PRODUCTIVE USE OF SOLAR ELECTRIC ENERGY: ORGANIC AGRICULTURE

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Introduction

Solar electric energy applications play a significant role in providing light for innumerous applications, power for communication systems and traffic control. However, the use for productive applications, specifically in the rural area, is somehow restricted. Common machinery and electric motors are designed for grid connection with little attention to low consumption. Just switching over to a solar electric power system is ineffective and uneconomic.

During a couple of years, some equipment has been developed to a useful state and can therefore be implemented with success in the rural area. It should be noted that the population out there in the Hinterland of the northeastern region of Brazil is already suffering due to adverse meteorological conditions and one should not come up with some experimental application, which may put in risk the already low income of those people.

The following solar electric equipment usable for productive applications has achieved already such high maturity that it can be implemented without constrains:

- Solar electric water pumping systems;
- Solar electric fences;
- Solar electric power systems for small motors (AC).

Besides being sold commercially, those systems still need to be perfectly designed and adapted to the specific case of application. Common energy systems (grid connection or diesel generator) allow over-sizing or mismatch of the components without compromising the final result, e.g. water output of a pumping system. The components are relatively cheap and the energy consumption, either electricity or diesel fuel, is paid by the end user. He will find out only later that the whole system is economically not feasible.

All components of a solar energy powered systems have to be matched precisely. If not, the investment in solar modules is in-proportional high or the system does not work properly. More over, a profound knowledge of the machinery or motors connected to the solar system is crucial. Therefore, just the above-mentioned three applications are satisfactorily mature to be used without problems in the rural area.

Project

IDER is accompanying since several years various rural associations and cooperatives, aiming to improve their living standards by introducing solar home systems, solar water pumps for drinking water, solar stand-alone systems to power sewing machines and freezers, and lately introduced even a solar powered ice factory in a fisher village.

The most promising application, which improves the overall food supply of the population and has already gained a remarkable market place, is organic agriculture. Irrigation with solar powered water pumping systems gives the opportunity to introduce this technology also in remote areas.

In the first place was administrated a course, which introduces the basic knowledge to the rural families in organic agriculture. This course is financed by INWENT Internationale Weiterbildung und Entwicklung GmbH, which concentrates their efforts on training and capacitating the population in any kind of area. The course is transmitting hands-on knowledge, leading to a 1 ha organic vegetable plantation during a one-year period. Along with this course is going training in irrigation and solar pumping systems. During one year are held one to two days in-field training courses. Both, the expert for organic agriculture and the solar pumping and irrigation expert are giving “Hands on” classes *in loco*. A group of 8 families from the community Bom Jesus located in the settlement from Maceio de Itapipoca, approximately 200 km away from the capital of the state Ceará, Fortaleza.

IDER has teamed up for this project with the local NGO “NEPA” which has a vast experience in organic agriculture. IDER will take care of capacitating in irrigation and solar water pumping systems and its installation. Financed by the British Embassy, the company BP-Solar delivered all solar equipment and the irrigation system while InWent. supports the project through financing of the Infrastructure, travel costs etc.

Basic considerations of organic-ecological agriculture

In the following sections are described the basic considerations and biological processes, which determine the growth of plants, and the rule of organic-ecological agriculture in order to guarantee sustainable vegetable production.

Sustainable Environment

A sustainable environment is dominated by a dynamic process of co-evolution of *any* living species (human, animal, bacteria, virus and plants) contained in the same environment. In order to prosper and live together, they respond to each others necessities, the environmental and meteorological influences and structural changes, and adjust their habits in conformity to future demands.

The organic-ecological agriculture adopts the knowledge about the ecological sustainability, were the local community interacts with the nature by using non-aggressive methods to sustain their living.

The real ecological community itself represents a community, which assumes a compromise between its associates and the nature, thus integrating and understanding their life style and working methods as part of the surrounding ambience.

The Landscape and the Agro- Ecosystem

The today’s agriculture should *preserve* the environment, but it is used as instrument to degrade, violate, destroy and transform the human ambience and the nature.

Being forced to obey economic laws imposed on our life and the necessity to generate profit are apparently the most important factors, which have changed the human attitude during this century. These economic conditions separate more and more the agriculture production from nature, and the same phenomena is observed in the industry were manufacturing processes are more and more inhumane.

