NEW KNOWLEDGE FOR FAMILY FARMING

3.1 Presentation of the project

The Polyculture in Semi-Arid Regions project began in 1999 and ended in mid-2011 by the Bahia Institute of Permaculture (IPB). It was based on a combination of environmentally and economically sustainable practices, an empirical understanding of small farmers, technical knowledge based on agro-ecological principles (agricultural practices based on natural systems) and permaculture (the design and planning of sustainable settlements). The project proposal defines polyculture as a way of imitating nature as closely as possible to enable a number of different plant species to coexist and cooperate within the same physical space, enabling the production of a number of agricultural products (IPB, 2007; 2012a).

Freitas (2009) writes that the project aimed to adopt techniques and crops suitable to the semi-arid climate and environment, creating units of production that have little need for external resources and are able to produce an abundance of food for human and animal consumption and for sale. For IPB (2007), polyculture "revives the old farming traditions of these regions". Referring to Feiden (2005, p. 66), Freitas (2009) states that the development of agro-ecological systems is not a step backward but instead makes best use of ecological processes and interactions by applying old logic to agro-industrial modernisation.

The project began by creating experimental polyculture fields on a number of rural properties in the municipalities involved. The initially ½ to 1 hectare and later no more than 1000 m^2 fields aimed to prove the effectiveness of polyculture (Sanches, 2011) and were organised to maximise the potential of each location, applying principles used in similar agro-forestry systems, i.e. imitating the natural succession of species, using plants with short cycles (e.g. beans, rocket), medium cycles (e.g. corn, sunflowers) and long cycles (e.g. castor bean, pigeon pea), mixing these with trees (e.g. Gossypium mustelinum) and creepers (e.g. pumpkins, sweet-potatoes, string beans, watermelons, maxixe) (IPB, 2007). According to the managers interviewed, the intention was to create agro-ecosystems similar to the original, natural ecosystem of Caatinga. The techniques adopted made farming possible without irrigation systems and kept fields green and productive throughout the year without the need for resources from outside the property (Freitas, 2009). The approximate cost of the project was just R$ 34.00 per family/month (IPB, 2012).

One of its main aims being to show that "a family can live well in a semi-arid region with a reliable food supply, good health and in harmony with nature" (Freitas, 2009, p. 1), the project was eventually extended to 65 rural communities in four municipalities in the semi-arid region of Bahia: Cafarnaum, Morro do Chapéu, Ourolândia and Umburanas. Also according to the author, another aim was to provide food security to farming families, to reduce rural depopulation and help combat desertification in the region. IPB (2007) states that the polyculture fields on average produced 40% more than monocultures. This was because agricultural technicians and farmers pooled their scientific and traditional knowledge to develop an alternative way of increasing the efficient use of available resources and to reduce financial risk.

The polyculture technique used in the project contrasts with the traditional monoculture approach widely used in modern agriculture (IPB, 2012) which, combined with the higher productivity obtained by using heavy equipment, fertilizers and pesticides, has extremely negative impacts, such as soil compaction, the elimination or reduction of microbial flora in the soil, the unbalanced absorption of nutrients, food pollution, high yields only for a few farmers and major natural imbalances, e.g. greenhouse gases (Lima, 2002; Salomón, 2012).

IPB data ((IPB, 2007; 2012; UNV, CAIXA, 2007) shows that the results obtained by the project include:

- An estimated around 1,500 families (over 400 properties) adopted more sustainable farming techniques;
- Over 300 farmers received technical training in polyculture;
- 10 community nurseries were set up to produce seedlings;
- Almost 80,000 trees native or suitable to the semi-arid climate were planted;
- The general productivity of land rose by just under 20%;
- An estimated over 50% of the products previously purchased on outside markets were now produced on farmers' own land. Over 1,000 beehives were installed;
- 50 farmers were trained to be leaders and to interact with communities;
- 40 young people were trained as rural community agents (RCAs);
- Four polyculture farming associations were created with over 100 members in total.

The project won 1st prize in the responsible action category at the 2004 Bahia Environmental Awards promoted by the Bahia Secretary of State for the Environment and Water Resources; 3rd prize in the humanitarian category at the 2004 Von Martius Environmental Awards of the Brazilian-German Chamber of Commerce; the 2006 Best Environmental Practices in the North-East Award promoted by Nordestina de Ecologia; it was a finalist in the 2005 UNDP Millennium Development Goals Award; it was selected as one of the "50 Brazilian Ways to Change the World – Brazil and the Millennium Development Goals" for the UN voluntary work programme published in 2007; and it was a finalist in the 2007 Bank of Brazil Social Technology Award.

