Proposed transversal technical solutions under PRODHAM for mitigation of environmental and socioeconomic degradation effects in Ceará hydrographic microbasins[1]

Francisco Mavignier Cavalcante França[2], Ricardo Lima de Medeiros Marques[3].

[2]Economist, M.Sc. in Rural Economy
[2]Secretariat of Water Resources of Ceará
[2]Email: mavignierf@yahoo.com.br

[3]Agronomist, M.Sc. in Rural Economy
[3] Secretariat of Water Resources of Ceará
[3]Email: ricardo.marques@srh.ce.gov.br

Abstract

In 1999-2009, the Secretariat of Water Resources of the State of Ceará designed, implanted and evaluated the Hydroenvironmental Development Project (PRODHAM), financed by the World Bank. PRODHAM was designed to developed, in a pilot and experimental manner, integrated and sustainable actions for recovery and preservation of environmental resources in hydrographic microbasins in Ceará semiarid region. Those included the construction of 3,332 successive dams, 27 underground dams, 470 plate cisterns; implantation of 47.6 ha of reforestation and ciliary forest, 2.2 ha of *dry farming*, 129,928 m of terracing, 70,682 m of surrounding stone barriers, 3,810 m of vegetation barriers; and recovery of 5.3 ha of degraded area. The following economic activities were also introduced or tested: apiculture, handcraft and agrosilvopastoral system.

In association with the actions referred to above, events were held to promote human and institutional development in 44 assisted communities, in addition to environmental education training, which allowed local communities empowerment and an environmental recovery process associated with economic development in four selected hydrographic microbasins.

In light of illustrative aspect of proposed solutions, replication of such experiments is encouraged, as they have contributed to reduce erosion, improve and increase water availability, increase the vegetative cover, diversify crops, increase preservation awareness, incorporate new production methods, and strengthen human and social capital. In short, to reduce the environmental degradation effects in the long run in a sustainable manner.

Key words: Semiarid; Ceará; PRODHAM; Hydrographic microbasin; Hydroenvironmental technologies.

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1. Introduction

The Hydroenvironmental Development Project – PRODHAM designed under Ceará Integrated Water Resource Management Program – PROGERIRH/CE, was implanted by the Superintendence of Hydraulic Works (SOHIDRA) in partnership with FUNCEME for supervision of socioeconomic and biophysical monitoring system. Its objective is to promote hydroenvironmental recovery in hydrographic microbasins (HMB) with active involvement of local populations.

PRODHAM actions stared in 1999 and completed in 2009 comprise the introduction of basic hydroenvironmental preservation, water and soil management, and participatory monitoring and environmental control techniques in selected areas. At the same time, the project encouraged the strengthening of local farmer organizations, and sensitivity, mobilization and awareness of HMB social actors.

PRODHAM constitutes a pilot, experimental project to be developed in four areas of the semiarid region of the State of Ceará. Selection of PRODHAM operation areas was based on a participatory diagnosis made in 1999. The four selected areas included the hydrographic microbasins of Cangati river in the municipality of Canindé; Batoque River in the municipality of Paramoti; Pesqueiro River in the municipality of Aratuba; and Salgado/Oiticica Rivers in the municipalities of Pacoti and Palmácia.

The original design of project included the evaluation of works carried out aimed at a far-reaching diffusion of tested methodologies tested and adapted to different areas of the State of Ceará semiarid region. Thus, in addition to the implantation of technologies and hydroenvironmental practices, participatory socioeconomic and geoenvironmental monitoring of PRODHAM actions was performed by FUNCEME.

Monitoring system included a diagnosis or a socioeconomic and biophysical starting point corresponding to the survey of initial conditions of all HMB families/producers, followed by a participatory systematic follow-up using socioeconomic indicators, and the evaluation through the constitution of Focal Groups, which gives the study the qualification of quantitative indicators obtained at sampling process.