The unsustainable conventional agriculture production system disintegrates the rural communities; initiates migration processes and makes the agriculture production addicted to no natural resources and foreign market regulations.

In contrast, the sustainable organic-ecological agriculture adopts the *natural* economy; as such the productive principles follow the permanent dynamic process of natural success of the species. The plants of human interest grow up in-between the natural system in conformity of natural criteria, which determine their living space. This space is created in function of the energetic flow of nature and is aggregated anthropological and ethno-biological components.

Qualitative Formation of the Agro- Ecological Systems

Diversity is the basic characteristics of nature and the basis of ecological stability. The conventional agriculture, created by the "Green Revolution", is characterized by the alliance of monoculture and synthetic chemical products. This combination established its particular integration with soil and water and created erosion of the bio-diversity with arduous ecological and social consequences. The natural composition of plant species is considerably changed by this adverse activity, which aims to boost productivity without considering the local environmental conditions.

The organic-ecological agriculture is developed on the principle of maintaining the life and the biodiversity, the symbiosis and replicatibility (Law of return).

The diversity offers a multiplicity of interactions, which can remedy ecological disequilibria in any part of the system. There are innumerous natural products, which can be added to the system using a "minimum of external influence". This guarantees diverse life conditions and satisfies multiple necessities by reciprocal interchanges.

The Soil as Living Organism

The malpractice of conventional agriculture has increased the hunger, the sterilization of the soil by synthetic chemicals, thus affected the social injustice and put at risk the ecological equilibrium of the planet.

The organic-ecological agriculture acknowledges the soil as living organism where the fertility results from the interactions of residing species, which form a production chain of life essential active substances passing to the plants, passing to the animals and to the microorganism in the manure and return back to the plants.

The Integration with Nature

The monoculture of conventional agriculture substitutes the harvest diversity of traditional agriculture and, with the erosion of the diversity, the new grains are in disequilibria with the environment and prone to diseases and infestation of varmints.

The primordial solar energy source moves all and any ecological cycle and living organism, which are necessary to sustain the ecological system and keep it in equilibrium.

Development of plants

The development of the plants is influenced by the environmental conditions. On the other hand, its vital activities have effect on the environment and the plants construct their complex categories by the help of heat and light. The plants impose its substantial exigencies to the soil and develop its characteristic specie and gender. The way of being able to do so or being impeded by unfavourable environmental conditions determines its aliment value.

Economic pressure forces farmers with commercial interests to do everything to increase their yields, annual and perennial production, to be concerned with large-scale production more than with the real nutritious value of their final products.

Although chemical fertilizers are the most efficient input in increasing production, there are also other aspects to be considered, such as its influence on the products quality, the strength of plants and their capacity to resist plagues and diseases. These benefits can be obtained using only an organic production system, without the need of deforestation and the use of synthetic chemical products and agro toxins.

The key to a program of organic food production is diversification of plant species, knowledge of basic principles of nature and awareness amongst the farming family in relation to the need to develop a productive chain founded on cooperation, solidarity and economic, social and environmental feasibility.

Introduction of Organic Farming of Fruits and Vegetables

The plantation of vegetables without using agro toxic products and inorganic fertilizers is not just a new way of growing vegetables, but has as background a innovative way of live.

The mission is to work towards mobilizing the rural and urban community in terms of conciliating the relationship between production and consumption of food, which do not harm nature and conserve natural resources. The vision is that of creating a benchmark for quality of life in which society participates actively in the preservation and conservation of the natural environment, where human production is seen as a co-production in which mankind creates in harmony with nature.

The main focus is family-based organic farming in the context of associative economics. This is also the basis for strengthening of civil society in the rural sector, forming a large network of the most varied forms of association, which will consolidate democracy and enable participation of the rural community in partnership with the consumer, building citizenship in the field and in the city.

Consequently, the “existing market” ceases to exist as an unknown, where “invisible hands” operate, using technology of negative impact upon the consumption of natural resources and energy, causing true genetic, cultural and environmental erosion, having as goal the concentration of income in the hands of a few and hunger and poverty for many.

Market for Organic Agriculture Products

In Table 2 (see annex) are given the market prices to compare vegetables produced by common means and by organic agriculture.

Not all organically produced products were found in the research performed in the local market (Itapipoca weekly street market).

The quality of products found at the market is very low. A comparatively lower price does not make up for the quality gap. This is particularly true for coriander; found only in very small limp bunches. Some products were similar in quality level, such as garlic, lettuce and tomato.