IPB had a number of partners during the project. These included Brazilian government bodies (National Environmental Fund/Ministry of the Environment – FNMA/MMA, Companhia Nacional de Abastecimento/Ministry of

Agricultural Development – CONAB/MDA), State bodies (General Office for Social Development and the Fight against Poverty in the State of Bahia – SECOMP, Companhia de Desenvolvimento e Ação Regional - CAR, which is connected to the General Planning Office of the State of Bahia - SEPLAM), municipal bodies (the municipal authorities of Cafarnaum, Ourolândia and Umburanas), private companies (BOM – Brasil Óleo de Mamona Ltda.), inter-governmental organisations (United Nations Development Programme – UNDP), local associations (Association of Semi-Arid Polyculture Farmers, the associations of polyculture farmers in the municipalities of Umburanas, of Catarina in Ourolândia, and of Tombador in Umburanas), workers' associations (the Bahia Vegetable Oil Industry Union) and NGOs (Both Ends/ Netherlands). According to UNV and the Federal Savings Bank (2007), the involvement of various local and external project stakeholders (government, companies, NGOs and associations) made it more sustainable.

3.2 Project location

The project was organised in four municipalities in the interior of the State of Bahia, Brazil – Cafarnaum, Morro do Chapéu, Ourolândia and Umburanas (figure 1), in a region known as the "drought polygon". The semi-arid regions of Brazil cover 1,134 municipalities and have a total area of 977.6 thousand km², of which 874.3 thousand km² in the north-east of the country.

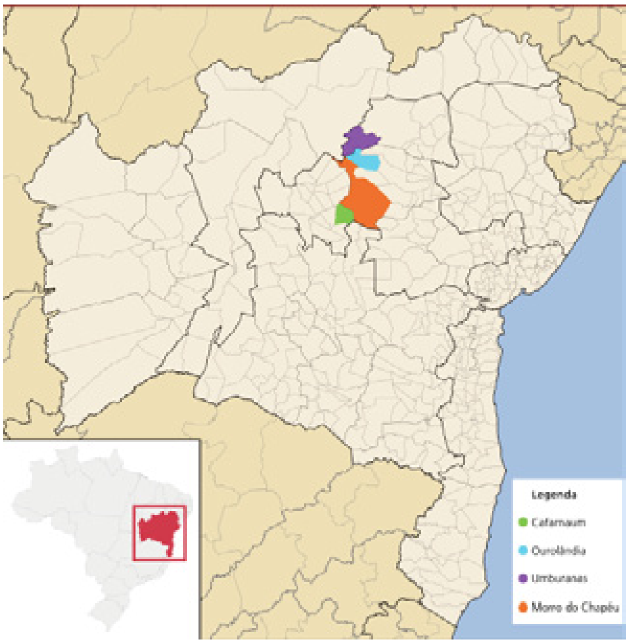

Figure 1. Location of the Polyculture in Semi-Arid Regions project
Source: Sanches (2011)

In percentage terms, the semi-arid area of north-east Brazil covers 53.3% of the country since the State of Bahia (BA), as covered in this study, represents 44.8% of the semi-arid north-east region (see figure 2).

The climate of this area has two seasons: a long, dry summer lasting 7-9 months of the year, and a short, rainy winter. In addition to the annual dry season, the region also suffers from regular droughts (about every 26 years) that can last 18 months or more. In 2012 the semi-arid region of Brazil was suffering a drought considered the worst in the last 47 years (G1, 2012). Of the 693 municipalities that had already declared a state of emergency, 228 were in Bahia (UOL Notícias, 2012).

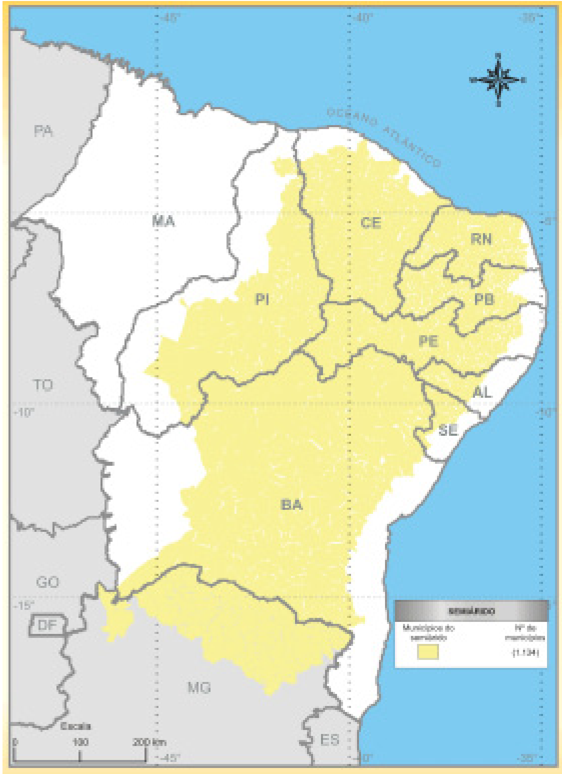

Figure 2. North-east and semi-arid region
Source: Banco do Nordeste (2010)

