# BIOREGIONAL PLANNING AND APPROPRIATE TECHNOLOGY FOR NICARAGUA'S MISKITO INDIANS

**Pliny Fisk III, M. Arch., M.L. Arch.**
**Gail D.A. Vittori**

**The Center for Maximum Potential Building Systems, Inc.**
**8604 F.M. 969**
**Austin, Texas 78724**

This paper has been presented in part or in whole at various national and international conferences including a

# INDIGENOUS BUILDING SYSTEMS FOR NICARAGUA'S ATLANTIC COAST

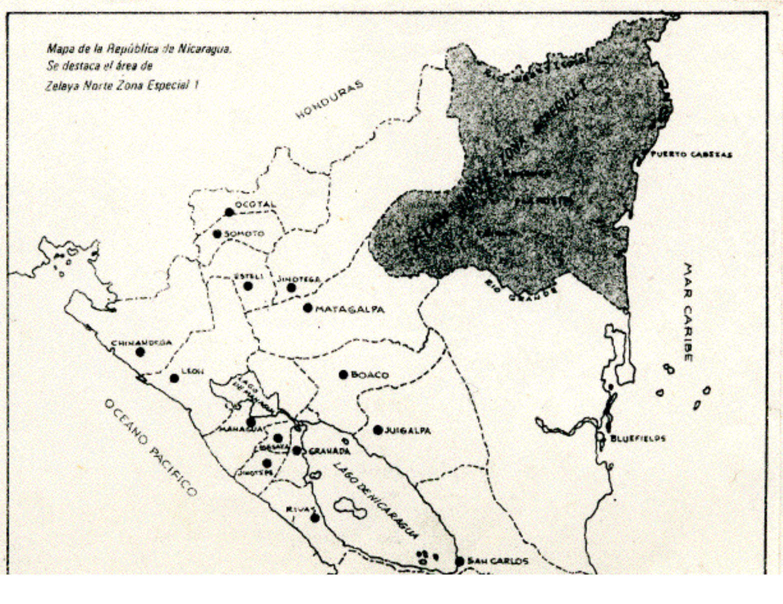

Pliny Fisk III, Gail Vittori
Center for Maximum Potential Building Systems
8604 F.M. 969
Austin, Texas 78724
512/928-4786


## INTRODUCTION

This presentation describes in brief the research and organizational procedure undertaken by the Center for Maximum Potential Building Systems to set into motion a large scale indigenous housing program under the sponsership of the Center for Investigation and Documentation of the Atlantic Coast (CIDCA), an autonomous Nicaraguan research organization. This housing project responds to an awesome shortage in available housing among the indigenous peoples of Nicaragua's Atlantic Coast, which is exacerbated daily as people are driven from their homes and villages to seek refuge from attacks. The housing is specifically adapted to the culture and traditions of these peoples, and corresponds to the availability of skills and materials within the region.

The presentation goes through the methodology used by the Center so that one may obtain the background necessary to develop a region's indigenous potential from a natural and human resource standpoint. The procedure includes two principal parts: A) the **Planning Methodology** and b) the **Development Procedure**. The first part is an identification process beginning at the macro level of the global biome that shows other world regions which share similar resource attributes as Nicaragua's East Coast, so that human experiences in dealing with similar resource conditions may be borrowed from. The process ends with the identification of who will become the human resource participants in the project. Part B shows how all physical and human resources, once found, are brought together into an integrated step-by-step procedure for the development of an appropriate housing system.

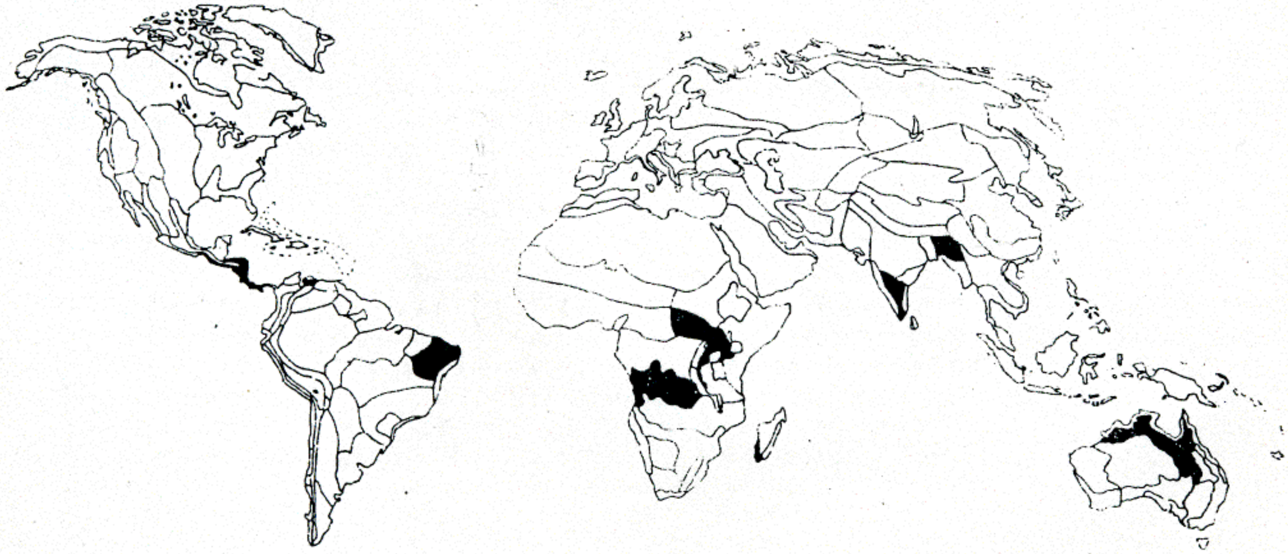
It is important to realize that the housing project is just in the beginning stages since only 18 weeks have been spent on-site by the Project Coordinator. This, however, was enough time to do the planning, most of the materials testing, and the design for a building system that could accomodate the 400+ homes required.



Along with plant and animal types, these subsystems become the basis upon which many indigenous technologies depend. We then combine this map with an inventory list of private and public institutions around the world which deal with a particular topic being researched. If, for example, we are dealing with indigenous materials, we bring out our constantly expanding list of institutions that have been using or researching indigenous materials in their particular geographic location. We then literally overlay this list with all geographic locations of all these indigenous materials institutions with the biogeographical map and send off a series of search questions dealing with various major housing components to those institutions which correlate geographically with the biome under consideration.

In the case of Nicaragua's East Coast, we find ourselves sharing similar resource conditions with nine (9) other areas of the world that are within our particular Tropical Grassland and Savanna biome. As we check out our list of institutions, including building research laboratories, grass roots non-profit appropriate technology groups, private laboratories, and individuals, we send off our search request. This direct search is also paralleled by searches into various data bases in the U.S. through keyword and geographic town/country indexes that already are contained in some of these data banks that we can cross-reference into our biome areas. Our own data base of institutions cross-referenced to the I.U.C.N. map identified 47 groups doing indigenous materials work in our global biome of Tropical Grasslands and Savannas, which is spatially mapped below. It was from this type of search that such diverse topics as coconut coir reinforcement, laterite clay cement and laterite clay low temperature brickmaking were discovered.

