THE USE OF RENEWABLE ENERGY IN THE PRODUCTION OF GOODS: SEAWEED

Jörg-Dieter Anhalt

IDER - Instituto de Desenvolvimento Sustentável de Energias Renováveis
Rua Dr José Furtado 1480, Fortaleza,
Ceará 60822-300, Brazil, Tel. ++55 85 271 1692

Introduction

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.

One promising application, which improves the fishermens´s income and has already gained a remarkable market place, is cultivation of seaweeds. However, the processing and particulary the drying process has to be enhanced to be concordant with the exigencies of the market. Solar powered dryers give the opportunity to introduce this technology, having minor operating and no energy cost.

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. Solar Dryers have already a certain market place and are well developed for a number of applications. However, the specific needs of a product and environmental conditions have to be adapted locally.

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 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).
- Solar dryers.

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.

All components of a solar energy powered systems have to be matched precisely. If not, the investment 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 or of the products to be processed is crucial. Therefore, just the above-mentioned four applications are satisfactorily mature to be used without problems in the rural area.

IDER has teamed up for this project with the local NGO “Terramar”, which has a vast experience in seaweed farming and is therefore in charge to capacitate the local people in cultivation and processing of the seaweeds. IDER will take care of capacitating in solar dryer operation and maintenance and its installation. Financed by the USAID., IDER constructed and delivered the solar dryer. Training of the local people during a one-year period, which covers not only technical issues but also covers marketing, management, accountancy etc. to enable the formation of a micro-enterprise is covered by a cooperation agreement with InWent –Internationale Weiter-bildung und Entwicklung from Germany. Last but not least, the project has found to be economically feasible and first discussions are under way with E+Co to obtain adequate financing for this and future projects.

REGIONAL CONTEXT

In order to assist understanding of the geographic location of the project region are enclosed two maps, one of Brazil and another one with the state of Ceará. The project itself is situated in a small fisher village called Flecheiras, northeast from Fortaleza in a distance of 150 km.

Fig 1 Map of Brazil

Description of the location

Flecheiras is located in the Municipal district of Trairi, approximately 150 km from Fortaleza, in the west coast region of the state. The districts main economic interests are fishing, agriculture and tourism. In terms of population, the region has some 40.000 inhabitants, 15% in the urban and 75% in the rural zone. About 50% survive in a state of poverty, i.e. without minimum health conditions, adequate nutrition and education as recommended by FAO/OMS/ONU.