Rain, when it comes, is torrential and irregular. Total average annual rainfall is 550 mm but water balance is a major problem, mainly because of high rates of evaporation. It should be noted that the semi-arid region of Brazil has one of the highest rainfalls in the world. The problem is therefore not a lack of rainfall but high levels of rainwater loss caused by the soil, wind and mudslides. Soil is generally shallow, stony or sandy, with pH around 6-7. Caatinga vegetation tends towards thorny, twisted, deciduous small trees and shrubs that have small leaves and are highly resistant to drought (EMBRAPA, 2009).

The vast majority of municipalities in the semi-arid region of Bahia are rural since one of the most quoted features of the State is the persistence of poverty in its semi-arid region (Lacerda, 2009). Even if factors that go beyond just income are taken into account, "the deprivation suffered by people in the rural areas of Bahia remains enormous and shows that the basic needs of a large proportion of this population are not met" (Lacerda, 2009, p. 182).

The municipalities that adopted polyculture have an MHDI (Municipal Human Development Index) that is among the lowest in Bahia – Cafarnaum (0.598), Morro do Chapéu (0.605), Ourolândia (0.542) and Umburanas (0.553). By comparison, the MHDI for the State of Bahia is 0.688 (UNDP, 2000). Ourolândia and Umburanas have the 11th and 23rd worst MHDIs in Bahia.

4. CONTRIBUTIONS MADE BY POLYCULTURE IN THE SEMI-ARID REGIONS OF BRAZIL TO HUMAN DEVELOPMENT

Analysis of the contribution made by Polyculture in the Semi-Arid Regions of Brazil to human development in the communities in which it was run took account of all published literature on ST (UNV, Caixa, 2007; IPB 2007, 2012; Freitas, 2009; Sanches, 2011), semi-structured interviews with project managers and members of the communities in which it was run and local visits to three families that adopted polyculture (all 2011). The basis was the Sustainability & Empowerment Framework analytical model.

Table 1. Contributions by the social technology to human development (Source: adapted from Fernandez et al., 2011)

PRINCIPLE	CRITERION	INDICATOR
Economic	Local economic development	- Impact on the promotion of tourism - Impact on migration - Local economic activity - Contracts with local suppliers of equipment, materials, resources etc.
	Job creation	- Number of jobs created - Jobs created for vulnerable groups, e.g. women and young people - Sustainability of the jobs created - Type of jobs created
	Economic sustainability	- Repayment of investment
Social	Access to basic services	- Impact on local infrastructure - Impact on the existence and reliability of, and access to, energy services
	Basic health and hygiene	- Impact on health services received - Impact on health conditions - Reduced exposure to pollution - Access to drinking water
	Education	- Hours of schooling received - Time children spend studying - Educational equipment/resources - Technical training for the jobs market
Empowerment	Technology transfer	- Transfer of technical knowledge to the community - Guarantee that technology will be maintained at local level
	Stakeholders	- Role of stakeholders consulted prior to start of project - Level of project acceptance
	Social capital	- Social associations created as a direct or indirect result of the project
Environment	Environmental health and safety	- Reduction in noxious odours - Reduction in fire risk
	Environmental aspects	- Improvement in air quality through reduction in greenhouse gases - Water quality and quantity - Deforestation and/or soil erosion - Waste management - Impact on the amount of food/crops produced by the community
	Environmental awareness/ education	- Increased environmental awareness

The following results were also achieved:

4.1 Economic indicators

The diversity of existing planting means that each plantation will fruit at a particular time of year without reference to the rainy season. The farmers maintain that even in summer, when fields growing traditional semi-arid crops are dry, the polyculture fields have remained green and productive since year 2. This not only provides food security to the family but also enables the farmer to continue to sell his surplus throughout the year.