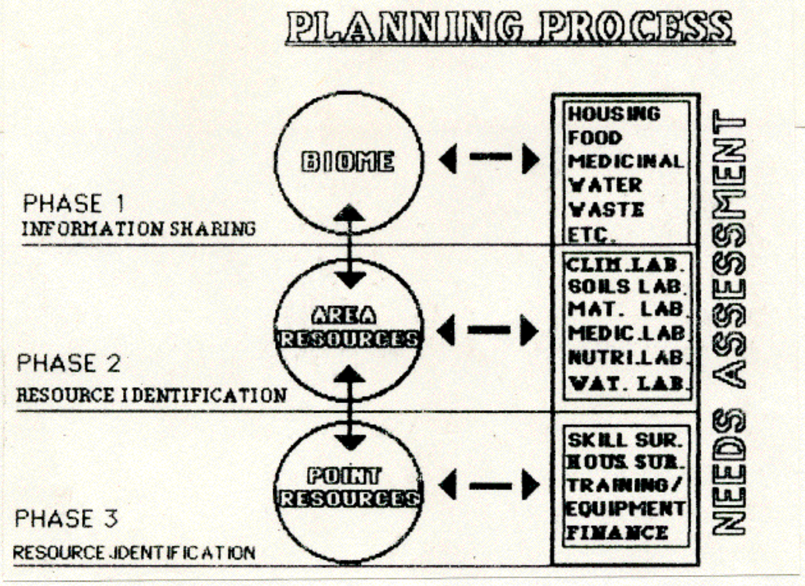
At times our investigation went beyond the biome in certain sub-category areas such as soils. For example, it was found by investigating building research in general regarding latisol-type soils which exist both within and outside the biome boundaries (into sister biomes), that some very low energy use latisol block fabrication techniques have been discovered in relation to laterite soils in Ghana in a sister biome* called Tropic and Humid Forests. It was found that soils from that area have produced a lime stabilized block under pressure of 300 Kg/cm(2) and cured at only 208°F. with a resulting compression strength of 1523 PSI. These will be more fully described under the section called **Area Resources**.



*Sister biomes are spatially adjacent to the parent biome being used as point of reference. They often share one or more characteristics with the parent biome; in the case of the Tropical Humid Forest Biome, it shares parent soil types, mean annual precipitation, and climatic

## PART A - PLANNING METHODOLOGY

The planning methodology used for this project consists of three (3) phases: 1) information sharing at the biome level as described later; 2) area resource identification involving the identification of potentially useful natural resources within the project area (for housing in this instance); and 3) the point resource identification phase which consists of identifying the available human resources, including equipment, that are being used or may be used to develop the area resources in the project area. Phase Three also includes a housing survey and training program. These phases are diagrammed below:




### PHASE 1: BIOME IDENTIFICATION

In the Project's first phase, preliminary work was done to identify the broad spectrum of experiences responding to the combination of resource conditions commonly found in this type of Tropical Savanna and other closely associated biomes, on-site and in other parts of the world. This biogeographic information base is a development of the Center for Maximum Potential Building Systems, and is used to familiarize ourselves and our clients with the problems and potentials that similar regions throughout the world have experienced under similar physical conditions related, in this case, to housing. This is done in order to supply the project with the most complete historical and up-to-date information available.

The procedure begins by utilizing the biogeographic map developed by M.D.F. Udvardy for the International Union for Conservation of Nature and Natural Resources (I.U.C.N.) prepared under contract with U.N.E.S.C.O.'s Man and the Biosphere Program. This resource map shows where similar plant and animal life appear. For our purposes, this resource map, containing 15 different biomes, also becomes an indicator of similar patterns of soil, climate, hydrology, etc. subsystems within each biome pattern.

## PART B - THE DEVELOPMENT PROCESS

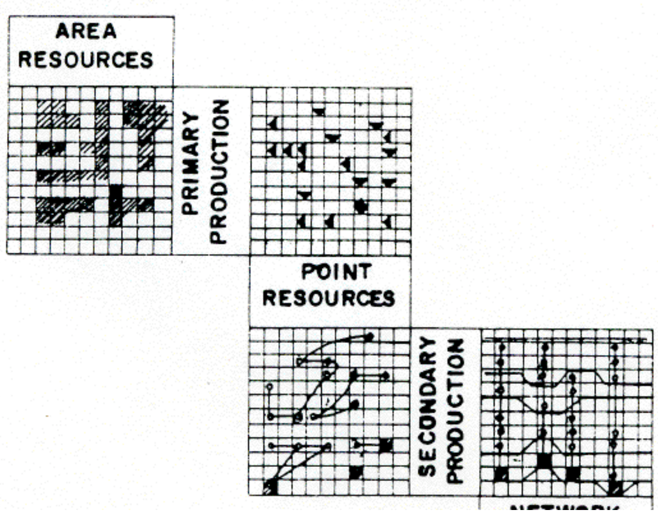
The Development Process brings together into a development sequence the various natural and human resources that have been identified in the Planning Process as they relate to the existing conditions in order to supply the requisite housing for this Project.

First, three resource components were identified: *Area Resources* (useful mapped physical resources that could, when processed, fulfill human needs for materials); *Point Resources* (the equipment and skills necessary to transform these raw materials into usable products); and *Network Resources* (the recording of already existing lines of activity from raw material to final housing components). Together, these activities represent examples of how Area Resources and Point Resources can be brought together to represent various levels of product development, all the way to a housing prototype. Essentially, the Point Resources (skilled people and their associated equipment) act as transformers of energy, materials or information supplied from another Point Resource or transformation process. The connections between these Point Resources (or transformation entities) consist of a flow of money, materials, energy or information. As you will soon recognize, since some of these flows do not exist because the point resources do not exist, we outline optional development alternatives in order to compare the number of non-existent and existent point resources represented in one development sequence vs. another.

The first phase of the project has identified most of the area resources, point resources, and some of the networks necessary for an indigenous housing project to occur in the region. We have also identified all those parts that need to be created in order for complete product development to occur. Phase II will place quantifiable units on the necessary production and flow capacities required, so that we can measure both existent and non-existent activity against a production goal.

### INTERACTIVE FIELD MATRIX

In order to represent the entire process from Area Resource identification through to Network, we have utilized a management tool called an interactive field matrix which has the ability to relate variables in a continuous manner. However, it was necessary to add two important elements to the matrix in order for the continuity between area, point and networks to be understood. These elements were: 1) primary production and 2) secondary production.

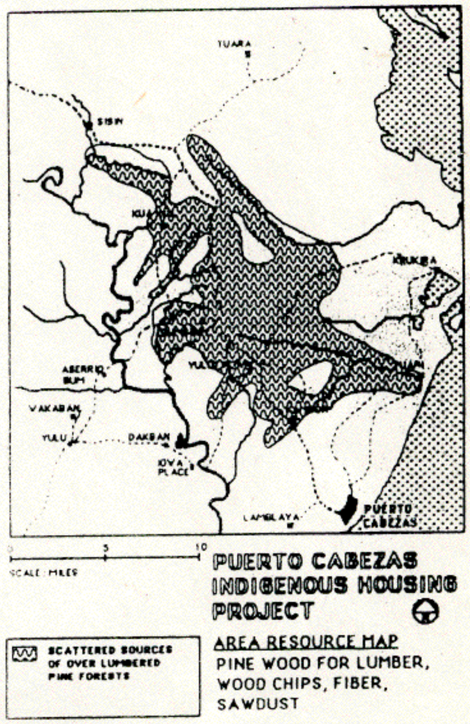


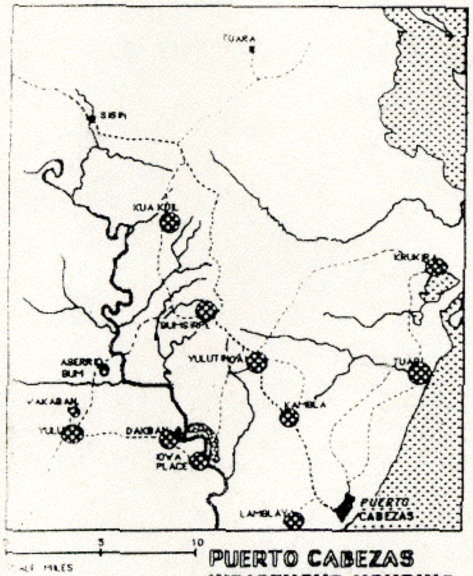
## PHASE 2 - AREA RESOURCE IDENTIFICATION

By using the investigatory processes outlined in Phase I, we are better able to understand and ask the necessary questions regarding the potential resources that we may find on-site. This is an important procedure for the following reasons:

(1) We may better ask local people the necessary questions so that we can better understand available building options.
(2) There may be no pre-recorded use of certain available resources that could be of use to the local population if the skills required to develop them meet the local skill standards.
(3) We may use biome criteria to design and choose the necessary equipment within a building material testing laboratory.

