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The Babassu as an Alternative Technology for Housing Construction

A Sustainable Development Approach

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***Abstract*—The paper approaches the production organization as the basis to reach a better quality of life for all human beings, and discusses especially a manner to guarantee housing quality for future generations living in poorer regions. In the paper the concept of sustainable development is addressed and discussed within the areas of economics, technology, organizational view, and housing. An alternative technology for housing construction with the utilization of babassu is then proposed. The utilization of babassu meets the concept of zero emission. Besides being used as input for construction, it can also be applied to other industries, such as chemical, food, and clothes industry. The paper presents the development of construction methods with the babassu.**

Keywords—housing construction; babassu tree; sustainable development.

I. INTRODUCTION

When addressing the development of new methodologies within environmental quality management, a series of aspects should be focused upon.

First, it is necessary to define the meaning of environmental quality and its context. The environmental quality management is in a field for specific action, although reasoning and holistic attitudes make each field of action a micro-cosmos of a greater organism, where several aspects of life are integrated. Thus, the methodologies for environmental quality management are not simply meta-methods, which can be developed out of regional, cultural, historical or technological context. However, society has fast learned in the last half of this century, that paradigmatic changes would be necessary to guarantee life in earth - and mankind life in particular – as well as minimum acceptable levels of quality of life. A synthetic manner that could cover a great variety of activities was defined as sustainable development or sustainability.

Concern with the quality of life of future generations – and the preservation of Earth - is a key aspect in the definition of sustainable development. More academically sustainable development may be defined as a development that serves the world's present needs, without threatening the needs of future generations. Brundtland, (1991)

A more radical attempt towards a paradigmatic change was based on the hypothesis that Earth is a living planet. It has encouraged philosophical thinking on what it means for a species to be part of a living planet. This hypothesis – the Gaya hypothesis that is today viewed as a theory- aims at establishing equilibrium between the planet's defense and the human beings' defense. It criticizes the belief that humanity can govern the planet, and suggests that humanity should follow the planet's orientation. This theory views the evolution of the material environment and the evolution of organisms as part of a unity, in a field of unique and indivisible action Sahtoris, (1989). The authors of the theory propose that the human species should be viewed in the context of the biological evolution of the planet, as a still recent and experimental species, with developmental stages similar to those of each single human being. The idea of preserving life in a living planet contrasted to the idea of a living planet where human beings are one more component shed light on an ecological discussion different from the usual one on the field. Human beings' role is not of preserving nature as its dominant, but rather to join nature in preserving Earth, as one more element of nature, that, although being intelligent, is an experimental being which may be extinct as other species were in the past. From this point of view, the preservation of natural means changes perspectives, and the human beings' comprehension of themselves and of nature becomes a way for self-preservation. Therefore, human beings would become more sympathetic to other beings in the present and in the future, and in this way become capable of taking action in several fields – such as politics, science, industry and technology – to guarantee sustainability.

Under this context, the change from a mechanistic to a biological or ecological paradigm results in a search for a value system that focus on conservation, cooperation and partnership, in opposition to a value system that highlights expansion, competition and domination. Leripio, (1996), Capra & Pauli,(1995) Approaching human activities from this paradigm, trades, business, and economics would be likely to follow the same pattern. Nobrega (1996) proposes that the business world should follow more closely the

scientific evolution According to him, the scientist of complexity and the businessman would ultimately face the same challenge. NOBREGA also raises the possibility for the existence of cooperation among enterprises in a market system.

In order to effect this new paradigm, within the production context, Pauli (1996) observes that engineering objectives evolved from the concepts of "zero defects," and "zero inventory"(from Total Quality Administration, and Just-in time respectively) to the concept of "zero emission". The latter is a process that eliminates all types of wastes, and therefore, contributes to cost reduction. However, the proposal of zero emission does not refer only to the operational level, but also to a way of approaching production. Graedel & Allenby (1995) say that no firm exists in a vacuum, in their discussion of the Ecological Industrial concept. They state that all industrial activities are linked to other transactions and activities, and their impacts to the environment.

The search for new technologies – accessible to lower classes and based on the new paradigm of a sustainable development – should be attempted. The utilization of constructing methods with basis on regional, cultural, technological, economical, and natural characteristics of different regions is the best way to guarantee quality of life for the present and the future generations - a fundamental within sustainable development.