2. Ceará semiarid region and hydroenvironmental practices

The State of Ceará covers a surface area of 148,016 km^2, populated by some 8.55 million inhabitants (IBGE estimate for 2009), more than 70% of which living in the urban areas, corresponding to a demographic density of 57.7 inhabitants/km^2, which exerts in a great anthropic pressure on the environment. In that same area, the combination of irregular precipitation regime with a high predominance of crystalline soil – occupying some 75% of the State surface area (Ceará, 1992) – determines that all its rivers are intermittent and may dry up in low precipitation years; in normal years, such rivers flow only during the rainy season.

Therefore, the water management model developed for the State, which is the best structured model among all Brazilian state models, derived from both a long process of fight against drought, and from an outstanding learning and political fight process. The innovating proactive behavior at the implementation of water resource management policies is explained by Ceará people's need of surviving to nature adversities.

In addition to the need of overcoming the water shortage and deficient distribution, other factors have contributed to this process, among which the following stand out:

- federal government's interventions through the National Department for Drought Relief Works (DNOCS) constituted a significant starting point, combined with DNOCS location in Fortaleza, which allowed the formation of an important technical staff specialized in water resources;
- political break-up and political-institutional reforms occurred as from 1987, and political-administrative continuity in 1987-2010 period;
- introduction of a scientific-technological mindset, and the more effective involvement of technicians specialized in that government area; and
- institutional-financial support of international bodies to consolidate the model under construction.

As stated by Teixeira (2004), that water resource policy has two quite different stages delimited by the creation of the Secretariat of Water Resources in 1987: the first stage (before 1987), when there was in the State no specific institutional instrument for water resource sector, or a planned and structured operation of that sector, what was limited to the construction of wells and small reservoirs, without the adoption of technical criteria, which did not contribute at all to decrease the State vulnerability to droughts.

During the second stage (after 1987), the Government of the State of Ceará actively undertook to establish technical, legal and institutional instruments for a new water policy for the State.

This way, between 1988 and 1991, the State Water Resource Plan (PLANERH) was formulated to support the design of several programs and projects aimed at expanding the water infrastructure and implementing Ceará water resource management model (CEARÁ, 1992).

Among such projects, the significant role of Áridas project should be highlighted, which was implemented under a strategy that gave priority to concerns with development sustainability.

For the first time ever, the planning process incorporated the sustainability concept recommended by both the International Conference on Climate Variability Impacts and Sustainable Development in Semiarid Regions (ICID-92) and Rio de Janeiro Conference (ECO 92), and expanded the meaning of that concept from just environmental to global, where economic, social and political aspects played a critical role Development would be sustainable to the extent that it showed durability conditions over the time. For that, it should be economically healthy, socially fair, environmentally responsible, and politically based on the population's participation.

Concept addressed by programs also incorporated a long-term view required for identification of immediate and future priorities to be given to planning efforts to definitively overcome the problems. It also considered the guidelines for decentralization and population's participation, the practice of which would require a new role for the government and the determination of social participation mechanisms at all levels (BRAZIL.MPO, 1995). It is clear, therefore, the need of taking both structural and non-structural actions, considering the trinomial: water, soil and vegetation.

As such, going ahead of the Federal Government, the Government of the State of Ceará established the Secretariat of Water Resources in 1987 and enacted Law no. 111,996/1993, providing for the State Water Resource Polity and instituting the Integrated Water Resource Management System. In the following year, 1993, the Water

Resource Management Company (COGERH) was established with the objective of implementing water resource management in the State territory.

According to Lobato (2004), Ceará model has allowed the State to eliminate eventual restrictions (competitive disadvantages) derived from uncertainties related to water supplies.

Another important factor in the State of Ceará is the incentive and support to the constitution of Hydrographic Basin Committees, which are collegiate bodies composed of representatives of the federal government, States, Federal District and Municipalities – the territories of which are located, even partially, in their respective operation areas – users of basin waters, and civil society entities.