Ideally, the area resource identification process therefore occurs through two different means: one, at the larger scale of the biome which sets the standard as to further searching the possible range that one should expect fo find at the on-site bioregion level; the other at the micro scale of identification using a laboratory. Combined, these two levels of identification become a kind of learning system that is almost self-critical at one end by showing what is hypothetically possible and what should be looked for, while at the other end what actually tests out identification-wise to be present and whether those materials that do exist are useful for building. Some of the accompanying area resource maps for the Puerto Cabezas Project follow.

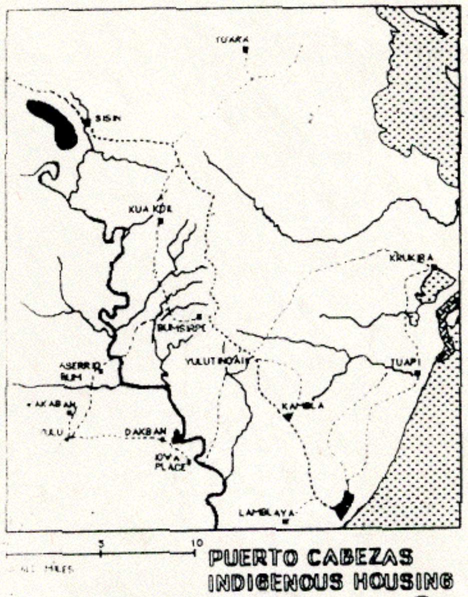



**PUERTO CABEZAS INDIGENOUS HOUSING PROJECT**

COCONUT PALM
BAMBOO

AREA RESOURCE MAP

FIBROUS MATERIAL FOR REINFORCING



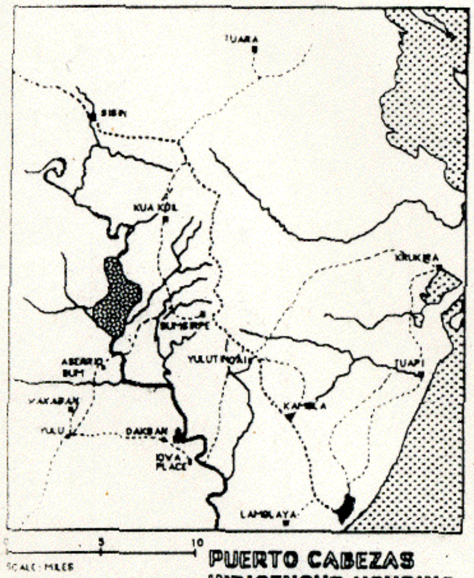

**PUERTO CABEZAS INDIGENOUS HOUSING PROJECT**

LIMESTONE
SEA SHELL

AREA RESOURCE MAP

LIME SOURCES FOR MASONRY AND CEMENT

SOURCE: WORD OF MOUTH

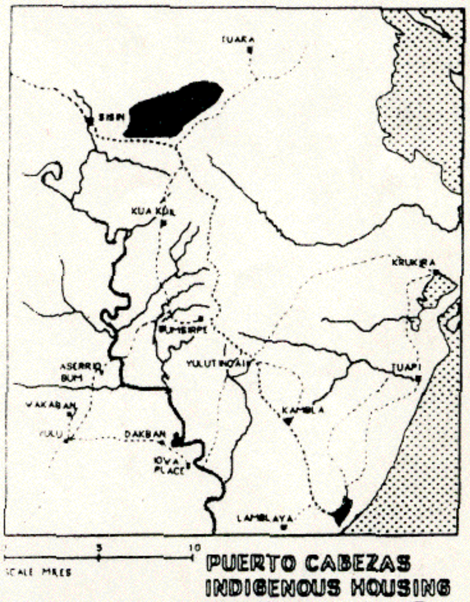



**PUERTO CABEZAS INDIGENOUS HOUSING PROJECT**

RICE PADDIES

AREA RESOURCE MAP

RICE AS SOURCE FOR RICE HUSK USED IN CEMENT MANUFACTURING




**PUERTO CABEZAS INDIGENOUS HOUSING PROJECT**

HIGH SILICA SAND

AREA RESOURCE MAP

SILICA SAND AS SOURCE FOR GLASS

KAOLINITE HIGH ALUMINA CLAY

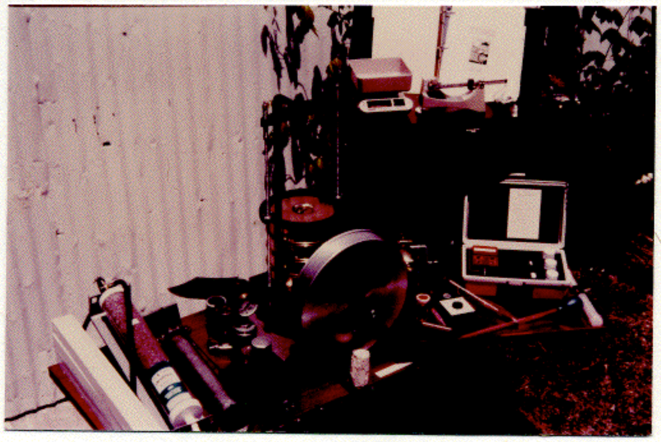
WASTE PINE SAWDUST AND WOODCHIPS

WASTE RICE HUSK

**THE LAB**

The laboratory design derives from this investigatory procedure. Its equipment contents and laboratory procedures lean toward what might be expected to be found not only around the information that exists on the site itself. Often, however, this approach is cost prohibitive and one must settle for a close approximation to what is known in the regional site conditions.

Our laboratory included the following: basic soil classification equipment, including sieve analysis screens with shaker; Atterberg limit device; two weighing scales; oven; salinity tester; pH tester; compression tester; water absorption tester; water spray test; five pound earth ramming device to determine optimum soil moisture and strength of rammed earth; high temperature potter's kiln; high temperature thermometers; and liquid limit tests specifically designed for potentially cementatious materials.



A summary of findings from this combined research can be divided into five (5) general areas. These include: 1) compression materials; 2) reinforcing; 3) materials useful for combined compression and tension; 4) preservatives and paints; and 5) insulative and transparent materials.

Compressive materials include indigenous cement, fired clay materials, and stabilized earth. More specifially we found cement type possibilities to be derived from waste rice husk, burnt kaolinite clay, and lime based materials. Portland type cement also seems probable. The quantities of these materials was found to be extremely plentiful including 34 tons of rice husk ash cement wasted within Puerto Cabezas each year, 14,800 sq. km. of kaolinite clay useful for possible cement production when fired and mixed with lime, and 5-10 sq. km. of lime based materials which can be fired and mixed with clay for portland cement production. As a fired clay material, the 14,800 sq. km. of kaolinite clay also contained perhaps as much as 20 sq. km. of high grade china quality clay material. Together, these clays, when fired, could produce many housing components including sewer drainage pipe, sinks and lavatories, brick, floor tile and roof tiles. Last, earth materials that are not fired include pressed laterite soils utilizing a lime admixture. This latter material processing technique could have the potential of utilizing the kaolinite which is a latisol thus placing this building technology at merely equal to the 14,800 sq. km. base material category.