The objective of this work is to discuss the concept of sustainable development, and apply it, presenting a proposal for an alternative technology of construction with the utilization of the babassu. In chapters 3 to 6 the concepts of sustainable development, and economics, as well as sustainable development and technology – with special function on the technology for housing construction – are discussed. In chapters 7 and 8 the babassu is presented as an input that may be applied in several ways, without producing waste, therefore, resulting in "zero emission" Finally, we present simple constructing techniques using babassu.

II. SUSTAINABLE DEVELOPMENT

Sustainable development is defined as a type of development that responds to present generations' needs, without endangering future generations capabilities of responding to their own needs.

Sustainable development holds two key concepts: the concept of needs, and the notion of limitations. The former focus mainly on the essential needs of the world's poor people (considered a priority), and the latter on the limitations that technology and social organization impose on the environment, preventing it from responding to present and future generations' needs.

Development takes for granted a progressive change in economy, and society. In case a development path is sustainable in its physical sense, theoretically it can be approached even in a very strict social political context. However, physical sustainability can only be assured if development policies take into account the possibilities of changes in relation to resources access, and cost and benefits distribution.

Fulfilling human beings needs and aspirations is the main objective of development. In developing countries, the basic needs of a great number of people, such as food, clothing, housing, and employment, have not been fulfilled. Besides these basic needs, people also wish a better quality of life. In a world where poverty and unfairness are endemic, crisis on ecology, and other types of crisis may always occur. Sustainable development can only be reached if people have its basic needs fulfilled, and the opportunity of reaching their aspirations for a better life guaranteed.

The fulfillment of essential needs depends partly on reaching full potential growth, and sustainable development clearly requires economic growth in regions where essential needs have not been fulfilled.

Therefore, a simple growth is not enough. Great production activities may co-exist with dissimulated poverty, and that would result in risk for the environment. That's why sustainable development requires that society respond to human needs by increasing production potential as well as by assuring the same opportunities for everybody.

There are many ways in which society can in the future be less capable of responding to the essential needs of its members. One example is the excessive exploitation of resources. Depending on the direction of the technological progress, some immediate problems may be solved, but more complicated ones may rise.

Sustainable development should not risk the natural systems that guarantee life in Earth: the atmosphere, the water, the soil, and the living beings.

As far as non-renewable resources are concerned, such as minerals, and fossil fuels, its use may result in a reduction in the available quantities for future generations. That does not mean that these resources should not be used. However, the use of these resources should take into account the availability of the resource, the adoption of technologies that minimize its exhaustion, and the possibility of spotting substitutive resources. In this way, Earth should not be exhausted beyond a reasonable limit, to allow for recuperation. Concerning minerals, and fossil fuels, it is important to watch their exhaustion levels, and emphasize economical use as well a recycling, as a way to guarantee their existence until a good substitute is found.

Development tends to simplify the ecosystems and reduce their species diversity. And once extinct the species do not renew themselves. The extinction of vegetal and animal species can dangerously limit the

options of future generations. That is why sustainable development requires vegetal and animal species' preservation.

The so-called renewable resources, such as air and water, are resources too. Only part of the raw material and energy used in the production process becomes useful goods. The rest becomes waste. For sustainable development to become true, it is necessary to reduce the harmful impact that waste produces in the air, water, and other natural elements, in order to keep the global integrity of the ecosystem.

Sustainable development is essentially a process of change in which the use of resources, the direction of investments and technological development, and institutional changes complement themselves and guarantee the potential fulfillment of future and present generations' needs and aspirations.

III. Sustainable development and economics

A common track to sustainable development strategy is the need to include ecological and economic considerations in the decision making process. Actually, economics and ecology are integrated in real world activities.

Economic and ecological matters are not necessarily opposing. Policies that aim at preserving the quality of agricultural lands, and at preserving the forests improve the agricultural development perspectives in the long run. Greater efficiency in the use of raw materials and energy may be an ecological objective, but it also reduces costs. Many times, however, compatibility between economic and ecological objectives is not reached when an individual or group attainment is taken as a priority, with no concern to its impact on others and the future. The inflexibility of institutions stimulates this situation to continue.

A serious inflexibility is the tendency to deal separately with each industrial sector, with no concern to inter-sector bonds. Modern agriculture employs great quantities of industrial products, and energy produced commercially. At the same time, the most traditional bond –agriculture as a source of raw material to industry – is getting weaker due to the more and more common use of synthetic products. The link between energy and industry is also changing. Industrialized countries have shown a trend of a less intensive use of energy in the industrial production.

