The University of Calgary

INTEGRATED RENEWABLE ENERGY DEVELOPMENT IN RURAL NICARAGUA

by
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in partial fulfillment of the requirements for the degree of
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The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled Integrated Renewable Energy Development In Rural Nicaragua

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ABSTRACT

Integrated Renewable Energy Development in Rural Nicaragua

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Prepared in partial fulfillment of the requirements of the M.E.Des degree in the Faculty of Environmental Design

Supervisor: W.A. Ross

This Master's Degree Project reports on the findings of an analysis of the basic energy needs of the rural Nicaraguan cooperative Marcellino Guerrero and its surrounding communities. The study combined the application of the Soft Energy Path and Integrated Rural Energy System models of energy analysis with, emphasis on community participation.

An inventory of the study area was carried out to identify characteristics relevant to renewable energy resource development. This inventory included an ecological profile; demographic characteristics; occupational profile; economic activity; industrial capability and existing infrastructure(roads, schools communications, and transportation).

The study community presently relies on woodfuel for 90 percent of its energy consumption. The per capita consumption of energy was calculated to be approximately 32,500 MJ/year. This is equivalent to one seventh the consumption of industrial economies. Potential annual renewable energy resources within the community of 6,170 MJ/m2 of solar energy; 740 MJ/m2 swept area of wind energy; 208 GJ/ha wood biomass energy and 2,400 MJ of biogas energy were then identified. The community's basic energy needs, for low grade heat and electricity, were calculated to be approximately 2,330 GJ.

The study reported herein demonstrates that it is possible to meet the basic energy needs of the community using the available renewable resources. Through this investigation, three small scale energy technologies were identified as appropriate to meet the community's needs - a solar grain dryer; a fuelwood plantation and improved cookstoves.

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Finally, I thank the people of the Cooperativa Marcelino Guerrero, Nicaragua, especially the Jiron Cortez family. It has been an honour for Linda and I to have the opportunity to bear witness to the Nicaraguan peoples' revolution. Their struggle continues to be an inspiration to us and gives us hope for the possibility of a more just world.

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CHAPTER ONE: INTRODUCTION

1.0 PROBLEM STATEMENT

The problem addressed in this Masters Degree Project is the need to identify, within the Nicaraguan context, a replicable strategy for enhancement of sustainable energy resource use, in rural areas of the developing world. This strategy should help alleviate the non-sustainable use of energy resources. It should also reduce the dependence upon imported fossil fuels, which are in part responsible for the poverty of these rural areas.

In Nicaragua today, as in the developing countries(1) in general, the majority of the rural population lives in poverty. There is a critical need to improve the living standard of this majority. An important factor in this situation is the lack of sufficient quantity and diversity of energy supply, and the inter-related degradation of the environment. Energy resources are important because of the central role their use plays in the development of human society. "Food and warmth, transport and jobs, standards of living and future prospects all depend on society's ability to continue supplying itself with energy."(Foley, 1981) Environmental degradation is a growing concern in the developing countries. It is in large part caused by the over-exploitation of energy resources. An example of the relationship between energy and environment is tropical forest destruction. "If overharvesting [of tropical forests] continues at present rates, by the year 2000 some 2.4 billion people may be living in areas where wood is acutely scarce or has to be obtained elsewhere."(World Commission on Environment and Development (WCED), P.172, 1987) Nicaragua's forests are being destroyed at a rate of 2.5 percent annually, in part due to their over-exploitation to obtain fuelwood.(Hedstrom, 1985)

It is the rural areas of the developing world which are especially in need of energy. Developing countries have concentrated their efforts on large scale energy developments which often benefit urban areas and are detrimental to rural areas.(Flavin, 1986) In Nicaragua 57 percent of the people live in rural areas.(Central American Historical Institute (CAHI), 1987) The majority of these people are not reached by the centralized energy projects. Rural communities need energy to meet their most basic human needs. These include the provision of fresh water, the preparation of food and the drying of crops. Energy is also needed to develop primary processing facilities for the crops. As well, the standard of living in rural areas must be raised to stem the tide of immigration to urban areas ill-equipped to deal with the influx.(Flavin, 1983)

Most developing countries have no fossil fuel reserves. They rely heavily upon energy imports. In countries with an already extreme debt burden, energy expenditures are a severe drain on the economy. This dependence on foreign resources also puts developing countries at the mercy of international markets over which they have no control. Non-oil producing developing countries find the value of their exports continuously declining in relation to oil prices. Whereas the developed countries have been able to maintain their standard of living in spite of oil price increases, less powerful developing countries have not kept pace. For instance, in 1970 one bag of coffee (100 pounds) bought 100 barrels of oil. By 1983, it bought only about three barrels of oil.(Flavin, 1983)

Developing countries cannot rely upon additional fossil fuels to improve their energy balance. Fossil fuels are being consumed at an unsustainable rate and the exhaustion of supply, particularly of oil, is foreseeable. Hence, "a safe, environmentally sound, and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative."(WCED, P.15, 1987) In the following sections Nicaragua's present energy strategy will be reviewed along with aspects of the country's history relevant to the development of that strategy.