The phenomenon at issue may be observed from the view of interrelations between the hydraulic development and the construction of citizenship in social change scenery. This way, democratization and environmental protection in Ceará seems to converge and feed themselves under new paradigms and challenges, as it comes to consider environmental studies, more specifically water studies, as a population's analytical tool: the way how decisions on water management are made and water systems are controlled greatly describes the democracy stages and health (Grigg, 1998).

Therefore, from the simple execution of water infrastructure works, SRH shifted to the development of complementary programs and projects, without which both the longevity of works and the quality and quantity of accumulated water resources and other natural resources would be seriously endangered.

In this sense, Ceará Government, strongly supported by The World Bank, has developed actions focused on the implementation of an integrated water resource management, reclamation of degraded areas, and preservation of natural resource in brushwood biome. Among such programs, the Integrated Water Resource Management Program - PROGERIRH stands out, under which PRODHAM - Hydroenvironmental Development Program was developed.

3. PRODHAM: design, methodology, proposed actions and results achieved

3.1 Design

According to SRH-CE (2010b), the Hydroenvironmental Development Project – PRODHAM designed as an integral part of the Integrated Water Resource Management Program – PROGERIRH, is a pilot project focused on the search for ways to promote the water resource and rural population sustainability in the State. It also aims to contribute to mitigate the social and economic drought impacts and correct the environmental degradation process resulting from the combination of cyclic dry periods and a strong anthropic pressure, especially in hydrographic basin springs.

In the area of influence of Project, environmental impacts concentrate on biodiversity destruction, by reducing water resource supplies and ecosystem resource potential, what prevents the maintenance of sustainability levels of populations settled in semiarid regions, and presents a high vulnerability and low life quality to the limits of human survival in more critical climate occurrences.

As target results, PRODHAM included the creation of hydroenvironmental conditions favorable to recovery of 4^{th} class and above river microbasins located on residual semiarid relief, by promoting the gradual development for the preparation of a layer and moisture reserve upon the creation of alveolar water tables, and promoting the maintenance of ciliary vegetative cover and subsistence crops.

PRODHAM developed articulated and sustainable actions to recover and preserve the environmental resources and foster the socioeconomic development in biomes/regions and rural communities in four previously selected hydrographic microbasins.

The following criteria were adopted for the selection of project areas:

- level of natural resource degradation;
- concentration of rural micro and small rural producers in HMB;
- areas served by 4th-order watercourses;
- good level of community association organization;
- high number of residents;
- higher occurrence of improved areas/rural settlements;
- Municipal Government's interest in establishing partnerships to take environmental recovery actions; and
- consent by the Basin Committee.

Among the most outstanding project characteristics, emphasis is given to its proposal for a participatory work with populations in pilot areas and the other social stakeholders (municipalities, community associations, women's groups, etc.), to allow everyone to feel fully co-responsible and participant of socioenvironmental recovery process targeted by the project. The public directly benefited comprised associations, rural producers and the local population of selected hydrographic microbasins.

Selection of Project implantation area was based on a participatory diagnosis made in 1999. According to SRH-CE (2010b), the four selected hydrographic basins included Cangati River microbasin in the municipality of Canindé; Batoque River basin in the municipality of Paramoti; Pesqueiro River basin in the municipality of Aratuba, and Salgado/Oiticica stream basin, in the municipalities of Pacoti and Palmácia. The main characteristics of such microbasins include:

a) Cangati River hydrographic microbasin

- Hydrographic basin: Metropolitan
- Municipality: Canindé / CE
- Location: District of Iguaçu
- Number of communities: 5
- Number of families living in the microbasin: 213
- Number of Associations: 5

b) Pesqueiro River hydrographic microbasin

- Hydrographic basin: Metropolitan
- Municipality: Aratuba / CE
- Location: upstream to Pesqueiro reservoir
- Number of communities: 6
- Number of families living in the microbasin: 441
- Number of Associations: 9

c) Salgado and Oiticica River hydrographic microbasin

- Hydrographic basin: Metropolitan

- Municipalities: Palmácia and Pacoti / CE
- Location: upstream to Acarape do Meio reservoir
- Number of communities: 17
- Number of families living in the microbasin: 1205
- Number of Associations: 17

d) Batoque stream hydrographic microbasin

- Hydrographic basin: Curu
- Municipality: Paramoti / CE
- Location: upstream to Pereira de Miranda reservoir
- Number of communities: 16
- Number of families living in the microbasin: 297
- Number of Associations: 11