These inter-sector bonds result in the constitution of economic and ecological contexts of inter-dependence that are rarely reflected in how policies are elaborated. Sectorial organizations usually have sectorial objectives and regard their effects on other sectors as side effects, ignoring them unless they are obliged to watch them. That is why policy impacts on forests rarely worry those responsible for public policies, or commercial activities in the areas of energy, industrial development, agronomy, and international trade. The sectorial segmentation of responsibilities originates many environmental and developmental problems. This segmentation should be overcome for a feasible existence of sustainable development.

Sustainability requires broader responsibilities towards the impact of decisions. Therefore, changes in the institutional and legal systems are necessary in order to emphasize the common interest. Some of these changes come from the idea that an environment that fosters health and welfare is essential for all human beings, including the future generations. This perspective leads to the possibility and right of regarding public and private resources in their appropriate social context. Moreover it allows for more specific measures.

Law itself cannot impose the common interest. The latter requires the community awareness and support, and consequently a greater public participation in decisions that affect the environment. The best way to reach it is through the decentralization of the administration of local community resources, which should be managed by the communities themselves. It is also important to encourage citizen initiatives, empower popular organizations, and make local democracies stronger.

It is also important to organize, in an international level, the integration of economic and ecological factors through the legal and decision-taking systems of the countries. The increasing use of raw material and fuel approximate the bonds among the ecosystems of different countries. Economic relations also increase through trade, financing, investments, and exchange, what results in a stronger economic and ecological inter-dependence. In the future, perhaps more than now, sustainable development will require the unification of economy and ecology in the international relations.

IV. Sustainable development and Organizations. The Zero Emission concept

The search for the industrial advantageous competitively led the industries to improve their performance. During the sixties, customers' wishes and preferences became more valuable than the products' selling price itself. As a result the western major organizations changed their strategy.

The concept of quality led the corporations back to competitiveness. They invested then in quality control and in Total Quality Management (TQM). More recently, western corporations – having had their market share reduced once more – invested in quality and productivity programs such as the just-in-time, an advanced production system.

The just-in-time manufacturing philosophy refers to the running of a simple and efficient manufacturing system capable of optimizing the use of capital, equipment's and human resources. The result is a production system capable of responding to

customers' quality and supply requirement at the lowest price.

The just-in-time goal is to eliminate any unnecessary function (in the manufacturing system) that would add indirect costs and that would not bring value to the corporation, or that blocks productivity, or aggregate unnecessary expenses to the customers' operational system.

In the 90s, the industry had to reevaluate its performance again. The reengineering was adopted, and the concept of zero defect was introduced. Following the search for zero defects (Total Quality Management), and zero stock, the concept of zero emission appears in the context of sustainable development as an objective to be chased.

Within the next 10 years, industries will have to review their procedures in order to reach the concept of zero emission. The concept of zero emission is highly costly in the present market. However the same happened to other competitive tools implemented in the past. Nowadays , high quality , as well as zero defects products are considered order qualifier to enter the market.

A business is considered sustainable when it fulfills today's demands without reducing the opportunities of future generations. The concept of sustainability says that in order to guarantee a long-term sustainable industrial process, all inputs should be aggregated to the final product. Wastes should always become the input for another production process, as it happens in nature.

Each industry will have to evaluate the way it will limit the use of natural resources, both extracted and cultivated, and the way it will continue using most parts of its waste.

The construction industry faces the same challenge. The fast urbanization leads to great building projects that require huge quantities of energy, materials and money. However, there are alternative building materials, such as the bamboo, known as the vegetal steel, which can be used as both structure, and plumbing in constructions. The total cost of building a house using bamboo as structure and plumbing is reduced in 20%, average. The house will stand for at least five generations. The bamboo tree planted in the raining season produces about 72 thousand litters of alcohol (fuel). In Japan bamboo roots are a highly costly food.

The zero emission concepts is essential for sustainability. Raw materials' productivity should be maximized, and corrective solutions should be pursued. Ethics and social aspects should be present at business decision-taking processes - including customers' concern for social justice and moral values - so that customers' total satisfaction be reached.

V. SUSTAINABLE DEVELOPMENT AND TECHNOLOGY

The direction of technology - the key link between human beings and nature - should be reviewed if we expect to reach sustainable development. First, technological innovation capability must increase a lot in developing countries, so that they can react more efficiently to the challenges of sustainable development. Second, It is necessary to change the direction of technological development, in order to give more attention to environmental aspects.