The lack of hygiene and training amongst vendors was also noted. Some ostensibly cheat clients during weighing of the products.

It is suggested that subsequently parallel markets to be held, when the community's production is more highly developed. Many prices of organic vegetables are lower, and when compared, those more highly priced offer greater advantages in terms of quality.

It is also necessary to inform the local community, if the goal is to sell into this market, that they have to show the advantages of the product they offer (marketing campaigns).

A front-up market study taking parameters from the already since 6 years existing consumer association ADAO, which has today ca. 400 families attended by 15 organic agriculture farmers, shows the following picture:

Table 1: Financial balance for organic products

Activity		Normal Investment		Investment solar equipment	Total investment	Revenues per unit	Administration / Operation costs	Maintenance costs	Liquid income per unit
	Production Unit	1	2	1		1			
Organic Agriculture	per hectare / year	4.000	3.500	30.000	37.500	63.000	28.000	12.300	22.700
		Irrigation System	Prep. terrain	Solar Irrigation pump		6 ton per month at R$ 0,90/kg	Mainly Transport and 8 minimum salaries		

Data are extracted from a market study financed by InWEnt

The figures reveal a high profitability in comparison with commonly known subsistence agriculture of the farmers in the northeastern region of Brazil.

Appropriate Solar Technology for Organic Agriculture

A solar irrigation system has to be designed and calculated properly in order to produce the maximum of water output at lowest costs under the given water source conditions. Along with the pumping design has to go the right choice of the irrigation system, according to the needs of the planned agriculture.

In this case, a flat area near a river is used, which has excellent water conditions for irrigation. The 1 ha area requires a daily water supply of some 4 mm, which, in turn, is a demand of 40,000 liters per day. The water is fed into an irrigation system composed of laser drilled plastic hoses, laid out at a distance of 3 m. Those hoses are readily available in the local market (Brand name: *Santeno*) and widely used for such irrigation purposes. They have the great advantage of being cheap and can easily be relocated.

Solar Pumping System

The solar pumping system is composed of a solar array, a controller and a submersible pump. To satisfy the demand for 40,000 liters per day a pumping system is necessary with the following technical data (considering the meteorological conditions at the site and a total head of 15 m):

- Solar array of approximately 1300 Wp,
- Controller SA 1500 (Grundfos), and
- Solar pump Type SP8A5 (Grundfos).

Recording the terrains profile and calculation of the pressure drop in the riser piping confirmed the assumption of 15 m pump head.

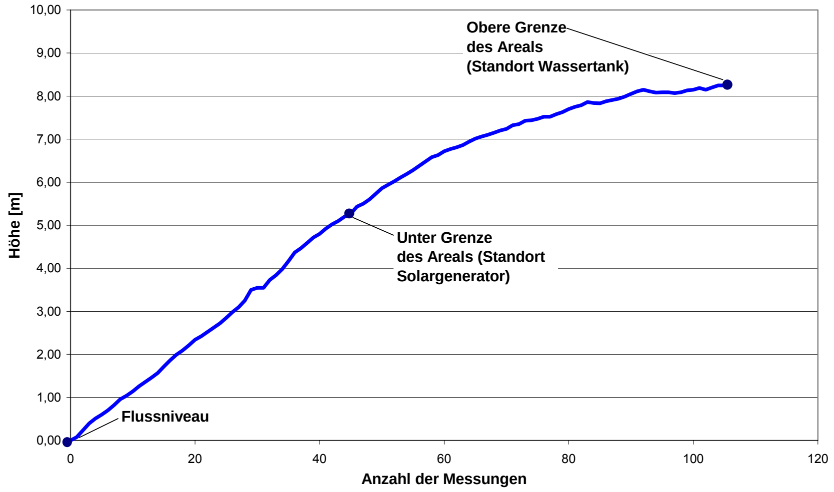

Figure 1: Terrain profile from the river until the place of the reservoir

Irrigation System

The irrigation system (for 1 ha) is composed of:

- 200 m feeder line 3" in diameter with hose-adapters every 3 m,
- 40 SANTENO laser drilled plastic irrigation hoses, 100 m long.

The lay out of the piping and irrigation system was made in conformity with the irrigation handbook of the compay SANTENO, the manufacturer of the plastic hoses.