The initial diagnosis of all four selected hydrographic microbasins was made. However, participatory socioeconomic and biophysical monitoring procedures were followed only for Cangati River hydrographic microbasin in Canindé-CE, which are published in SRH-CE (2010a) and FRANÇA (2010).

3.2 Work Methodology

The basic strategy for all PRODHAM actions was the hydrographic microbasin (HMB), due to the fact that it is a natural landscape where rainwater converges to a single site: river, stream or reservoir.

HMB, as a planning and rural space occupation unit, has been adopted in other projects similar to PRODHAM, like in Paraná, as they adopt the hydrographic microbasin as a practical for results that are more consistent with a vision of a single cohesive world. The joint efforts by the population, community and governmental bodies have been the basic requirements for the achievement of expected benefits under a sustainable development project.

This way, promoting actions for integrated, sustainable rural development where the hydrographic microbasin is the planning unit, and the producer organization as the action strategy, is the best work process to obtain gains of productivity and use of adequate technologies from environmental, economic and social standpoint.

Components addressed by PRODHAM, as listed below, were implanted in an integrated way to provide the transversal aspect required by the project and consistent with the sustainable development.

a) Construction of environmental infrastructures

The geoenvironmental profile of selected areas guided the selection of hydroenvironmental works implanted by the Project to mitigate drought and environmental degradation process effects, by using the construction of sediment accumulation and soil and water management works with adequate preservation techniques. In parallel with the hydroenvironmental work construction process, a physical plan of the area, a work execution schedule, a detailed cost estimate of each intervention were prepared jointly with the producers, in addition to the formulation of standards for participatory monitoring of work construction in selected areas and occurrences of changes related to agricultural/physical productivity. That allowed the

beneficiaries to be qualified and obtain information on costs, maintenance and evolution of environmental conditions.

Producers' capacity building in that thematic area allowed the formation of rural multipliers, who are responsible, jointly with project technicians from several municipal secretariats, for replication (implantation and monitoring) of such activities in other areas of the State.

To ensure a better understanding of works and their impacts by population resident in hydrographic basins and direct project partners, several communication events were scheduled, which contributed to the population's maintenance and acknowledgement of problems generated from non use of correct water and soil management techniques.

b) Development and test of production systems

The project promoted the test of alternative production systems that are consistent with the biophysical environment preservation and producers and rural families' income and life quality improvement. For that, institutional capacity building and training for farmers were provided, with the objective of encouraging non-agricultural activities that would reduce the anthropic pressure on natural resources and offer economic options for income maintenance in critical times. Most typical examples include: apiculture, agrosilvopastoral exploration system, "pet" broom manufacture, straw and wood handicraft, waste recycling, in addition to the offer of skilled labor.

c) Institutional and citizenship development

Proposal for joint work with communities was formulated to ensure an effective participation of social actors in project planning and management, and a greater transparency of actions and application of financial resources. A word method was developed, leaderships and representatives of several communities were made aware of the project scope, the importance of discussion forums about the project and other activities performed in the area. The importance of electing representatives committed to the community development and participatory management process was emphasized.

To ensure the correct application of funds allocated by the State to community associations, all leaderships participated in training in basic accounting, which allowed the selection of "community accountants" that were responsible for the whole project management selected areas. This action accredited the communities with bank institutions and ensured a better promptness in release of funds from other governmental projects.