The project requires the adoption of new agricultural practices that do not require major financial investment. "The practices are simple and can be easily replicated without onus on families or the need for outside resources (financial, material or human)" (UNV, Caixa; 2007). The biggest investment required is human resources, who are now more concerned with preparing the soil in an ecologically friendly manner with the rotation of crops and with ensuring the soil is always covered (see 4.3 and 4.4 below). The result is easily achievable economic sustainability for the polyculture fields.

Along with increased production of fruit, vegetables and legumes, farmers now have the incentive and will to speak up in associations to promote the sale of surplus produce. With IPB support in project preparation, the new associations have managed to buy sheds for shared use and pulpers to enable them to sell some of their produce in already industrialised form as juice pulp and jellies, thus seeking to increase family income and prevent waste (see figure 3).

Figure 3. Storage and use of surplus fruit
Source: IPB, 2009

Assessment of participation by Freitas (2009) shows that farmers feel a sense of achievement through the work they have invested in their fields and no longer see themselves as drought victims. This has simultaneously increased the self-esteem of farmers and the value of their work on the land. Young people directly involved in the project are consequently abandoning the idea of migrating to big towns and are instead working on family properties, reducing the rural exodus. This view was confirmed during field research.

The project also directly provided medium-term work to an initial 25 young people. In 2008 six were put under contract to carry out duties that included replacing agricultural technicians (Sanches, 2011) and were selected from among the people trained to work on the project with the job of extending knowledge of polyculture and more sustainable agricultural techniques within the communities involved.

Since the project began in 1999 and the last 2003 MHDI report uses 2000 data, it has not been possible to check whether this index has seen change in the municipalities involved in the project. However, the perceptions of the families interviewed is that there has been a significant improvement in family income, mainly thanks to the reduction in dependence on external resources.

4.2 Social indicators

The main social impact achieved by the project, as perceived by its managers and the communities involved, has been the increase in food security for families. Adoption of polyculture has not only increased the range of foods eaten by families - who previously planted only beans, corn and castor beans but with the start of the project began also to grow pigeon peas, sorghum, sesame, pumpkins, cashews, papaya, pineapples, mangoes, palms and many other crops, depending on local potential - but has also improved food quality since the practices now used no longer require the use of any chemical herbicides, which means famers are no longer at risk of contamination.

The training of community agents and farmers also covers food security so that they now place more value on what they produce on their own land and also on native Caatinga fruits (e.g. umbu and palm) that grow in abundance but were previously underused as a food source.

It should also be noted that the training provided during the project gave those involved a technical basis that can be used to enter the jobs market.

4.3 Empowerment indicators

The families participating in the project were effectively given the ability to adopt polyculture techniques, turning them into owners of the technology required. By developing simple techniques that local family farmers could access directly, the project dispensed with the need for external maintenance contracts.

The technological knowledge acquired through workshops and exchanges with farmers include:

- agro-ecological cultivation and management practices (soil cover, diversified planting, agro-forestry systems, organic fertilizer);
- recovery, selection and storage of seeds from species best suited to the location;
- use of native species able to cope with semi-arid conditions;
- food processing;
- animal farming (chickens, pigs, goats) and native beekeeping.

Another important aspect is that all farmers have been given an awareness by their own young community agents and by agricultural monitors of, and have been properly consulted about whether they were interested in adopting, polyculture. This ensured a high level of acceptance of the project by the communities interviewed.

According to the managers interviewed and as confirmed by Freitas (2009), one of the actions most directly associated with project acceptance and community participation success has been the training of agricultural monitors and young rural community agents belonging to the communities involved. These were trained by IPB to be the direct contacts of most farmers and led to the creation of extremely local and accessible channels of communication.

Throughout the knowledge acquisition process, farmers were encouraged and trained to take part in associations. The result was four community associations created for those involved in the project. Farmers were selected during integrated training lasting 24 months in associations, cooperativism, leadership and political negotiation.

Each year the project organised a polyculture festival during which, for three consecutive days, the farmers of the participating municipalities met to celebrate family farmers' training in polyculture techniques. The programme included the award of certificates, conferences and testimonials from the trainees.

Social capital (trust among stakeholders) was improved to the extent that in most cases, polyculture fields have been planted and managed jointly. The sale of surplus produce has also been organised on a collective basis through one of the associations created as a result of the project.

Figure 4. Farmers and their families in the project
Source: IPB, 2009

It should be noted that decisions on practices and project direction were taken collectively during quarterly meetings attended by the IPB technical team and occasionally by representatives of the farmers and partners.

4.4 Environment indicators

One of the biggest differentiators of this project is its concern to ensure agricultural production without damaging the environment. For example, soil cannot be prepared by burning or chemical herbicides used to control pests. Polyculture's own biodiversity significantly reduces the growth of weeds, insects and disease.