Industrial countries' technology is not always appropriate, or easy to adapt to the socioeconomic and environmental characteristics of developing countries. Moreover, most part of the research and development in the world neglects developing countries' crucial issues, such as agriculture in dry areas, and tropical diseases control. Recent innovations in the area of energy conservation, technological information, and biotechnology have not been successfully adapted to developing countries' needs. More effort should be addressed to these issues. These gaps need to be encouraged in the Third World through support in the areas of research, planning, development, and specialization.

Concerns with natural resources should worldwide direct alternative technology development, as well as the improvement of traditional technology, and the choice for importing technology. Most technological research originated from commercial organizations address issues that are market valued. It is necessary now to develop technologies that improve welfare, such as better air quality, or longer-lasting products. However, technologies that solve problems such as pollution and waste destination are not usually taken into account by organizations.

Public policies should guarantee, through incentives and disincentives, those commercial corporations observe more seriously the environmental aspects involved in the technologies they develop. Research institutes supported by government should follow the same direction.

The development of environmental respecting technologies is related to the issue of risk management. A careful analysis of the shortcomings and vulnerabilities of the implementation of technologies, as well as the adoption of manufacturing patterns, and contingency plans for its operations may reduce the catastrophic consequences of failure, or accident.

The environmental risks resulting from technological and developmental decisions affect individuals, and areas that do not influence these decisions. These areas should be taken into account. National and international institutional mechanisms are crucial to evaluate the potential impacts of new technologies, before they become widely used, so that the resulting production and waste do not excessively ware away natural resources. These mechanisms are necessary whenever there is intervention in natural

systems, or forests destroy. Besides, it is necessary to reinforce compensations for involuntary damages.

VI. Housing

There is not much low-cost housing in developing countries. Lower class people usually either rent rooms in cheap guesthouses or other people's houses, or build or buy houses illegally in other people's or public land. There are different levels of illegality, and each determines which government policies will be addressed, and how much public service and resources will be provided in a certain situation.

In general, most types of low-cost housing have three common problems. First, services and infrastructure are either inadequate, or nonexistent, including sewage and piping systems, and other hygienic systems used to eliminate human waste. Second, people in these houses live crowded in small rooms, what may result in the dissemination of contagious diseases, mainly because they present low resistance due to sub-nutrition. Third, poor people usually build their houses in types of lands inappropriate to human housing, such as swampy and desert areas, erosive hills, or areas close to polluting industries. These areas are commonly chosen for having low commercial value, and thus reducing people's likelihood of being expelled.

The structures of land ownership and governments incapacity or ill will to address this issue are the main causes of illegal settlement, and the increasing urban chaos. Whenever half or more of a city workforce does not have any chance of legally obtaining a parcel to build a house, or the possibility of legally buying or renting a house, the balance between the rights for private properties and the welfare should be reevaluated.

The increasing urbanization in most developing countries won't benefit from slow and uncertain programs. Governmental interventions should be redirected so that the limited resources improve the housing conditions of the poor. There are many possibilities of intervention.

Most cities urge for ample and continue availability of places for cheap housing near the main employment centers. Only the government can provide it, but there are no general prescriptions for that. Societies vary a lot in the way they face the right for land use, and the right for private property. Their objective, however, should be the same: the guarantee, supported by the government, of the existence of low-cost legal lands that react against the tendency for illegal settlement in developing countries. Otherwise, the chaotic growing will continue endlessly, as well as the high costs derived from that.

Besides the land itself, building materials are also highly costly to housing building. The government support in the production of all types of materials, even certain structural components, could reduce housing costs, and create employment.

Above all, the development of low-cost technologies is likely to improve in the future, as the resources become available.

VII. The Babassu Tree

The babassu may contribute in a crucial way to the diversification of Brazilian exports, and so to the decrease of its trade balance. It may even become one of its most important products in the future. Nowadays, its importance as an exporting product is secondary. Its main value consists of the oil present in the nut.

The exploitation and growing of the extremely rich babassu palm tree are also important for the Brazilian internal development, as it will be explained bellow. It could be used for example in the social and economic development of the Northeast Region in Brazil, where the babassu palm tree grows in abundance.

Products originated from the babassu palm tree

As an autochthon plant, the babassu palm tree, together with the carnauba palm tree, is a very common Brazilian palm tree. It grows freely in the virgin forests and jungle regions in Brazil. Its economic importance was recognized relatively late. The babassu palm tree existence was first accounted in 1820.

The great number of products that it originates can highlight the potential importance of the babassu palm tree to Brazil. We will be now focusing on these several products, showing the great multiplicity of its exploitation.