Aiming to support the information community, a socioenvironmental and economic diagnosis of communities was made, which served as a basis for the formulation of Integrated Hydrographic Microbasin Plans.

To further strengthen that co-management action, training / monitoring of activities was developed for several local community associations and informal groups with the main objective of support their internal organization and provide them with instruments for transparent operation, by encouraging the adoption of strategies for social inclusion (gender equilibrium and youth participation), rendering of accounts, population's mobilization, and consultation/information among members.

In close partnership with municipal education secretariats, a literacy system was implanted for all adults involved in project activities, which led to the knowledge democratization and social inclusion process.

Aiming to increase the self-esteem of population residing in the area, strengthen the speculative mind and redeem the local cultural identity, the project supported the formation of cultural groups.

d) Population's environmental awareness and education

Discussion on the interrelationship between environmental degradation, poverty and socioeconomic development led PRODHAM to formulate an intervention proposal aimed to encourage the general population to adopt environmental practices consistent with the environment where they lived, and other economic activities to mitigate drought effects and reduce anthropic actions on the semiarid region.

Actions encouraged included: tree plantation in urban areas, replacement of ciliary forest, selective waste collection, composting, adequate handling and use of water resources available for human and animal consumption (cisterns, wells and reservoirs), adequate domestic animal management, change of inadequate agricultural practices, control of ground clearance by fire, and adoption of sustainable technologies.

Operation took place in communities and households with the assistance of municipal school teachers and environmental overseers, which acted on risk factors to which the population is subject, by giving priority to family and establishing ties between the community and the government. A substantial improvement of environment conditions monitoring was immediately sought, especially with respect to waste issues, to reduce significantly the pollution of water resources and the risk of drinking water supply identified in the region.

e) Biophysical and socioeconomic monitoring

For a better tracking of project results and impacts (expected or not) and its adjustment for replication in other areas of the State of Ceará, an integrated biophysical (determination of results of hydroenvironmental infrastructures) and socioeconomic (determination of socioenvironmental and socioeconomic impacts) monitoring system was designed for project activities, with the active involvement of associations and local producers' families, by means of participatory methodologies and definition of indicators, using the focal group methodology.

3.3 Components

a) Implantation of water works and conservational practices

- Construction of natural moisture/sediment accumulation mechanisms for soil preservation and recovery and water erosion control; sediment retention dams, underground dams, terraces and surrounding stone barriers, dead cover, contour line plantation, crop alternation, control of surface runoff in areas upstream to reservoirs and hydrographic basin rivers;
- replacement of ciliary vegetation on watercourse margins, reforestation of river springs and reclamation of degraded areas in river springs and upstream to reservoirs;
- increased water availability through the construction of multiuse reservoirs and piezometric wells; and

- adoption of mitigatory desertification control actions, such as, for example, controlled deforestation and controlled ground clearance by fire.

b) Environmental education

- capacity building of rural producers on conservational techniques and construction of small water works;
- control of water resource polluting agents and rational use of surface water and groundwater;
- control and prevention of mining activities in river beds;
- solid waste: recycling and rational disposal; and
- Involvement of municipal teachers in dissemination of the importance of maintenance and preservation of natural resources.

c) Organizational strengthening

- support to association development (organization, transparency, democracy, autonomy, operation capacity, etc.);
- incentive to social inclusion in association movement (especially women and youngsters);
- participation of several rural social actors in planning and relevant public policies, and their engagement in hydrographic basin committees;
- implantation of PRODHAM integrated, participatory management system, i.e., the Management Board.

d) Development of production systems

Development and test of alternative production systems that are more consistent with the preservation of biophysical environmental and improvement of income and life quality or rural families, such as, apiculture exploration of apiculture, agrosilvopastoral system, and implantation of small factories, e.g., for manufacture of "pet" brooms.

f) Participatory Monitoring

- Monitoring of project activities and interventions in partnership with local communities through formal involvement instruments;
- follow-up and evaluation of socioeconomic and biophysical changes directly or indirectly resulting from project implantation.

e) Experience dissemination

- publication of technical textbooks on experience and topics related to PRODHAM;
- availability of Technical-Operational manual in the Internet;
- publication of textbooks on hydroenvironmental technologies and practices;
- creation and availability of PRODHAM website;
- availability of videos on the Project;
- availability of database of field surveys.