Fig. 2: Map of the state of Ceará

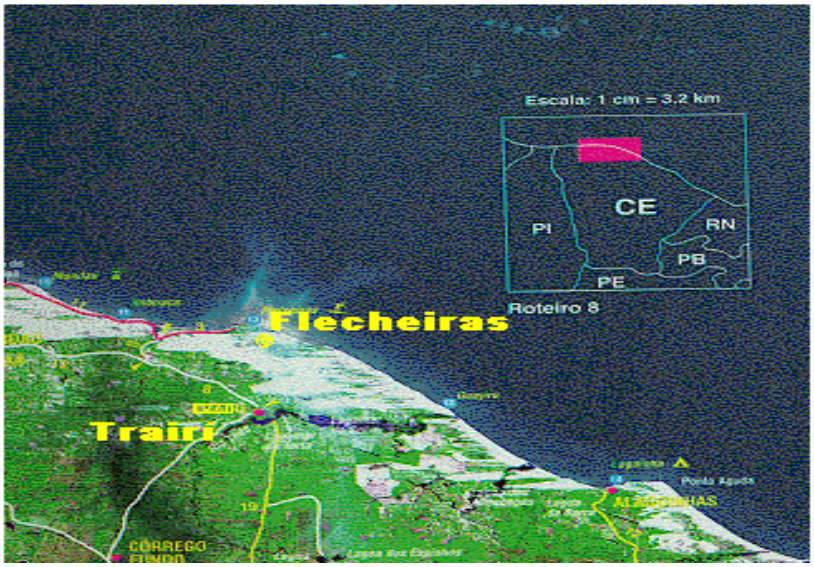

Figure 3: Satellite photo of the project region *Flecheiras*

As with most of the Municipal districts of Ceará, Trairi has serious social problems in the areas of health, education and employment. For example, there are only 31 public hospital beds for the entire region, i.e. 1 bed per1200 people.
Serious problems are also found in education, because of too many pupils for too little teachers and lack of equipment. The average net wage of a teacher in a government school is R$ 100,00 (US$ 30), The municipal Trairi possesses about 115 schools, 400 teachers and 10.000 enrolled students.
Unemployment is another serious problem, because help does not exist for people without work. It is therefore of fundamental importance that government policies enable generation of jobs, that help the local economy, such as fishing, tourism and agriculture.
Flecheiras is the second largest district of Trairi, and it is locate 16 Km from the center of the municipal district. As with of the rest of the district, the community faces other problems, besides those already mentioned. The real estate speculation is troublesome because the district is located at the coast; quite valued area for tourist interest with the risk of displacement of the local people.

The Association of Community Development of Flecheiras (ADCF), is a community organisation located in Flecheiras that carries out a number of activities for the benefit of the local community. ADCF has had an active role, participating in the process of both Municipal and State government, although after facing organisational difficulties, ADCF has tried to increase its influence by working in association with the Terramar Institute in an attempt to increase the quality of life of the communities inhabitants.

Recently it was decided that ADCF needed to increase its performance in several segments of local society, such as fishing, teaching, women's rights, mothers, the young and merchants amngo others. In the legal sense, the organisation is a registered charity (CGC) whereby it can legally receive external support.

The restructuring has accomplished, a number of objectives among others, a modernisation of the rules governing of the Association, and incorporation of new partners, mainly young people, and others linked to the productive section, i.e. fishermen and seaweed farmers.
The fishing, in spite of the difficulties and lack of support, is still maintained as the main economic activity as it occupies most of the active labour. The conditions of work of the fishermen are the worst possible. The arduous days at sea are not rewarded, mainly because of

the commercialisation of the fish is monopolised in the hand of some, which pay little for the fish, while charging high prices for the supply of necessities such as ice.
In the search for new natural resources, there has been a growing interest in what else the sea can offer. The wealth of marine flora and fauna provide countless resources that can be used for the benefit of man. Given the amount of marine flora alone, and the variety it represents, it has countless potential uses for the good of man.
In the case of Flecheiras, the seaweed project will benefit about 50 families that are devoted to the seaweed farming, however mainly women are involved in this activity.
It is worth pointing out that the project structure to be built up for the seaweed commercialization should be also applied to fish commercialisation by ADCF. This would diversify the capital, as well as strengenthing the administration of ADCF.

Background

Seaweed is mostly harvested by simply ripping off the plants from their naturally place of growing. This will lead soon to over harvesting and loss of productivity. The degradation of natural seaweed stocks (alga), off the Northeastern coast, could be reduced through environmental education of the fishing community and adequate cultivation of the alga. The option to *farm* seaweed instead of destroying their natural habitat is a way of adding value more quickly, with less environmental impact. This is especially true if fishing communities are able to form partnerships with industries capable of transforming the seaweeds into extracts and blends, normally demanded by industry. Today, a kilo of seaweed is sold, on average, for R$ 0.40, however one kilo of extract (10 kg raw material) is imported at a cost of US$ 20.00.

The cultivation of seaweed is performed by using kind of rope structures attached to the sea bottom and to buoys near the beach, to which are tied the seaweed plants. Planting is therefore carried out at the sea, not very deep, and care depends upon frequent visits by boat.
After approximately 3½ months, the plants can be harvested, cleaned and dried for later sale. In general, seaweeds lose 80% of their weight after drying. According to an consultant from FAO, the goal is to add value to the product in order to generate an increase in income for the population. It is expected that the income of families participating in a pilot project to increase by R$ 45,00 up to R$ 120,00 per month, which, in some cases, may mean an increase of 100 % of the current income It is possible to grow artificially several tons of seaweed in each location and studies have already been made to reduce the growing period to 1½ month. This would generate more income and reduce the seasonality of production at the same time. In Flecheiras and Guajiru, harvest times as low as two month have already been achieved.
In addition to increase income, farming of seaweed generates parallel benefits, such as the attraction to the area of fish and crustaceans, which serve as sustenance for the communities. Side by side with fishing, the families obtain additional income from agriculture and handycrafts.