A. Babassu Coconut Nuts

The present interest in the exploitation of babassu is centered in its nuts, located in the coconut, which is extremely hard and has the size of a lemon. The babassu oil, the most important product originated from the babassu palm, is extracted from the nuts.

The oil's tenor is of about 60 to 70%, and constitutes only a tenth part of the coconut total weight. Around 40 liters of oil are extracted from each ton of babassu coconuts.

The oil presents the following characteristics: (a) the color may vary from whitish to yellowish. It is a little bit less acid than the oil from the coconut pit. It presents a very singular, not unpleasant smell (it reminds the hazelnut oil), and its proprieties are similar to those of the African oil palm nut oil and (b) the oil looks almost transparent when melt, and becomes white fat, extremely crystalline at room temperature. It takes time to become soured, thus being more easily stored than other palm oils.

The babassu oil can be used both as food and as fuel and lube.

As a food it replaces the pork fat and the olive oil, and may be used for producing a kind of butter. It also makes excellent input for the margarine industry, as a refined product.

The ester, resulted from the des-esterification, can be used as cocoa butter. The oil can also be used in the soap industry to make soaps and shaving creams. In soaping, it is capable of easily retaining great amounts of water, resulting in a hard and foaming product that does not need to be granulated, contrary to what happens to other white soaps prepared from fat. The oil can also be used to the manufacturing of perfume, plastic, cleaning agents (such as detergent), shot-proof glass, and explosives. During Second World War the babassu oil was used in laminating mills and tinning industry in U.S. to cover for the lack of African oil palm oil which was usually shipped from Western Africa, Indonesia, Malaysia, and the Philippines. As lube, it has shown to be superior to the oil from the coconut pit, for not attacking bronze. It is also used as fine oil in high precision devices and airplane engines.

As both fuel and lube, the babassu oil may be used in gasoline and diesel engines. The mixture of babassu oil at 20%, and methanol at 99.6% produces good results.

The wastes resulting from the nuts press in the extraction of oil make a high quality fodder, as far as digestibility is concerned, this is superior to those originated from African oil palm nuts waste. The babassu nuts wastes ("oily babassu pie", pie, and flakes) present albumin and fat tenor of between 19% and 27%, and 1% and 15% respectively.

B. Babassu Coconut Sub-products

As mentioned above, the nuts constitute only 19% of the coconut total weight. The 90% left are constituted by the following layers: a fibrous outer layer (exocarp), a pulpy intermediate layer (mesocarp), and of a very rigid and thick internal husk, hard as a stone (endocarp), whose weight is greater than half of the total weight of the coconut.

Economic value derives from the use of the parts of the coconut described above. Thus, their exploitation should be taken as a condition for the profitable exploitation of the babassu.

The epicarp represents about 11% of the coconut weight, and may be used in handcraft production, such as brushes, mats, and ropes, resistant to salty water. The mesocarp, which accounts for 23% of the coconut weight, is used as food by the native people in the region, and as fodder for the cattle. The starch and the babassu flour make nutritive diet flour used to feed the children and the sick. In Maranhao State, a small factory produces a kind of "babassu chocolate" from this flour, which is used for the preparation of a chocolate drink.

Before maturation, the fruit contains a type of tannin as fuel .A type of oil that can be used as an input in the preparation of beverages, and in the pharmaceutical industry is extracted from the yellowish fat. It is also used as a type of butter in the Amazon region.

An insulating material can be extracted from the mesocarp, and can be used as input for electrical wire manufacturing.

The most interesting economical uses of the babassu fruit come from the utilization of the endocarp, though. It makes a great fuel (caloric value of between 4,000 and 5,000 Kcal/kg), and can be used in the manufacturing of buttons, spoons, and other small objects, and also as an insulating material. Economically, its use in the production of coke through a process of carbonization at low temperature is particularly important. In this way not only a high quality coke and the usual non-flame combustion products are obtained from its peel, but also the furfural of up to 17%, and a solvent that is used as raw material in the chemical industry. The coke produced from the babassu coconut endocarp, which is considered better than the one from the Cardiff charcoal, would be precious input (as a reductant charcoal, and metallurgic coke) for Brazilian steel industry.