Polyculture is extremely efficient in (and can even dispense with) the use of water. This is because a large proportion of the plants grown (e.g. umbu, maniçoba, palm, sisal, jack beans) collect water in their roots, stalks and leaves, moistening the soil without irrigation. Managers interviewed said the model had built-in "natural irrigation systems" since the planting cuts temperature, reduces evapo-transpiration, keeps the soil moist during droughts and allows healthy farming.

One of the techniques applied was the use of palm and mandacaru, plants native to Caatinga, chopped into small pieces and then placed in holes around other crops (see figure 5). Since palm and mandacaru naturally store a lot of water, they therefore release some of this for use by other plants.

Figure 5. Farmers chopping palms, plants native to Caatinga, that are about 90% water, to prepare the soil
Source: IPB (2009)

During visits, it was also noted that large areas of land that had previously been degraded by inappropriate agricultural practices had now been recovered. Thanks to plant diversity and many roots, channels had been opened that allowed better gas exchange between the soil and the atmosphere (aeration), helping with soil structure.

The ground cover technique (see figure 6) has been shown by project participants to be a highly effective way of reducing the amount of water needed in irrigation and of increasing productivity. Farmers put crop waste (e.g. corn, castor bean and bean straw and sisal waste) over the ground and around plant stems. This creates dense plant cover that is rich in nutrients and organic material and has two purposes: it feeds the soil without industrial fertilizers and reduces ground temperature and therefore evaporation.

Figure 6. Farmers covering soil
Source: IPB (2009)

Another important feature that was observed is that by cultivating different species in the same area, the area itself becomes more resistant to pests, dispensing with the need for chemical pesticides.

There has been a change in farmers' relationship with the land and their property, such as greater respect for the environment, the elimination of destructive techniques such as burning and the search for harmony between the farmer and the environment. The change in farmers' perceptions has been accompanied by greater climate awareness, a subject dealt with in all training.

5. CONCLUSIONS

Since the semi-arid regions of the world, which are already suffer from poverty and inequality, are among the most vulnerable to climate change, it is now urgent that we develop solutions that will help reduce the impact of global warming and promote sustainable development. However, development proposals must focus on empowering the communities involved, allowing real human development in the communities in which they operate. Reporting successful practices that ally the fight against climate change with human development should therefore be an aim that is pursued throughout the semi-arid regions of the world to enable their replication in other communities with similar environments. The present study has demonstrated that the Polyculture in Semi-Arid Regions of Brazil project run in the State of Bahia, in one of the poorest of the semi-arid regions of Brazil, is a practical example that because of its relative simplicity and low cost can be replicated in other semi-arid regions of this country and the rest of the world. It should be noted that recognition of polyculture as a social technology in a certificate presented during the 2007 Bank of Brazil Social Technologies Award clearly indicates that this project can be replicated elsewhere. And indeed it has already been replicated in 65 different communities in different municipalities.

It should be noted however that the data collected shows that the success of this project was only made possible because the Bahia Permacultura Institute (IPB), the NGO managing the project, effectively involved the family farmers benefiting from the project in all actions undertaken. The participation of local farmers as monitors to give demonstrations to other professionals in the region, particularly by setting up experimental polyculture fields, and the participation of local young people trained to become community agents meant that the knowledge of technicians and other farmers was properly incorporated into the lives of the four municipalities in which the project was run.

According to the managers, the results achieved would not have been possible if the project had not been able to bring various stakeholders (government, companies, associations and NGOs) together with a common aim: to improve family farming in the semi-arid regions of Brazil.

The real improvements achieved, as confirmed during this research, were also only made possible by the project's ability to integrate the three basic pillars of sustainability (economic, social and environmental) and by the real empowerment of farmers thanks to the use of cultivation and management techniques and access to markets in a consistent form that enhanced the value of the community's work.

The effective involvement of the communities in the creation of simple techniques and procedures (social technologies) contributed significantly to the improvement in the quality of life of those involved. However, this involvement must be accompanied by community empowerment to make decisions, particularly concerning the social, economic and environmental changes that will follow climate change.

The fact that this research was carried out only in one of the States with a semi-arid climate in Brazil, a country whose semi-arid regions are differentiated by the amount of rainfall they receive, does restrict its generalisation. New research is now needed in different areas of Brazil and the world into social technologies such as Polyculture in Semi-Arid Regions of Brazil in order to establish the extent to which they can be replicated and used effectively in different circumstances. This will show whether this type of technology can make a major difference to human development and the ability to deal with climate change in the arid and semi-arid regions of the world.

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