Primary studies are already under way, which will enable certification of the origin of these farmed seaweeds, so as to assure the quality and display that it is an environmentally and socially sound product. In the case of the cosmetics industry, certification is especially valued as it is used in marketing and advertising.
The commercially useful seaweed *Gracilaria* provides *agar-agar*, *carragena* and other sub-products, used in the food industry as thickeners, coagulants and stabilizers for sweets, yogurts and ice cream, for example. In the cosmetics industry they are used as moisturizers, emollients and antioxidants.
Farming of seaweed may also reinforce the Brazilian trade balance. Furthermore, Brazil imported around US$ 15 million in seaweeds and derivatives in 2001. By counting products derived from seaweed in the form of formulas or blends for industrial applications, this value rises to US$ 20 million.
The pilot project shows the potential to make Brazil self-sufficient in seaweeds and derivatives. Amongst the industries, which depend upon products extracted from seaweed, are the dairy and meat sector, and cosmetics industry. The country fails to produce even 10% of its needs, despite having potential to supply domestic demand and expand the market further.
Over the past two years, two traditional fishing communities in Ceará state exchanged predatory harvesting of seaweeds for farming, in a pilot project financed by the United Nations Organization for Agriculture and Food (FAO) and run by the Brazilian Cooperatives Organization (OCB) with support from the Ministry of Fishing, Farming and Supply (MAPA). The FAO Project is run in partnership with the NGO Instituto Terramar.

Innovations in the productive process

The drying process of the alga is still extreme rudimental and does not enhance the final product quality. A solar dryer added to the processing will reduce considerably the drying time of seaweed and increasing its quality and the hygienic conditions. Considering industrial uses of the sub-products extracted from seaweed, this is a factor, which adds enormous value to the product.

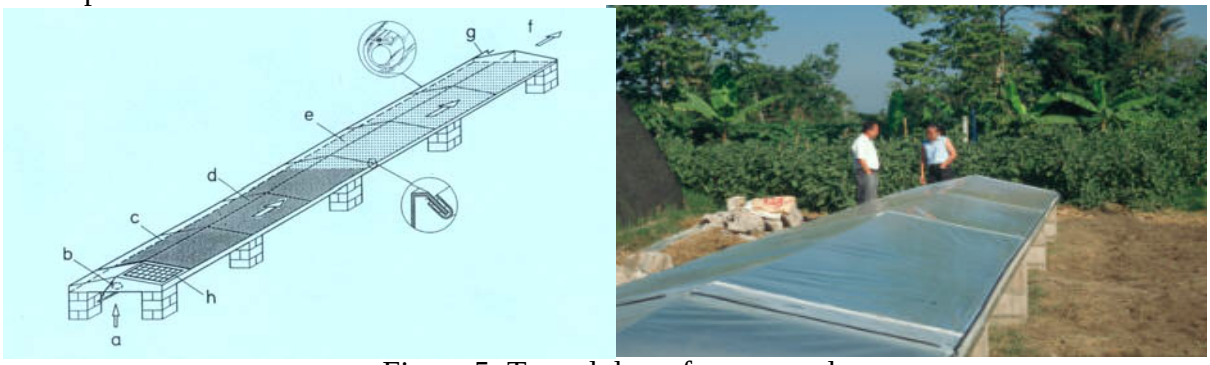

Figure 5: Tunnel dryer for seaweed

Appropriate Solar Technology for this Product

The appropriate solar dryer for this application is the so-called “tunnel dryer” This kind of dryer has been developed during several years ago to be used for citron grass in Thailand and different kinds of fruits all over the world (Agriculture University of Hohenheim, Germany, Prof. Mühlbauer, today commercialized by the company *Innotech*, Germany).
This dryer has the advantage to be easily adaptable to the specific plant / fruit and its necessities in temperature and drying time. The product to be dried is distributed on a grid of appropriate mesh size. The sun passing through a transparent plastic foil heats up the alga. Air is flowing through the tunnel by means of small fans powered by a solar photovoltaic module. The temperature and the airflow are adjusted according the necessities of the alga, presuming there is the need of some experience to find out the appropriate values.