1.1 NICARAGUA'S PRESENT ENERGY SITUATION

Nicaragua is an excellent location to investigate solutions to the defined problem because it is vigorously pursuing an energy policy in favour of a sustainable energy future.(Manwell, 1986; Kuhn, 1983) In the early 1980's, the government commenced implementation of a two-pronged policy with the goal of energy self-sufficiency by the year 2000. That policy called for the development of abundant renewable energy resources both on a large and small scale. Government incentives were given for the development of small scale technologies such as grain dryers. (Personal Contact, Rafael Asevedra, Centro DINOT, Managua, 1988) International financial and technical assistance was sought to develop larger projects such as the 35 MW Momotombo geothermal station. This energy policy has been successful over the past nine years. (Manwell, 1986)

An examination of three factors can help explain this current disposition of the government. First of all rural Nicaraguans have a very limited access to energy resources. Second, continued dependence upon imported energy carries a heavy financial cost, and third, the security of access to foreign energy and technology has been shown to be precarious.

Nicaragua relies on wood for 50 percent of its energy consumption.(Manwell, 1986) The major portion of wood consumption is in the household sector. The majority of rural households have no access to electricity. The only energy sources available to them are animal and human energy to carry out the planting and harvesting, fuelwood and unenhanced solar energy for drying of crops.

Reliance on imported energy has brought to Nicaragua a heavy financial burden. (CAHI, Vol. 7, 1988) With a population of three million it carries a debt of six billion dollars U.S. (CAHI, Vol. 7, 1988) It's petroleum imports account for about 45 percent of its export earnings.(CAHI, Feb., 1988)

More recently, it has become apparent that a reliance upon imports can create major problems of security of supply. This is in part related to the lack of currency to pay for oil. However, more effort has had to be directed towards the maintenance of the country's existing electrical grid which has been a prime target of the Contra2 (e.g. power lines and sub-stations have been destroyed). With the U. S. economic embargo of Nicaragua it is now impossible to obtain parts for the deteriorating facilities. U.S. pressure has also effectively extended the embargo to other countries. For example, the country's major oil fired, West German built, power plant is more than 30 years old and in disrepair. The West German government will not allow the export of parts to Nicaragua to repair the plant. (Personal Contact, Chief Engineer, INE, Diriamba)

1.2 RELEVANT HISTORY

To successfully develop a strategy for sustainable energy use it is vital to understand three aspects of Nicaraguan history which I believe are relevant to the problem at hand. First of all the unique participatory style of democracy which has resulted from the Nicaraguan revolution is exploited in this study to advance participation and partnership in a sustainable energy project. Second, this study is set within rural Nicaragua. The present structure of rural society is a result of historical factors specifically related to land ownership. The ownership of the land by the people who make their living from it, facilitates their participation in achieving a sustainable energy future. Third, Nicaragua's emphasis on reaching self-sufficiency in energy is important to the success of this project. In order to understand where that motivation originates and what obstacles face achievement of that goal in the future, the recognition of the colonial history of Nicaragua is important.

One of the unique features of the Nicaraguan revolution is the participatory style of democracy which has evolved. The revolution which overthrew the dictatorship of the Somoza family in 1979 was in large part a result of the spontaneous efforts of the people of Nicaragua. (Lappe and Collins, 1985) Through years of repression, a high level of organization had been achieved. This organization, within all sectors of society, manifested itself in the formation of mass organizations3. The new government of Nicaragua recognized the importance of the mass participation of the population. The people continue to be democratic participants in the development of the country through these mass organizations.(Lappe and Collins, 1985)

For rural Nicaraguans perhaps the most relevant feature of the country's history is the displacement from the land. This began with the original shift from communal to private ownership of the land as a result of the arrival of the Spanish. The next major event which precipitated the concentration of the ownership of the land was the growth of agro-industry in the mid-1800's in response to the growth of the coffee export market in particular.(Berry, 1987) The trend of displacement from the land continued into the 1900's. In recent times, the growth of the cotton industry in the 1950's and 1960's intensified this trend. In fact much of the land confiscated for cotton was eventually controlled by the Somoza family.(Environmental Project on Central America (EPOCA), 1987)