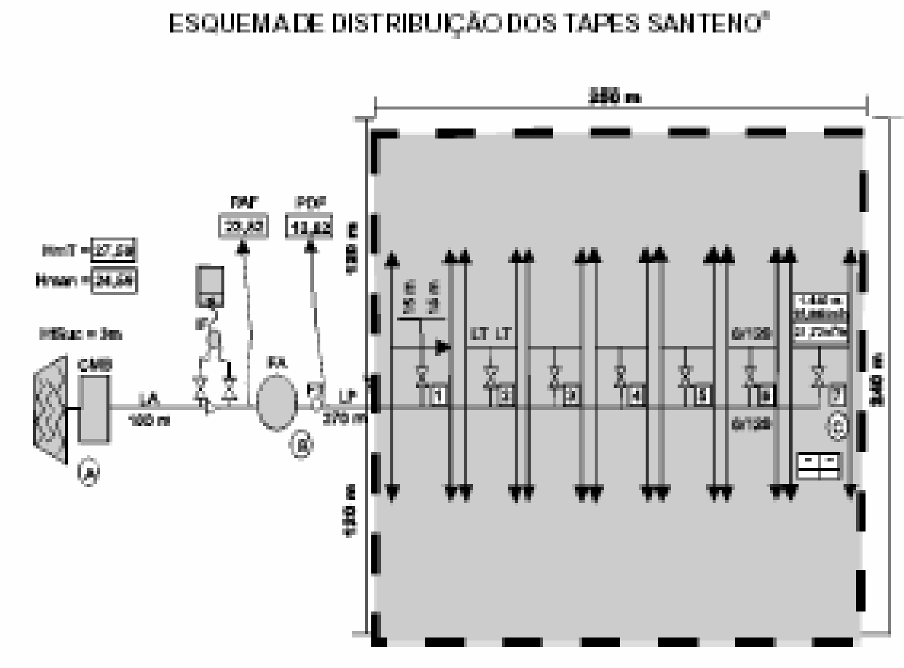

Figure 2:Installation scheme of irrigation system

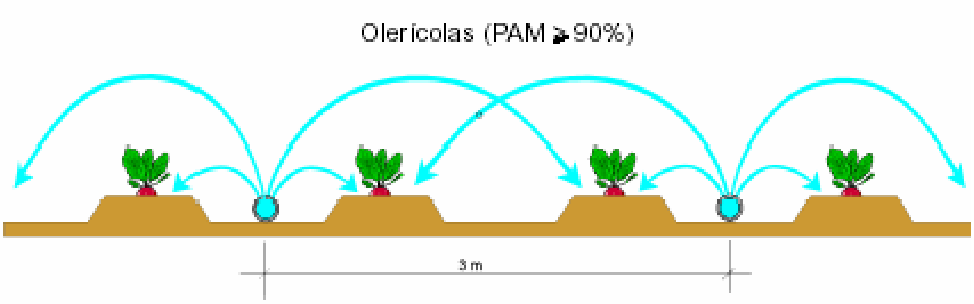

Figure 3: Optimal distance to irrigate vegetables with hose type I

Project Implementation

Methodology

The training modules (see below) cover the real needs of the community. The trained persons work on their land and will be the „Monitors“ for further projects in the region. At these workshops are invited other communities and interested Institutions in order to disseminate the knowledge.

The workshops are generally composed out of different modules that have several objectives. All aspects of training are covered, which are necessary to make the specific project sustainable. This involves a broad scale training starting with personnel formation, enterprise management, and accountancy. The specific technical training covers all steps from cultivating the raw product, processing until marketing, where the productive use of renewable energy is part of the process.

The practical part of the workshops, which are following the training concept „Hands on” and „ Learning by doing“ is carried out in the community where already exist renewable energy systems and specific technologies, e.g. solar pumping and irrigation systems.

Some of the training modules demand accompaniment during several month. The first workshops will give a comprehensive introduction in the subject, while smaller working modules throughout the year *in loco* cover the real in-field work.

Structure of the Training Program

In the following are listed all training modules of the project. Some of them have already been administrated. Others are due in 2004.