Due to its easy construction the dryer can be fabricated at most locally without any sophisticated materials. Some plastic foils, and wood sheets, and a good carpenter are all what is needed. The modular design allows very simple upgrading when more production capacity is asked for.
In the first moment, in order to familiarize the fishermen with this new technology is thought of a solar dryer, which may dry one batch of semi-wet alga weighting about 50 kg. Pre-drying at open air is advisable to enhance the efficiency of the solar drying process.

Cost of technology

The solar dryer described above costs about R$ 4000,00 completely ready installed, including the solar module and fan. IDER re-calculated and re-constructed a commercially available design and used locally available construction materials. The lay out is very simple and could be fabricated by a local carpenter (boat builders) since he would be also responsible for eventual maintenance and repair works.

Adding value with Innovation

Prices currently paid for seaweed products are, on average, R$ 0.40 per kilo. The community's experience of drying without any technique has increased the price to the level of R$ 1.20. With a solar dryer the quality of the end product can be enhanced even more and sold for approximately R$ 1.70. This means that the market is prepared to pay a better price for a product of superior quality. Information gained "in situ" as well as importers' records reveal that market prices for seaweeds produced with appropriate processes to enhance the overall quality may triple these prices, which would be by far enough to prove the sustainability of the initial project.
Providing that receant studies are correct[1], and that Brazil is importing for an amount of US$ 20 million per year in products associated with these seaweeds and that it really is possible to make Brazil self-sufficient in this product, the future of this Pilot Project is more than guaranteed.

COST ANALYSIS OF THE PRODUCTIVE OPTIONS

Most important is to raise the standard of living of the communities, in this case Flecheiras, and establish methodologies, which ensure the sustainability of the project.
With a little help in form of subsides to acquire the essential equipment, and in training for administration, operation and maintenance, and in marketing the products, the project can be a turn point in the human development of the community.
In the following spreadsheet are summarized the economical parameters of the seaweed enterprise[2].

Table 1: Economic parameters for seaweed production

Activity	Unit	Normal Investment		Investment solar equipment	Total investment	Revenues per unit	Total Revenues per unit	Administration / Operation costs	Maintenance costs	Liquid income per unit
Sea Weed Cultivation	2.4 ton / year; two cultivation sites	2 600	700	2 500	5 800	3 400	3 400	2.400	580.00	420.00
		Ropes, buoys, ankers	Pre-drying facility	Solar tunnel dryer		200 kg/ month R$ 1.70/kg		One salary minimum / month		

[1] Consultants Christo, Manesco & Associados
[2] Extract of a market study developed for InWent

The investment is rather low and therefore this enterprise is feasible. It does also not need permanent attention and the persons involved can work elsewhere, e.g. fishing. The income is classified as "additional income" to other activities. This enterprise has also the potential to add more value to the end product by producing blends with simple additional technology. The production of algae known as *Gracilaria* in the Northeastern coast is already a reality, although still relatively incipient and little professionalized. From these algae is extracted the agar-agar, carragena and other sub-products, used in the industry as fillers, gel and stabilizers to produce candies, yogurts and ice creams, for instance. They are also used in the cosmetic industry as moisturizers, emollients and antioxidants.

The price per kg processed raw dried alga would rise to R$ 20.00 (now R$ 1.70), using simple technology (cooking, filtering and extraction) with little additional investment and operational costs.

After the initial pilot project phase will be established measures to make the enterprise sustainable and more profitable that the involved persons can make a living out of it.