3.4 Results

A very positive aspect of PRODHAM development was the increasing participation of several social actors involved in discussions on implementation of actions and management of funds for hydroenvironmental works, and their increasing interest in ensuring the application of such funds in sustainable activities that could result in life improvement, especially for youngsters and women.

Another outstanding issue was the knowledge acquired by general population about environmental problems and the importance of hydrographic microbasin preservation.

The main measurable PRODHAM results are shown in Table 1.

Table 1 - Results obtained by PRODHAM in 1999–2009 period in Cangati, Pesqueiro and Salgado/Oiticica rivers and Batoque stream.

Description of actions	Unit	Achieved
Hydroenvironmental works		
Sediment retaining dams	Each	3.332
Underground dams	Each	27
Plate Cisterns	Each	470
Ciliary forests	Hectare	18,03
Edaphic works		
Dead cover	Hectare	42,48
Dry-farming system	Hectare	2,20
Surrounding Stone Barriers	Meter	70.682
Level vegetation barriers	Meter	3.810
Terracing	Meter	129.928
Reforestation		
Implantation of forest reserve	Each	2
Seedling production	Each	95.553
Reforestation	Hectare	29,49
Reclamation of degraded areas	Hectare	5,23
Production system		
Demonstrative technical unit – DTU	Unit	17
Environmental education and technical capacity building		
Events of environmental education	Each	79
Events of technical capacity building	Each	42
Organizational Strengthening		
Events of organizational strengthening	Each	100
Dissemination of successful experiments		
Technical-scientific books	Each	6
Academic dissertations	Each	3
Instructional textbooks	Each	11
PRODHAM information gateway	Each	1

Source: SRH-CE (2010c).

3.4.1 Generated benefits according to PRODHAM component

The main benefits provided by works and practices developed by PRODHAM in all four selected microbasins are shown below, including a representative photo of related interventions. More details on PRODHAM results and impacts maybe obtained from socioeconomic and geoenvironmental evaluations contained in SRH-CE (2010a) and FRANÇA (2010) works.

Terracing	
• Increased water retention by soil; • improved soil topography; • flood reduction; • increased soil depth; • improved agricultural use capacity and skill; • higher resistance to dry periods; • possibility of multiple use of cultivated vegetation.	

Surrounding vegetation barriers	
• Modification of microrelief in soil strip between two successive barriers, in addition to increased soil depth; • improved agricultural use capacity and skill; • possibility of multiple uses of vegetation in barriers (forage, firewood, fruits, stakes).	

Successive dams for sediment retention	
• Flora and fauna revival; • improved forage biomass availability; • improves water quality in tributaries; • reduced reservoir sanding-up; • creation of tillable soil; • perpetuation of generated benefits; • assurance of soil moisture for a longer time in dam hydrographic basin.	

Surrounding Stone Barriers	
• Modification of microrelief in soil strip between two successive stone barriers, in addition to increased soil depth; • improved agricultural use capacity and skill; • increased soil moisture and fertility; • increased agricultural productivity; • permanent work.	

Underground dam	
• Assurance of water for human, animal and agriculture supply; • moisture assurance all over the year; • permanent benefit to producer; • expansion of tillable soils; • flora and fauna strengthening.	

Community supply (Wells and Cisterns)	
• Water supply in dry periods; • assurance of drinking water for the family; • low construction cost; • easy construction; • high acceptance by rural families; • no need of tank truck; • provision of 27 piezometric tanks close to underground dams.	