In the category of <u>reinforcing materials</u> we found six (6) prospective materials with a history of processing and use existing in other geographic biomes. These include: coconut fiber, pepta palm fiber, pine fibers, various bamboo species, and elephant grass. Of these, the coconut fiber and pine fiber have had the most use and experience where a high degree of success has resulted from their use with concrete type reinforcing applications.

<u>Materials useful for compression and tension</u> in the form of roof joists, columns, and lintels, etc. were the wood species. This category included native species such as pine, zopelota, bamboo, leucaena, and eucalyptus. The unique attribute about building materials based on plant species is that relevant species derived from the Tropical Grassland and Savanna Biome can be transplanted from other geographic areas. However, this is also a delicate process because certain very tolerant species can dominate and upset the potential for the proper propagation of regional species. Species that therefore looked like potential candidates for an experimental and controlled introduction procedure were looked at particularly if their growth rates and environmental tolerance were attractive. Due to the fact that this Savanna was nearly all lumbered by U.S. companies, candidates which tolerated the poor soil, high clay and high flooding conditions of this tropical location were the following: Australian pine (ironwood), Australian acadia, gumbar, India blackberry, and Indian almod, a Trema species from Madagascar, and *Eucalyptus grandis* from Brazil.

<u>Preservatives and paints</u> can be derived from combinations of plant and mineral based materials. A preservative called fout, for example, is derived from the trunk and roots of the pine tree species in the project area. Resinous materials that are the basis for shellacs, varnishes, lacquers and paints are derived from a series of plants referred to as Copals, a number of which could be grown or already grow in the region. There is the possibility that the well-known Nim tree from India could be introduced for purposes of producing a safe pesticide for other less tolerant but more plentiful wood species.

<u>Insulative and transparent materials</u> could be derived from a combination of waste wood from sawmills in the form of chips and sawdust combined with cement to make building panels that are self-supporting and moderately insulating. This well-proven technology can also incorporate rice husk in place of wood, according to one building research group in India, discovered through our computer data base searches of groups in this biome. Approximately 20 sq. km. of a high grade silica sand for glass manufacturing was found about 30 km. northwest of Puerto Cabezas.

## PHASE 3 - POINT RESOURCE IDENTIFICATION

The third phase of the planning process involves the identification of the human resources found within the project area. The human resources are identified as the skills relative to the prime area resources within the region and the tool and equipment capability of the local population relative to the development of the region's resources. The financial requirements result from the deficiencies of the above combined survey.

The skills, equipment, and other facilities required are most often only partially fulfilled when we compare the ideal point resource combination necessary to develop the region's resources to what actually exists at the present time. This need gap results when a local population has become dependent for one reason or another on external political and economic forces that have resulted in a skills and equipment shift that no longer fully relates to the capabilities of the region. This gap between what is presently used and what could be utilized from within the region itself is reflected in housing deficiencies, skill deficiencies, and equipment mismatches which in the end culminates in an identifiable economic deficit in the region. The latter occurs because the region had been forced more and more to depend on outside goods and services at the expense of developing its own productivity potential in order to remain internally stable or develop into a small scale exporter of certain goods not found in other neighboring regions.

The survey that was made in Puerto Cabezas and the surrounding region was therefore designed to help identify this gap; first in housing, then in skills and equipment. Once this information is compiled, the biotechnology/bioregional planning team helps to formulate the **development process** described in a following section. Ideally, this final development process step follows a line of least resistance; i.e. incorporating the maximum number of existing skills without retraining, using the maximum amount of existing equipment and facilities without importing more, while subtly transforming the whole into a regional manufacturing entity. This procedure does not at all imply that a regional manufacturing facility should result, but more likely that individual skills and family enterprises are reinforced by better connecting one small business to the other and to a regional material base that can better guarantee long term stability. The following paragraph describes briefly some of the discoveries made in our survey with the indigenous people of Eastern Nicaragua.

## HOUSING SURVEY

General:

(1) Nearly all families who had a home wanted to have it repaired; if they did not have a home, they wanted a home similar to their traditional housing.

(2) Nearly all families wanted to have their own backyard garden. They also desired fences to keep out stray animals.

(3) Most families wanted their small backyard businesses, if they had one, reinforced through economic or other support.

Building Related:

(1) Nearly all metal roofing was found to be in disrepair, usually leaking (with 120 in. rainfall per year) and too hot in the tropical sun.

(2) Better sanitary facilities including the availability of private water supply, latrines, and safer waste water disposal.

(3) Better cooking facilities that depended on inexpensive fuel sources, although kerosene stoves were preferred; also in this category was the need for better food storage facilities.

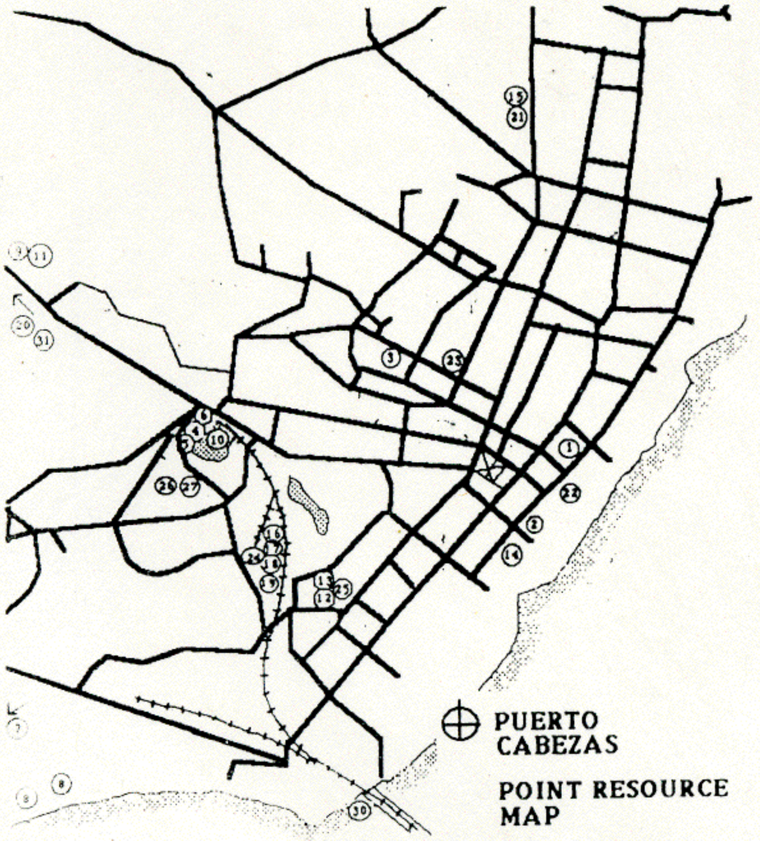
(4) Since most all structures are elevated for purposes of receiving good breeze and protection from animals, good floor structures were required but usually in disrepair as were steps.

**SKILLS AND EQUIPMENT SURVEY**

Apoproximately 25 skills and equipment sources have been identified within and immediately around the Puerto Cabezas town proper. The following skills areas were identified:

Masonry Block and Masonry Sink Production; Welding and Machining; Thatch Roof and Corrugated Roof Installation; Lumbering, Sawmilling and Planing; Baking with Brick Ovens; Small Boat Fabrication; Gasoline Engine Repair (all sizes); Backyard Gardening, including many edible native plants; Basic Cistern and House Plumbing; Septic Tank Manufacturing; Heavy Equipment and Road Scraping Capacity; Carpentry; Sheet Metal Fabrication; the Use of Forges.