Training Program Objective

The training program is fruit of a market study[3] and does concentrate on innovative products in the community with the use of renewable energy sources. The aim is not just to teach renewable energy use but concentrate on training of a complete production chain where renewable energy is a tool to enhance the product quality. The products themselves are known in the community but it demands specific training to make the enterprise sustainable.

Methodology

The training modules (see below) cover the real needs of the local people. The trained persons will be the „Monitors" for further training sessions in other communities or Municipals with the same needs. At these workshops are invited other communities and interested Institutions in order to disseminate the knowledge. The maximum number of participants is however limited to 20 persons in order to guarantee didactically efficient work.

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 workshops are designed to take care about this integral concept and have real projects as background.

The practical part of the workshops, which are following the training concept „Hands on" and „ Learning by doing" is planned in the community where already exist renewable energy systems and specific technologies, e.g. solar dryer.

Some of the training modules demand accompaniment during several month, like the seaweed cultivation. 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.

[3] The Use of Renewable Energy in the Production of Goods and/or Services as a Contribution to Regional Development in the North and Northeast of Brazil; IDER 2002 under contract of InWent

Structure of the Training Program

In the following are listed all planned activities:

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
E4 Solar Thermal Dryers
T Specific Technologies
T3 Cultivation of sea weeds

The renewable energy and technology modules are under way to be carried out, while the administrative capacitation will be covered in 2004.

PROJECT IMPLEMENTATION - SEAWEED CULTIVATION

The partner organization Istituto Terramar is working in the fisher community since several years. However, the seaweed cultivation was tackeled only one year ago.Together with IDER, the training program started out in the direction of looking to the subject more economically, enhance the product quality and processing. In conjunctions was elaborated a detailed training program based on the training modules mentioned above with the following target figures:

- Construct put progressively at sea several rope structures;
- Establish a administrative and processing infrastructure;
- Implement a Solar dryer;
- Iniciate a commercially feasible production and marketing.

In detail are under way the following trainig measures:

Farming of Seaweed

- Knowledge about sustainable aquiculture;
- Economic and ecologic value of seaweed;
- Sustainable handling of natural recources;
- Fico-culture in Brazil and overseas;
- Basic knowledge about seaweed especies and identification;
- Methodology of seaweed cultivation and farming.

Figure 6: Farming of Seaweed

Seaweed Processing

- Construction of rope structures and seaweed cultivation modules;
- Methodology of seaweed harvesting;
- Seaweed selection and pre-processing.

Drying with Solar Dryer

- Basic principles of drying;
- Procedures of drying;
- Working principles of a Solar dryer;
- Construction and operation of the Solar dryer;
- Quality Control.

Administration and Management

- The importance of associative work;
- Management of *sustainable aqui-culture*;
- Basic knowledge in accountancy;
- Basic knowledge about financing;
- Marketing and commerzialization;
- Quality Control;

- Product Certification;
- Environmental protection.

This highly diversified learning material was and is administered by a methodology, which considers the capacity of the local people to assimilate the training content. Besides appling dynamic education methods and tecnics, which involve as much as possible the students, some kind of comic books is used.

Most of the educational work is hands-on training out at sea or at the processing facility.

The rope structures are prepared either at the beach or in the association building. Each rope structure is approximately 25 m long and the seaweed grafts are tied to it with special plastic straps in a distance of about 40 cm. Care has to be taken not to injure the tiny plants. During the process the seaweed have to be kept always wet with seawater. Otherwise they die or do not develop as expected. (See enclosers for rope structure design and lay out at the beach). The ropes are linked to anchors and bouys and put out at sea by the locally used flat boats, so called “Jangadas”. The ankers and bouys are adjusted that the rope will hang in approximately 1 m depths under the surface. In that way the seaweed get still light enough for the photosynthese process, are protected against the waves and find sufficient nutrients in the water for prosper growing[4].
After a period of approximately two month the seaweed have grown to a length of about 50 cm and are ready to be harvested. Longer time does not add any more quantity but reduces already the quality. Again, the boats go out and the ropes are pulled in with the seaweed attached to it and brought to the beach.