A General Management training
A1 Management and operation of small enterprises
A2 Financing and accountancy;
A3 Identification of the market
A4 Marketing and transport
A5 Quality control and certification of the products
A6 Environmental protection.
E Renewable energy systems
E3 Solar powered pumping systems
T Specific technologies
T1 Modern, water-saving irrigation methods
T4 Organic Agriculture of Vegetables

The project started with the selection of the appropriate site. This was already a difficult task since it was needed apiece of land with easy access to a water source and not too far away from the community Bom Jesus. The first two attempts failed due to problems with the landowners. Even though the whole area is under the administration of the settlement, there have been designated some land to private users, which do mostly not make use of the land. However, if somebody needs specifically that piece of land, trouble will arise. Finally it was decided on an area with no occupation from somebody, which has the advantage to be expanded, if more families want to join the project.

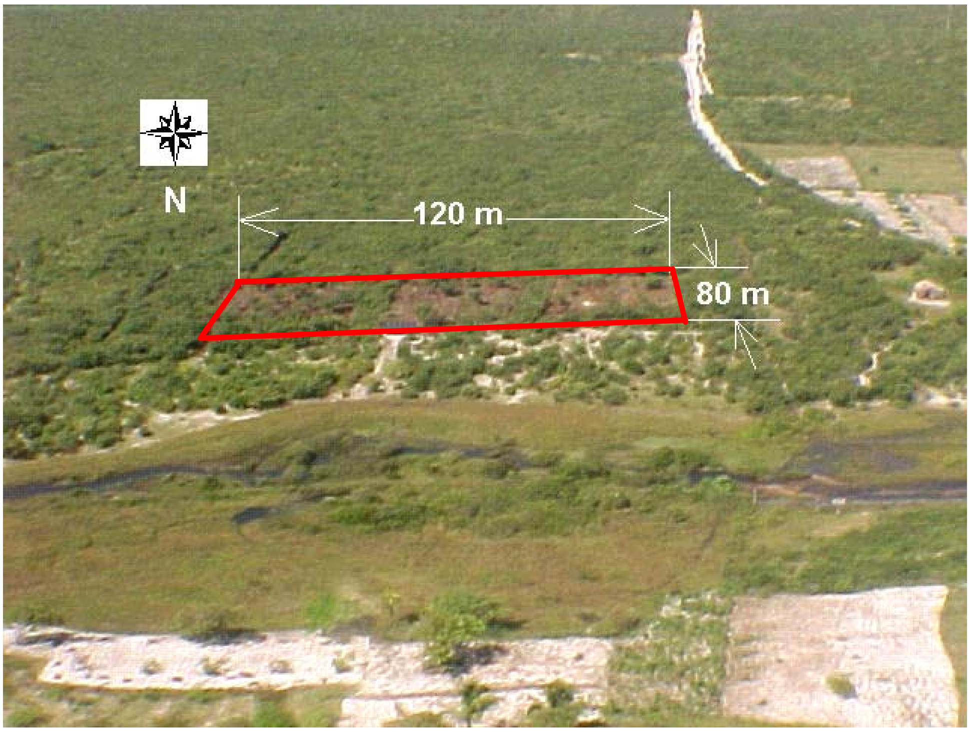

Figure 4: Aerial view of the site located along a river

In the meantime, the *theoretical* training started already with tasks mentioned above. Once the land has been selected, the *practical* training began. During this phase was also installed the solar pumping and irrigation system. A water analysis (see enclosures) showed that the river is perfectly suitable for irrigation purposes.

Production of Biological Compost

The animal's metabolism is one of the most important stimulator of the soils life and the healthy growth of the plants. The methodology adopted by the organic-ecological agriculture uses two different kinds of broth originated of the ruminants.

<u>Ruminada</u>

The ruminants channel the food during digestion through four stomachs, at first provoking a revitalization by means of microorganism and afterwards pass its content on to the intestine. This " Food cake" is the basis of the *Ruminada* – broth.

<u>Chorumada</u>

After being processed in the stomach, the food is transformed and absorbed nearly completely by the animal in the intestine. The rest is carried on to the colon where again a bacterial vitalization occurs and then excreted. The dung produced is the basis of the chorumada-broth. Clearing of the terrain with special emphasis to preserve the natural ambient as much as possible

Figure 5: Preparation of soil conditioner

Figure 6: Transport of water tank

The one-hectare land is divided in 6 modules with the natural plants, bushes and trees being preserved and forming kind of fences between the modules. These “fences” protect the plantation against wind, excessive sun and insects, and retain the ground water at its natural level. The cleared bushes were hackled and used as soil protection. The soil conditioners Ruminada and Choromada are highly concentrated and have been distributed via the irrigation system.