Reforestation	
• Reduction of watercourse and reservoir sanding-up; • reduced soil loss; • flora and fauna strengthening; • increased vegetative cover; • reintroduction of native species; • improved water and soil quality; • increased water availability.	

Ciliary forest recovery	
• Reduction of watercourse and reservoir sanding-up; • increased water availability in watercourses; • flood reduction; • flora and fauna strengthening; • contribution to environmental preservation.	

Organizational association strengthening	
• Association strengthening; • creation of three new associations; • increase of number of members; • greater claming power in other government levels; • modernization of financial management; • creation of association financial fund; • association as the leader of community governance; • strengthening of partnerships with other local associations.	

Building of labor in hydroenvironmental practices	
• Capacity building of workers and landowners; • building of skilled labor; • provision of labor for construction of hydroenvironmental technologies; • possibility of income increase; • increase of worker's self-esteem.	

Environmental Education	
• Increased preservation awareness; • adoption of new production methods; • incorporation of environmental topic to school; • spontaneous replication of techniques adopted by other producers; • awareness of importance of vegetation burning and brushwood felling control.	

Apiculture	
• Employment and income generation; • diversification of agricultural activity; • ecological exploration; • increased pollination of forests and agricultural crops; • supply of healthy food; • emergence of a new economic activity; • good profitability for the farmer; • more than 300 beehives and one honey house.	

Factory of brooms made of recycled “pet”	
• Employment and income generation; • diversification of agricultural activity; • ecological exploration; • reduction of non-degradable waste (pet); • emergence of a new economic activity; • activity appropriate for youngsters; • three plants installed; • good profitability for the farmer.	

Local banana tree straw and wood handicraft	
• Employment and income generation; • diversification of agricultural activity; • ecological exploration; • low raw material cost; • activity appropriate for youngsters; • emergence of a new economic activity; • good profitability for the farmer.	

Solid waste – collection and recycling	
• Regularization of municipal systematic collection; • recycling (metals, plastic and cardboard); • reduction of disease transmitters; • reduction of waste burning; • better waste storage.	

4. CRITICAL PROJECT ASPECTS

4.1. Hydrographic basins

The most important critical aspect related to the selected microbasins refers to the occurrence in HMBs of many landless producers and workers, the most part of which cultivate in other owners' land under partnership regime. This practice has restricted the performance of economic exploration of hydraulic infrastructures, which were further affected by two years of scarce precipitation (2005 and 2007).

The construction of stone barriers, terraces, successive dams and underground dams very often in areas of absent landowners, has not allowed the full economic exploration, as the landowners were not interested in maximizing the exploration of their properties or assign them to tenants, even under a signed formal commitment for that purpose.

4.2. The communities

In communities, the most critical aspect was the occurrence of a great number of illiterate producers without a fixed economic activity, which depended on fund allocations by the federal government, whose local economic activity was solely related to subsistence agriculture.

4.3. Project management

Tue most critical aspect of program management was the infrequent Project management. During PRODHAM effective period, there were many managers and many changes. Each management change required a long lapse of time for the normal resumption of Project, which generated discontinuous implantation of actions and cost increases.

4.4. Inter-institutional integration

Inter-institutional integration was adversely affected by the lack of synergy and institutional cooperation. Many institutions were invited to integrate PRODHAM works. An example of lack of integration includes EMATERCE, SEMACE and even the municipal government of Canindé, even though they were invited to participate.

5. Conclusions and Recommendations

5.1 Conclusions

PRODHAM proved effective in the control of anthropic actions in natural resources, by increasing the resistance to dry season effects and enabling the sustainable development of rural populations of related hydrographic basins. By reducing the harmful effects of water erosion, it provided better conditions for farming productivity increase, including by expanding the hydroagricultural use of soil through the exploration of humid sediments retained by successive dams, surrounding stone barriers and underground dams.

PRODHAM showed that basin management is not only restricted to the control of water downstream to dams, but also upstream to dams in the springs of different basins.