In most all of the above cases, inadequate back-up equipment existed or equipment that was in serious need of repair. An exception to this was the overabundance of electric welding machines, especially in the vocational school, where no welding rod exists. The repair and maintenance of sawmilling equipment was well covered.

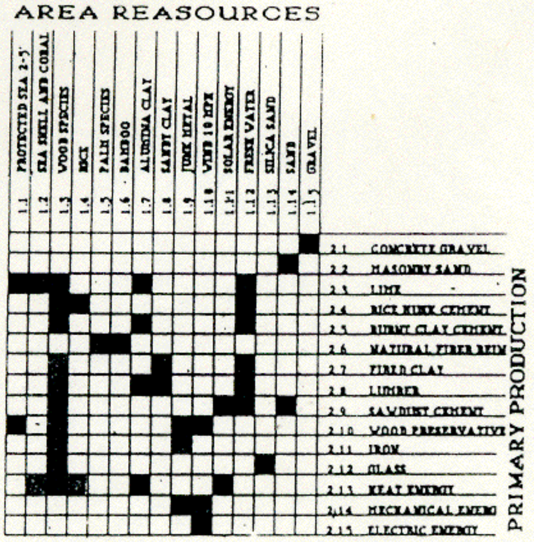


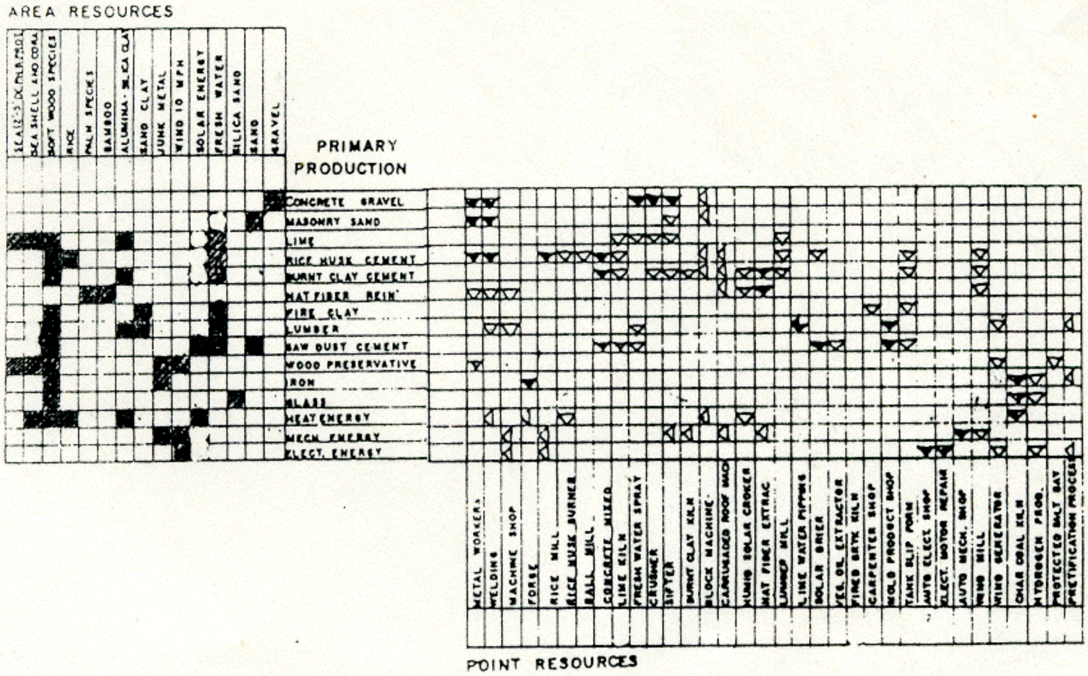
PUERTO CABEZAS POINT RESOURCE MAP

PUERTO CABEZAS POINT RESOURCE LIST

1 SAN PEDRO CONCRETE BL. YARD
2 SAN PEDRO CONCRETE SINK YARD
3 ABANDONED CONCRETE BL. YARD
4 RD. PAVING CONCRETE BL. MACH
5 RICE HUSK MILL
6 OLD KILN FIRE BRICK
7 CHARCOAL KILNS
8 2-6' NAT. SALT WATER TUBS
9 CEMENT MIXERS
10 FRESH WATER POND
11 SAND AND GRAVEL SEIVES
12 RICE HUSK INCINERATOR
13 BALL MILL COMPONENTS
14 ROLLER FOR FIBER SEPARATION
15 OSCAR PALMER ROLLER FOR FIB. SEP.
16 SHEET METAL WORKING
17 WELDING
18 MACHINE SHOP
19 FORGE
20 LUMBER MILL
21 OS. PALMER CARPENTRY SHOP
22 CHURCH CARPENTRY SHOP
23 AUTO ELECT. SHOP
24 ELECT. MOTOR REPAIR
25 WELDING EQUIPMENT
26 WELDING SCHOOL
27 WOOD WORKING SCHOOL
28 SHEET METAL SCHOOL
29 TANKS FOR PRES. PROCESS
30 ELECT. AT SALT WATER EDGE
31 SAWDUST PILES

***Primary Production*** **can be identified as the primary product resulting from first level processing; i.e. coral into lime or trees into lumber. The** ***Secondary Production*** **list includes all primary production categories and adds to it more finished materials; i.e. indigenous clay sources into bricks or roof tile, or lumber into building components ready for home construction. Secondary Production, therefore, represents enough steps within the whole production process that when it is correlated to point resource equipment and skills, points can be connected so they show a diagrammatic representation of the entire production process.**



## NETWORK RESOURCES

Network Resources are represented when these flow and transformation processes are identified by labor organizations. For example, cement products manufacturers are linked by common suppliers, resources, and even transportation means. In a similar way, one can identify clay products, lumber products, metal, hardware, sanitation facilities, energy equipment manufacturers, etc. Depending on the stage of development within the social and institutional infrastructure, one can find trade organizations that are organized either around production sequences, i.e. (vertically), concrete product manufacturers associations, or around different stages of end-products, ie. (horizontally) raw material suppliers, product manufacturers, energy producers, building contractors, etc.