Installation of the solar pumping system

During this phase of land preparation has been erected the solar generator and installed the solar submersible pump in the river. A little dam was also constructed in order to guarantee always enough water for the irrigation. The water is feed in a 5000 liters reservoir installed at the highest point of the terrain to provide sufficient manometric height for the irrigation hoses (minimum 2 m).

The solar array is composed out of 36 modules mounted in six rows of six modules each, from which always two are connected in series to produce 200 Volts output. The inverter and connection boxes are mounted below the array in the shadow. The modules are connected to the inverter via two connection boxes including lightning protection (Varistors). A level switch in the water reservoir turns off automatically the pump when the tank is full. Special protection circuits of the inverter protect the pump from dry running and overpressure if the filter is blocked. The users were instructed which measures have to be undertaken in any case of a failure detection.

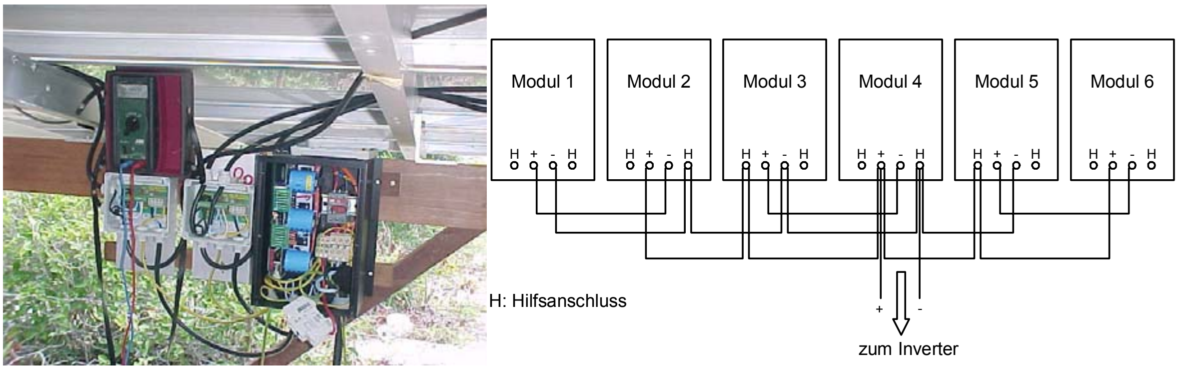

Figure 7: Interconnection of the PV modules.

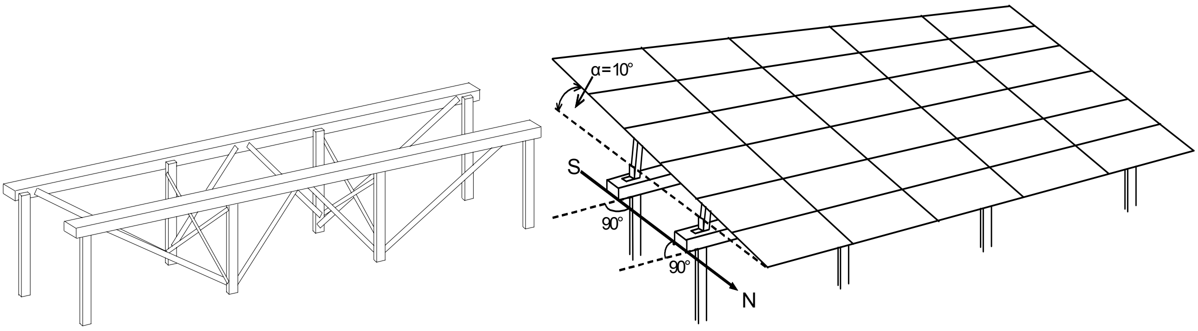

Figure 8: Mounting structure of the PV panel

The amorphous modules were very heavy and demanded a sturdy basic structure. Wooden poles and horizontal bars where used and the whole structure was inserted ½ m in the ground. The modules are mounted to the wood structure by means of aluminum profiles in an angle of approximately 10° facing north.

Figure 9: The PV system

Figure 10: Pumping components

The submersible water pump was mounted on an aluminium basis to be settled down to the river bed. A three-core submersible cable connects the pump to the inverter while the water is flowing via a 100 m long pipe of 50mm diameter to the reservoir. This type of pump does not need any other protection sensors. All protection circuits are installed in the inverter and monitor the pump load.