Figure 6: Pre-processing: Rinsing and detaching from the ropes

Pre-processing

The seaweed has to be carefully detached from the ropes in order not to damage its structure. Part of the seaweed is immediately put back in seawater to be used as seed plants. Afterwards the seaweed have to be washed in sweet water to be ready for drying.

This flushing has to be carried out very carefully to expel the salt from the plants. They are rinsed until the plants are getting a light pink coloring. Before being put in the solar dryer the plants are pre-dryed at open air in the sun to loose the surface water being then less soppy.

[4] Exhaustive test with seaweed revealed that the growing process is severely influenced in greater depth than 1 m. Seaweed grows naturally in shallow water or riffs.

Figure 8: Types of solar dryers: set-up and loading

Solar Dryers

The drying process applied by the community was very simple and rudimentare. In the beginning, the seaweed was spread out at the beach in the sand. The quality was rather low with a high content of salt and sand. Putting the plants on a mesh above ground made little improvement. Still, the drying process did not achieve the low humid content (less then 20 %) expected from the industy.

However, a new solar dryer it had to be build at first. After having examined several types and the construction materials used, IDER came up with a very simple wood construction. The dryer is in total 18 m long and has 2 m width. The bottom is made out of waterproof flake board, wereas the structure is made out of sturdy wood beams. All is bolted together for easy installation. Three-meter segments were pre-fabricated and brought to the site by trailer. Between the two sidewalls was stretched out a plastic protected garden fence. On top of this fence was layed out a network of small mesh size, to support the seaweeds.

The whole structure was covered by transparent plastic plane supported by semicircle bended wooden bars (see Fig. 9). Five little 12 V ventilators powered by an 80 W solar module installed at one long side, provided a constant airflow through the tunnel dryer.

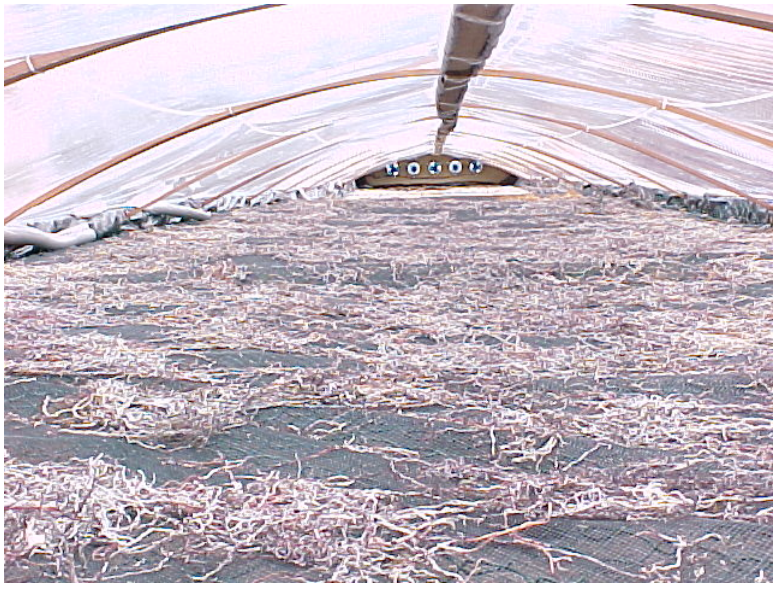

Figure 9: Inside the new solar dryer.

The dryer was installed together with the local people. Instructions how to use the equipment were provided during the installation phase and could be easily assimilated.

The newly introduced solar dryer cut down to 1/10 the drying time and lead immediately to the quality asked for by the industry.

FUTURE PROSPECTS

Currently are under way the training measures mentioned above. Beside these activities is developed a business plan together with E+Co in order to get the seaweed cultivation financed. In terms of quality control and enhancement is under way a certification procedure with the respective governmental entities. Through several financial sources is expected too increase the rope structures laid out at sea. Neighboring communities, which are still practicing predatory seaweed collection at the offshore barrier reefs, are invited to participate in the project and some success is already visible.