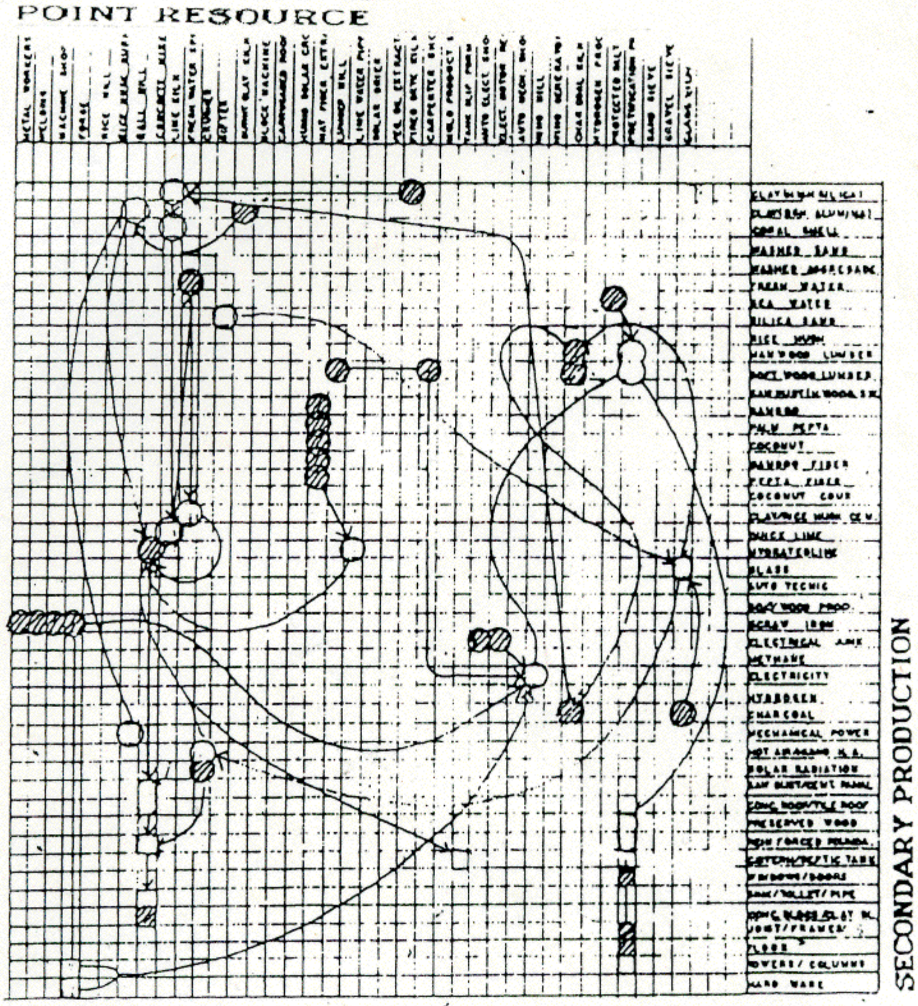
By recognizing both the horizontal and vertical orders of organizations, different types of coordination can be recognized. For example: (vertically) overall production of masonry products, both cement and clay, can be better coordinated to meet the structural wall goals for housing; or (horizontally) worker issues related to working conditions, safety, pay, etc. can be discussed at the different supplier levels, from mining at one level through to subcontractors who together can be represented by worker organizations at another level. Organizations which already exist can aid greatly in these organization efforts. If they do not exist, these different associations might gradually have to be created so that both human production and technical production issues are fully recognized to foster a home building industry which can function through the long term. Many of these network resources have yet to be identified for the Puerto Cabezas region.

## CHOOSING A DEVELOPMENT STRATEGY

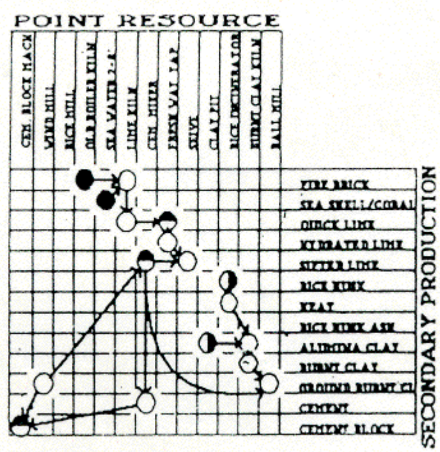
The final housing development process is chosen by considering a combination of factors that try to fit the need for the number of required homes into the simplest strategy of utilizing the existing natural and human resources, recognizing environmental and sustainability parameters. This strategy is chosen from a variety of development alternatives that cover each major part of the physical housing environment. Six major housing components were chosen . These include: Materials (roof, walls, floor, foundation); Climatic System; Water System; Sanitation; Food Preservation; and Insect Issues (human and material requirements).

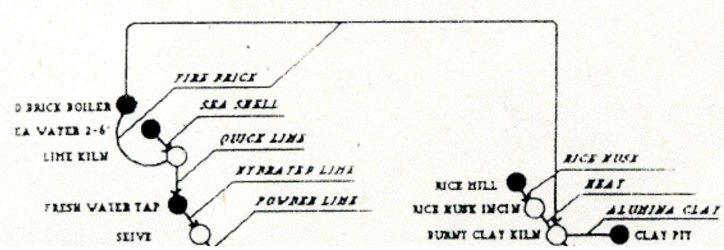
Each of these physical components with their individual alternatives were diagrammed in a similar analysis, as was the rice husk ash cement shown earlier. A simplified version of the materials component in form of (1) walls and foundation; (2) roof; (3) water and sanitation is shown below in order to give some concept of the work procedure.

Each development strategy covering major building components was critiqued using an appropriate technology assessment procedure sheet, as briefly outlined below. This critique approach assesses the skills and equipment used in a given development strategy against two major parameters: (A) Ecological Constraints and (B) Network Resources. The Network Resources in turn deal with the four primary network flows of information, money, materials, and energy. Depending on the depth to which a project can be taken, this critique process can become as quantitative as necessary. For example, it can be shown that if a cement development strategy were chosen, that per dollar increase in output, the cement industry is one of the highest users of energy and one of the lowest users of labor. On the other hand, clay fired products and wood products show much better ratios regarding both energy expenditure and use of more local labor skills. Other factors affecting choice of production means was the accessibility and quality of prime materials such as wood vs. masonry products. Since the Savanna was over-lumbered, wood




**A detail of Burnt Clay-Rice Husk Ash Cement is detailed as a more specific demonstration of this procedure.**



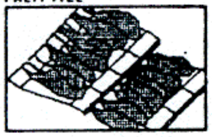



# ALTERNATIVE DEVELOPMENT STRATEGIES

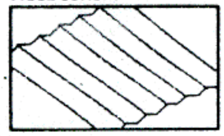
## ROOF

THATCH

PALM TILE

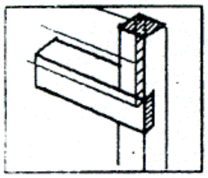


FIBER CEMENT

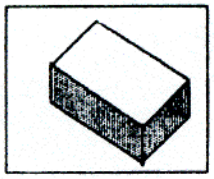


## STRUCTURE

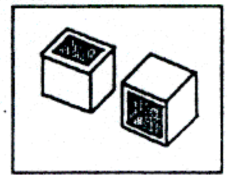
BALOON FRAME



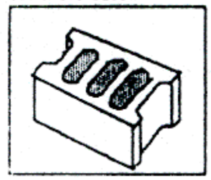
FIRED BRICK



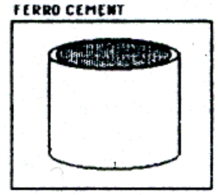
PRESSED BLOCK



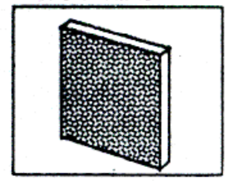
CONCRETE BLOCK



FERRO CEMENT

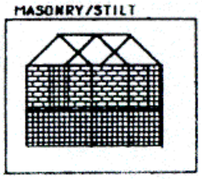


WOOD CHIP PANAL



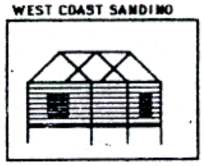
## CLIMATE SYSTEM

MASONRY/STILT

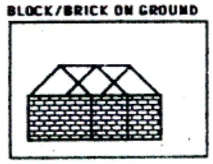


WOOD/WASTE STILT

WEST COAST SANDINO

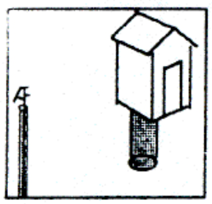


BLOCK/BRICK ON GROUND

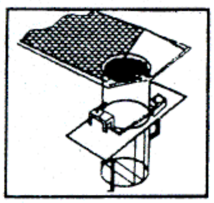


## WATER/WASTE WATER

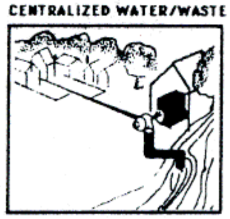
WELL/OUTHOUSE



CISTERN/SEPTIC TANK



CENTRALIZED WATER/WASTE



DEVELOPEMENT ALTERNATIVES

STRUCTURAL

**WOOD FRAME**

- WOOD
- TRANSPORT
- SAWMILL
- FUEL
- SIZING MILL
- FASTENERS
- PRESERVATIVES

**FIRED BRICK**

- KAOLINITE
- TRANSPORT
- SEPARATOR
- MOLDER
- KILN
- FUEL
- BRICK LAYERS

**PRESSED BLOCK**

- KAOLINITE V.AL.
- TRANSPORT
- PRESS
- LOW TEMP HEAT
- BRICK LAYERS

**CEMENT BLOCK**

- LIME/CLAY
- TRANSPORT
- KILN
- FUEL
- BALL MILL
- BAGGING/STOR.
- SAND/GRAVEL
- TRANSPORT
- WASHERS/SEIVES
- MIXING
- MOLDING