Coke charcoals, coal tar, fuel and gas, phenol, and acid derivatives can be obtained through the dry distillation of endocarp - process that is still being used in an experimental scale. The very absorbing charcoal is appropriate to be used as a filtering charcoal in ancient masks, and in the manufacture of dynamite. The coconut distillation makes it possible its full utilization. Some examples of products are: calcium acetate, methyl alcohol, acetic acid, *pyroligneous acid* and derivatives, light and heavy grease (lubricant), metallic pigment, phenol and cresol.

Actually, when green, the entire coconut can be used as manure, and occasionally, as fuel to produce oil-smoke for the coagulation of the rubber tree latex, and the rubber production.

C. The Babassu Palm Tree Utilization

The babassu palm was used as food, fuel, and input for knitting baskets and mats by the Brazilian aborigine. It is still used for the same purposes in some regions in Brazil.

The babassu palm young leaves make walls, partition-walls, and roof for the native cottage where the babassu is found. Nets, baskets, saddlebags, sacks, hats, and fans are produced from the dry leaves. The trunk is used in house construction, and the fruit peduncle can be used as manure.

The palm vegetative part ("palm eye" or apical meristem) named palm cabbage has a very interesting economical application, and constitutes the basis both for the exporting and internal industry. The palm cabbage is a tasty food very much appreciated by the native people. Canned palm cabbage is highly

consumed in Brazil and presents excellent selling perspectives in the foreign market.

VIII. Construction Methods with the Babassu

Some stages of construction methods using babassu will be described below.

A. Foudation

Bricks in the horizontal position are used for the foundation. The vertical position is adopted for producing higher load capacity, as suggested by tests carried by The State University of Maranhao. A brick that supports a load of 1.52MPA in a horizontal position can support up to 4.3 MPA when positioned vertically, according to ABNT specifications, and the test results. If the contact surface changes, the block assumes a structural function.

For the foundation, a ditch of 15 cm. in depth and 33 cm in width is made. The size is determined by the pillar base width, which will be constituted by two bricks horizontally positioned. The ditch length is usually 3 meters. It is determined by the length of the wall to be built. These measures should be adopted as a pattern in order to facilitate the building itself that should be carried out by the community.

The truss will be built with two horizontal lines of brick in the vertical position. The bricks are located side by side one from each line in turns so that opposite half of their surfaces keep aligned. The alignment will be kept through the insertion of cement building cement (bond) between the bricks.

B. Pillars

When the foundation is ready, the pillar construction starts. The pillars are made through the piling of two bricks horizontally positioned. The holes of each two bricks should be located 90 degrees from the holes of the following two bricks. In this way, the pillars will be squared (20 cm^2). The pillars' location will originate the corners that will be used in fastening the net to the pillars, and consequently drawing the walls together. The fastening is achieved through the insertion of cement first, and then the rods in the brick holes. As a result pillars and walls should be fastened.

The brick arrangement, described in the previous paragraph, should follow some rules, so that the wall can be perfectly built. When the bricks are settled in pairs, cement should be placed in each brick separately, in order to increase the adherence between them. Moreover, plumb and level should be watched in the process of brick arrangement to guarantee vertical alignment. For the same reason the pillars should be supported when ready, at 2.5 meters in height.

C. The Net

It seems important to highlight that women and children can perform the net assembly stage, as it is a very straightforward practice. Any non-trained person can perform it, after some instruction by a supervisor. In this way the non-specialized labor force from the community can be hired

The net assembly starts when the pillars are ready. First the brick holes are filled with cement (foundation and pillar bricks). Then the net construction itself starts through the insertion of the rods in the holes. For the insertion of the rods, foundation and pillars should be completely dry in order to avoid their displacement. Each pair of rods should be inserted in the outer brick holes of each brick line in turns, so that there is room between the two alignments of rods for the cement insertion. When the rods are placed, they should be tied with nylon thread (both vertically and horizontally). This process should be carefully approached; otherwise the cement weight can make the net bend, and cause the incurvation.

When the net is ready, the cement is inserted from the bottom upwards so that the load is uniformly distributed in the horizontal direction. The process should continue until the cement insertion reaches 2.5 meters in height. Then the superior truss is built similarly to the inferior one. When it is done, the wall fastening is concluded, and only the pillars' plaster is missing. The plaster is made with the same cement used for the sealing.

IX Conclusion

An alternative technology for housing construction using babassu could be developed within the context of sustainable development. In getting at this conclusion, the present technical, social, economic and entrepreneurial development stage in Brazil, especially in the poorest areas - north, northeast, center- west, and parts of the southeast was taken into account. Other facts considered were the great availability of babassu in these regions, and the huge scarcity of appropriate housing in the area.

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