One of the legacies of the dictatorship is a severe ecological crisis. The most severe problems of rapid deforestation, and excessive use of agricultural chemicals are a result of the historical patterns of land ownership.(EPOCA, 1988; Berry, 1987) Since 1979 the new government has overseen the return of millions of hectares of land to the landless campesinos of the country.(CAHI Vol. 6, 1987; CAHI Vol. 5, 1986; Lappe and Collins, 1985) Table 1 illustrates this trend showing land ownership before and after the revolution. The land has been entitled to the people in the form of individual plots and as cooperatives with the cooperatives being the leading agency for agrarian reform since 1979. Literature shows that the feeling of control over land is an important factor in communities taking the responsibility of sustaining the environment.

(Chambers, 1988; Bandyopadhyay and Shiva, 1988; Winterbottom and Hazlewood, 1987)

TABLE 1: LAND OWNERSHIP IN NICARAGUA BEFORE AND AFTER THE REVOLUTION

	(percent of cultivated land) 1978	1984
Private Ownership		
Over 500 manzanas*	41.2%	11.0%
200 - 500 manzanas	13.8%	12.0%
50 - 200 manzanas	30.0%	28.9%
10 - 50 manzanas	13.0%	8.3%
less than 10 manzanas	2.0%	2.6%
Credit and Service Co-ops		
50 - 200 manzanas	-	1.3%
10 - 50 manzanas	-	5.5%
less than 10 manzanas	-	3.9%
Production Co-operatives	-	8.2%
State Co-operatives	-	18.3%
TOTAL	100%	100%

* 1 manzana = 2.42 hectares

Lappe and Collins, 1985

As did the other Central American countries, Nicaragua developed out of a colonial experience. Nicaragua was originally colonized by the Spanish in the 1500's and later, as an independent contry, came under the influence of the United States. The United States military interventions into Nicaragua, beginning in the mid-1800's, increased the political and economic dependence of Nicaragua on the United States. These interventions continued into the 1900's and resulted in the installment of General Somoza as the dictator of the country in the 1930's. (Black, 1981) Political self-determination was gained in 1979 with the overthrow of the dictatorship. Since 1979, the government program to deal with the problems which were the legacy of the dictatorship has been severely jeopardized by the need to divert more than half of the budget of the country to fight the eight year old war sponsored by the United States.(Chompsky, 1987) It is this legacy of intervention which in part fuels Nicaragua's desire to plot a path of energy self-sufficiency.

The understanding of these aspects of history and energy policy in Nicaragua is important first of all because it provides a base from which to work when addressing the issue of energy needs, and second, in the effort to achieve the trust and confidence of the Nicaraguan partners in the study; a necessary prerequisite to effective community work.

Footnotes

1. In this document the definition of Developed and Developing Countries is the definition used by the Canadian International Development Agency. These countires are defined by the CIDA world map.

2. The Contra is the military force fighting to overthrow the government of Nicaragua. It is led by the army officers of the ex-dictatorship, and funded and organized by the United States.

3. Mass Organizations are grassroots organizations which were formed in the years before the 1979 revolution and continue to function today. They include organizations of teachers, women, youth, and communities.

CHAPTER 2: APPROACH AND OBJECTIVES

In this section three topics will be addressed. First, the conceptual framework, from which the approach to the problem is drawn, will be outlined. Second, the specific objectives of this study will be outlined. Third, the methodology, which transforms the conceptual approach to the problem into a concrete plan to meet the stated objectives, will be presented.

2.1 CONCEPTUAL FRAMEWORK

The conceptual framework is the enunciation of the theoretical perspective from which the problem at hand will be addressed. It is a general outline of the theory and literature which have shaped the approach to the problem.

The conceptual framework of this study is based upon the convergence, into the notion of sustainable development, of various concepts and social movements, which have developed since the 1960's. These include environmental conservation, appropriate technology, diversification and sustainable use of energy resources, and participation and education as requirements for development.