**FERRO-CEMENT**

- LIME/CLAY
- TRANSPORT
- KILN
- FUEL
- BALL MILL
- BAGGING
- SAND/GRAVEL
- TRANSPORT
- WASHERS/SEIVES
- COCONUT FIBER
- FIBER EXTRACT

**WOOD CHIP PANAL**

- LIME/CLAY
- TRANSPORT
- KILN
- FUEL
- BALL MILL
- BAGGING
- SAND/GRAVEL
- TRANSPORT
- WOODCHIP WASTE
- MIXING
- FORMING

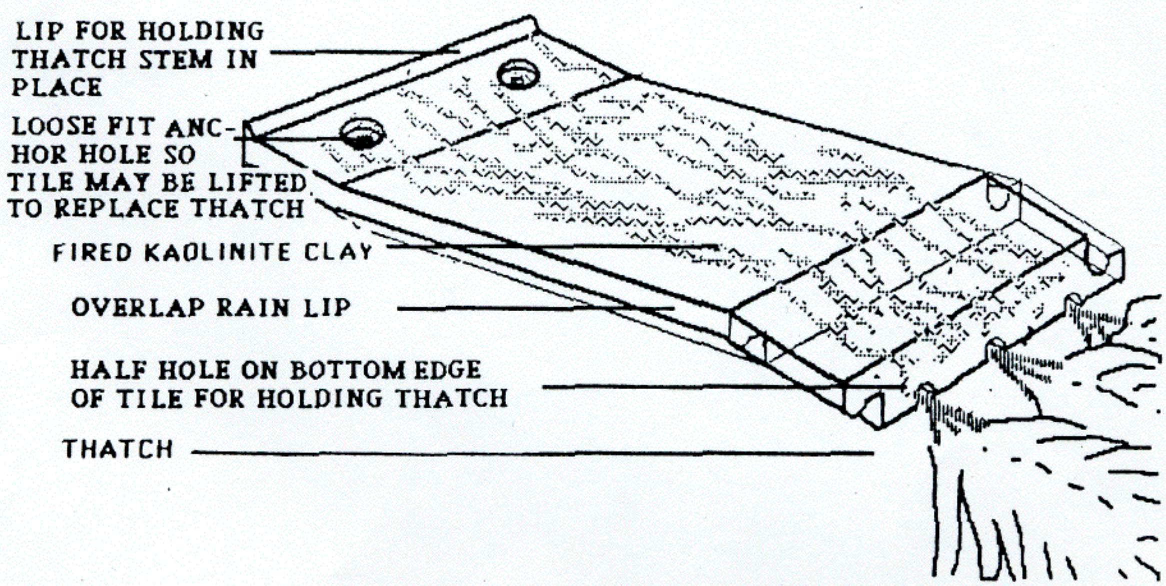
The final housing component choices are diagrammed below and are in response to this type investigation. Some back-up photographs are supplied to show where the project stood several months ago in Nicaragua. More detailed reports are available upon request. Please send for our publication list or inquire directly about this indigenous housing project.

This paper originally appeared in **Earth Systems Reporter**, No. 6, Fall '85 (Earth Systems Development Institute, Robert Proctor, Editor, 7921 E. Horseshoe, Scottsdale, AZ 85253).

ONE EXAMPLE OF STUDIES DONE SHOWING THE USE OF LOCAL SKILLS AND LABOR COMBINED WITH AN IMPROVED PRODUCT STILL TOTALLY BASED ON INDIGENOUS MATERIALS. IN THIS CASE A CLAY ROOF TILE USING A TYPE CLAY HISTORICALLY USED FOR POTTERY BY MISKITO INDIANS INCORPORATED INTO A SPECIALLY DESIGNED TILE THAT USES ANOTHER TRADITIONAL MATERIAL, THE PALM TO KEEP THE SUN OFF THE ROOF. THE PALMS CAN BE REPLACED SIMPLY BY LIFTING THE TILE FROM INSIDE THE DWELLING AND PLACING NEW STEMS AND LEAVES (EVEN TIED IN THE TRADIONAL MANNER). THE PROPOSED ROOF WOULD THEREFORE BE FIRE PROOF FROM WITHIN AND COOL DUE TO THE SHADING AND JUST AS IMPORTANTLY INCLUDE A MORE ADVANCED COMBINATION OF INDIGENOUS SKILLS.

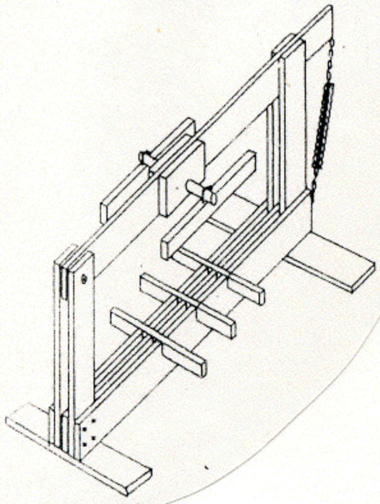
FIRED CLAY PALM TILE

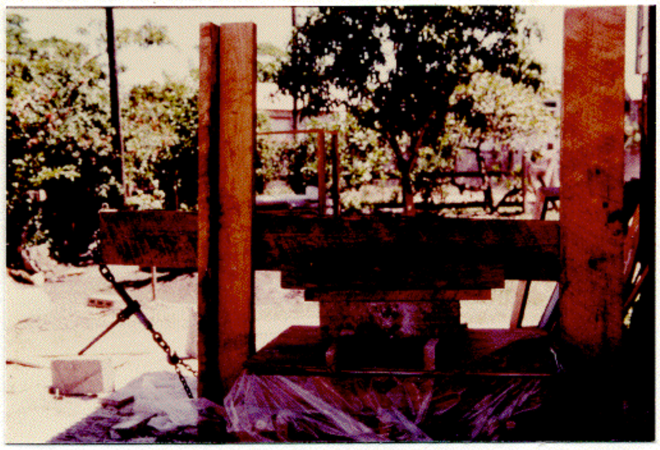
( THATCH IS REPLACABLE AND IS HELD IN PLACE BY WEIGHT OF TILE )