Installation of the Irrigation System.

The irrigation system is composed out of feeder lines and the irrigation hoses. The feeder lines are connected to the water reservoir running downhill in direction of the river. The hoses are connected by adapter pieces to the feeder lines every three meters being laid out always on the same level curve.

Figure 11: Preparation of the irrigation system

During the installation of the first module the users were instructed in the installation procedure. They will install the other seven terrains on their own. After the installation was tested the water output and found to be in the limits given by the manufacturer, considering the manometric height of the reservoir. The terrain will be irrigated only in the morning and late afternoon. It is probably necessary to install more two 5000 liters tanks to secure the irrigation in the afternoon hours.

Preparation of the soil

In-field instructions and hands-on training are the keys for successful and appropriate training. Organic agriculture needs special attention when clearing the area. The natural vegetation is respected as much as possible. Only the areas to plant vegetables are opened.

Together with the natural trees are planted fruit trees. This multi-mixture of plants defends itself against diseases and predators.

Figure 12: Hackling by a diesel powered "disintegrator", use as fertilizer.

The bushes taken away are hackled and serve both as fertilizer and soil protection against the sun. During the irrigation this organic material will absorb the water and keep the soil moistly during a long time. A so-called "disintegrator" powered by a locally available eight horsepower diesel engine performed the hackling. The hackled material was also used as fertilizer and together with the rests of gras and leafes integrated in the soil. The women of the group performed this work, since at that time the men were occupied with more heavy work.

Future Prospects

Until end of September 2003 the above mentioned steps have been performed. The first little plants from the multi-mixture seeds are beginning to grow at the first module. In the next weeks will be planted there the vegetables. The other seven modules are under preparation and currently found in different development phases. The irrigation system is expanded in conformity of the preparation process.

The project has received much attention from other communities and is frequently visited. It is believe that till end of the year the fist harvest will take place. In 2004 will be accomplished the follow-up educational measures regarding marketing and accountancy. Organic Agriculture is one of the opportunities for farmers living under subsistence conditions to plant their own healthy food and sell their products at competitive prices on the local market. Therefore, the project has been brought to the attention of E+Co, found to be economical sound and discussions are in progress have this and future project financed.

Annex:

Table 2: Price comparison of organic and non-organic produced vegetables

Product name	Unit	Common product price (R$)	Oranic product price (R$)
Chinese Leaves	kg		1.65
Zucchini/ courgette	kg		1.60
Leek	kg	6.00	3.59
American Lettuce	Head	0.40	2.01
Banana	kg	1.40	1.75
Sweet Potato	kg	0.50	1.05
Eggplant/ aAubergine	kg		0.85
Beetroot	kg	1.30	3.99
Broccoli	Bunch		1.23
Onion	kg	1.30	0.69
Spring onions	Bunch	0.15	0.34
Carrot	kg	1.30	2.03
Squash	kg	0.50	0.60
Coriander	Bunch	0.15	1.95
Kale	Bunch		2.01
Cauliflower	Cab		4.59
Spinach	Mol		2.39
Green beans	kg	2.00	4.34
Pumpkin	kg	1.20	0.99
Manioc	kg	0.80	0.69
Yam	kg		2.23
Maize	kg		1.89
Cucumber	kg	1.00	0.70
Pepper	kg	0.90	2.65
Radish	kg		0.60
Cabbage	kg	1.00	0.87
Cherry tomatoes	kg	1.30	6.50
Runner beans	kg		4.75

Source: *Enterprise 21* and own research, 2002.

Table 3 Chemical Analysis of the river water

	Reference value	Measured value
pH	6.0 - 9.5	6.8
Conductivity (µS/cm)	---	350.0
Ca (mg/l)	---	3.9
Mg (mg/l)	---	14.0
Cl (mg/l)	250.0	107.2
Fe (mg/l)	0.3	0.02
NO_3 (mg/l)	10.0	0.012
SO_4 (mg/l)	250.0	7.8
CO_3 (mg/l)	---	---
$CaCO_3$ (mg/l)	---	41.6
Na (mg/l)	200	45.4
K (mg/l)	--	5.2

Source: Laboratory University of Ceará, Fortaleza, 27/02/2002