The project also showed that it is possible to develop technologies for the semiarid region in Northeastern Brazil, which would promote the economic sustainability for hydroenvironmental resource preservation.

Finally, it was evident the empowerment of local communities and an environmental awareness and recovery process associated with the socioeconomic development in all four selected hydrographic microbasins.

5.2 Recommendations

a) For the Government of the State of Ceará and Governmental Agencies

This experience is most effective for Ceará semiarid region, given the holistic aspect of problem of man's survival under extremely unfavorable conditions. By covering the physical, social and environmental aspects, PRODHAM places a special emphasis on man as a solution for that problem. Local conditions may be improved, provided that man is able to identity in his environment the means necessary to ensure that survival and then grow up.

By using the techniques of participatory system organization, based on environmental recovery works, one moves to decentralized planning and identify potentialities that can be developed using all strength of local organization for social management.

In the lack of a longer time to identify greater changes in local scenario, due to the short monitoring period, for a more attentive observer the solution of Northeast semiarid region will depend on the process of degraded area recovery using the successful technologies tested by PRODHAM, associated with the continued capacity building of rural population, even with respect to what is considered a problem, like waste.

Therefore, for the government of the State of Ceará and governmental agencies, this is a proposal that can be adopted by the whole State with small local adjustments.

Main reasons for PRODHAM indication as a governmental proposal for the semiarid region:

- Sustainable technological process: PRODHAM adopts technologies that make economic activities based on natural sustainable;
- fight to desertification: every Project work assumes that any activities must adopt technologies that will preserve the environment or at least reduce to extent possible any damages caused by those activities.
- soil quality improvement: soils are given a special treatment by PRODHAM methodology, as they are the main base for all other events.
- enhancement of implementation of hydroenvironmental practices developed by PRODHAM in dry years, like in 2010, as a way to employ rural manpower for long-term sustainable activities.

b) For non-governmental organizations

Non-governmental organizations – NGOs may draw on PRODHAM experience as great work opportunities for such institutions.

c) For Banco do Nordeste

Banco do Nordeste, as a leading financing agent for developmental actions in Northeastern region, which has given priority to the environment may draw on that experience and work together all other institutions in Northeast States to implement actions consistent with PRODHAM techniques.

In its capacity of development bank, Banco do Nordeste must lead and join together all development agents in the States. Everything should focus on the territory herein delimited by the microbasin, where production chains are formed, and even extend beyond its borders if supported by other development agencies having Banco do Nordeste as the process leader.

d) For international institutions operating in the semiarid region

The World Bank, as the financial supporter of PRODHAM, serves as an example for all other international institutions of the importance of believing in local technical capacity for solving their own problems. PRODHAM showed that rather than just an environmental recovery project, it was and is especially a local development project. The environmental recovery process includes a wide range of work for development of actions to improve socioeconomic conditions of families living in the microbasin.

As such, PRODHAM is a project that can be disseminated to the whole semiarid region, having the region development as its ultimate objective. With PRODHAM, local conditions are not restricted to what is viewed in the degraded natural scenery, but it is rather related to the field of possibility of recovery of that scenery and consideration of local issues, having man as the target.

f) For farmers and their associations

The Hydroenvironmental Development Project has contributed to developing a practical approach with the involvement of local community, by implementing sustainable solutions that help to promote the better soil and vegetation management in hydrographic basis, enhancing water preservation, minimizing erosion, and maximizing

the natural water storage mechanisms with the primary objective of improving the population's life in those areas and creating economic sustainability conditions.

Using a methodology where area recovery is based on human resources' capacity through the involvement of all farmers and associations in several communities, PRODHAM showed that there are solutions for all farmers' problems in semiarid region, provided that they organize themselves.

g) For teaching institutions

For teaching institutions, this new education view developed by PRODHAM for semiarid region is available, which is based on the comprehension and awareness of current reality and identification of deficiencies to find the required solutions. Nothing can be done, unless there is a full understanding of that reality.

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