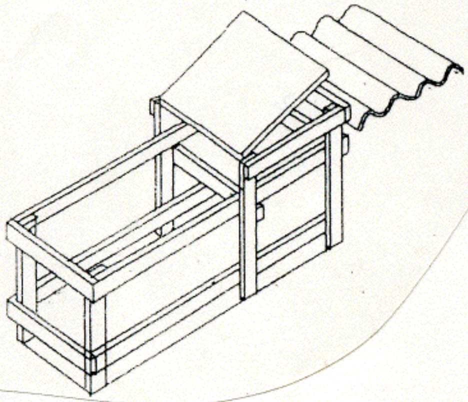
# SOME FABRICATION EQUIPMENT BEING TESTED

SAWDUST PANEL PRESS TABLE

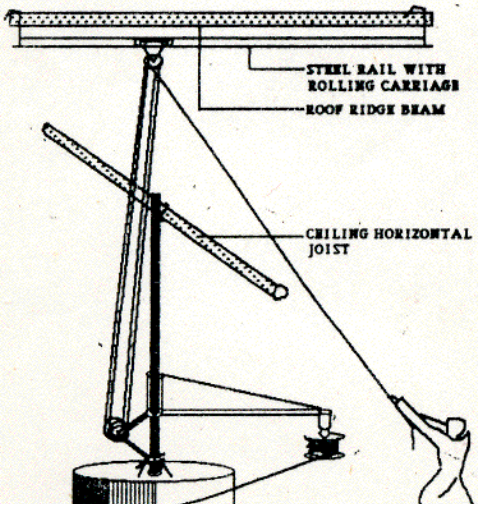


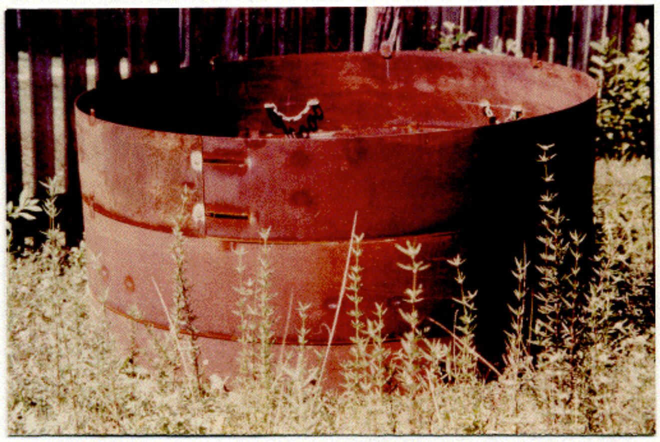


FIBERCRETE CORRUGATED ROOFING

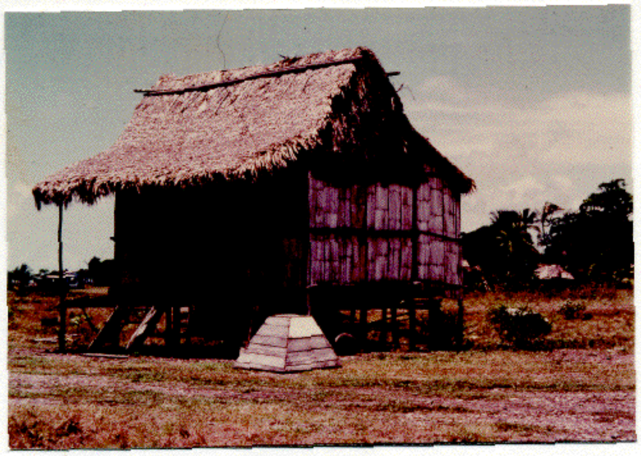


SLIP FORM FOR SEPTIC TANK /CISTERN

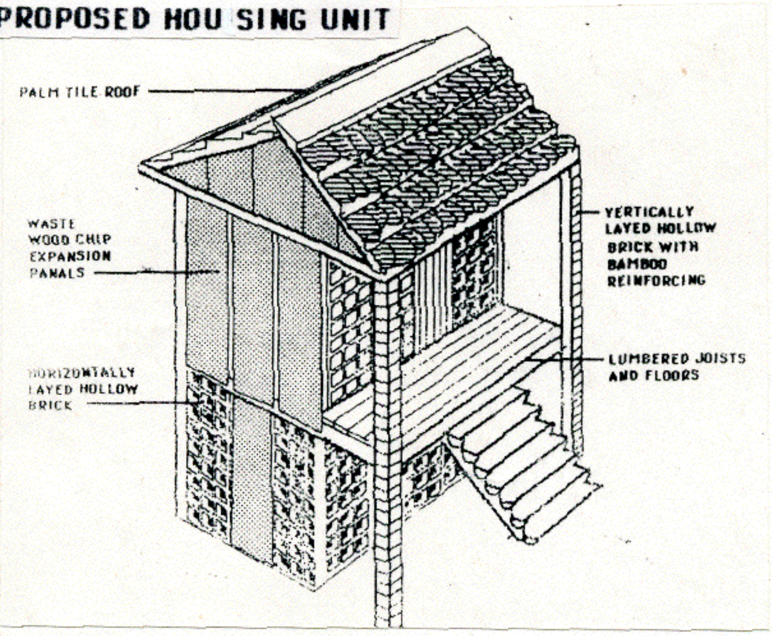


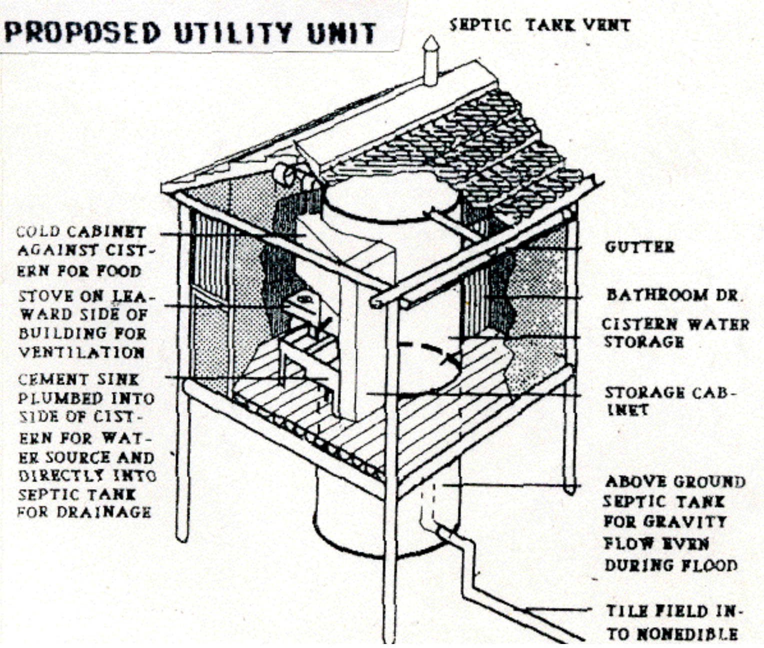
## INDIGENOUS HOUSE



## PROPOSED HOU SING UNIT




## PROPOSED UTILITY UNIT



## BIBLIOGRAPHY

Berg, Peter and Tukel, George. Renewable Energy and Bioregions: A New Context for Public Policy. Planet Drum Foundation. San Francisco, 1980.

Clements, Frederic E. and Shelford, U.E. Bio-ecology. John Wiley & Sons, Inc. New York, 1939.

Critchley, Michael. "A Conscious Politics of Austerity". 34 Bedford Square, London WclB 3ES, England.

Daley, Herman. Steady State Economics. W.H. Freeman, 1977.

Dansereau, Pierre. Biogeography: An Ecological Perspective. Ronald Press, New York, 1957.

Dasmann, R.F. "Biotic Provinces of the World". I.U.C.N. Occasional Paper No. 9. 1973.

Koenig, H.E., Edens, T.C., Cooper, W.E. Ecology, Engineering & Economics. Electrical and Electronics Engineers, Inc., Annals No. 503PR020, 1975.

Robinson, A.H. and Petchenik, B.B. The Nature of Maps: Essays Towards Understanding Maps and Mapping. The University of Chicago Press, Chicago, 1976.

Udvardy, Miklos D.F. A Classification of the Biogeographical Provinces of the World. I.U.C.N. Occasional Paper No. 18. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland, 1975.

Wilkinson, Richard G. Poverty and Progress: An Ecological Model of Economic Development. Methuen & Co. London, 1973.

Holdridge, L.R., Toxi, J.A. The World Life Zone Classification System and Forestry Research. Proceedings of the Seventh World Forestry Congress, Buenos Aires, Argentina, 1972.