2.1.1 Conservation

Since the publishing of Silent Spring by Rachel Carson in 1962, the topic of environmental conservation has received increasing attention. Through the 1970's events

such as the 1972 U.N. Stockholm Conference on the Environment and the Club of Rome reports (Meadows et al, 1972; Mesarovic and Pestel, 1974; Tinbergen, 1976) highlighted the growing awareness of the inevitable ecological crisis. This concern was originally predominant in the developed countries, but has been increasingly recognized by the developing countries. The World Conservation Strategy recognized the global dilemma of "the combined destructive impacts of a poor majority struggling to stay alive and an affluent minority consuming most of the world's resources."(International Union for the Conservation of Nature and Natural Resources(IUCN), 1980) The World Conservation Strategy has been a catalyst for developing countries to articulate their own conservation strategies. Most recently, Our Common Future re-iterated this call for resource conservation. The World Commission on Environment and Development recognized that one of the major risks the world faces in future energy development is the global warming caused by the 'greenhouse effect'. The major contributing factor to this phenomenon is the burning of non-renewable fossil fuels.(WCED,1987)

2.1.2 Appropriate Technology

The concept of appropriate technology was first articulated in 1973 by E.F. Schumacher in his book Small Is Beautiful. An appropriate technology he defined as a technology which considers not only the technical and economic factors, but also the cultural, social, political and environmental factors which vary throughout the world. He proposed that technological advance in and of itself is not necessarily good. In his book Schumacher outlines a strategy to benefit the most dispossessed of the world, the rural third world poor. The concept of appropriate technology was his answer to the problem of the inability of modern technology, from the developed countries, to benefit the developing countries.(Schumacher, 1973)

Many authors such as David Dickson (<u>The Politics of Alternative Technology</u>, 1974) have expanded the concept of appropriate technology to the developed countries and in fact the argument is valid that all technology should be subject to some criteria of appropriateness. However, appropriate technology defined as a technology which benefits the most marginalized sectors of society in developing countries is the definition of interest to this thesis.

Harrison discusses the subject of appropriate technology in <u>The Third World Tomorrow</u>. He defines appropriate technology as "any technology that makes the most economical use of a country's natural resources and it's relative proportions of capital, labour and skills and that furthers national and social goals."(Harrison, 1983, P.140)

The <u>Handbook On Appropriate Technology</u> stresses the importance of the community level, non-technical factors, of appropriate technology. It states that appropriate technology should have "it's roots in the people and resources of a community."(Canadian Hunger Foundation, 1983, P. D1.8) Appropriate technology can fulfill the real needs of a community "because it arises from, or is adapted to, the human and material resources within the community."(Canadian Hunger Foundation, 1983, P. D1.8) The author states that "technology only determines what can be done, but values and attitudes are major factors in determining what actually will be done."(Canadian Hunger Foundation, P. D5.2, 1983)

Marilyn Carr emphasizes once again appropriate technology's priority for the weakest of society. She states that "..the fundamental objective of those who advocate A.T. is to enhance the economic position of the impoverished, and those who have not fully participated in the orthodox growth process."(Carr, P. xv, 1985) Carr also brings the concept of sustainable development into the definition of appropriate technology. She states that "the ultimate objective of A.T. is a sustainable system of production and consumption in which every member of society participates."(Carr, P.xv, 1985)

The Brace Research Institute is one Canadian institution where much work has been done in the field of appropriate technology. Lawand, Coffin and Alward define appropriate technology as "a tool, equipment, system or process which responds to a basic need of a group or community and is compatible with the human, material and financial resources of the society."(Alward, Coffin and Lawand, n.d.)

The interesting aspect of the latter definition is the inclusion of system and process. The early enthusiasm for A.T. after Small Is Beautiful resulted in the development of many "appropriate technologies". However, the success of these technologies was very limited in comparison to mainstream technological innovation. This led many people to go beyond what Jequier has called the 'hardware' of appropriate technology (tools, implements, machines, devices and equipment). He focused on the 'software' of appropriate technology. Software he defined as the "non-material dimensions of technology, e.g. knowledge, experience, organizational forms, managerial tools, institutional structure, legal provisions and financial incentives." (Jequier and Blanc, 1983).

This concern is mirrored elsewhere in the literature. In Experiences in Appropriate Technology the authors state that "in the 1980's as much emphasis has to be placed on developing strong local and decentralized organizations which can choose and implement the hardware as on developing the hardware."(Canadian Hunger Foundation, 1983, P. 2)

Substantial space in the Intermediate Technology Development Group's publication, Appropriate Technology, has been devoted to the software of A.T. People such as Marilyn Carr and M.L. Byram have explored the successes of technology introduction and dissemination techniques, including popular theatre.(Carr, 1985)

2.1.3 Diversification and Sustainable Use of Energy Resources

One aspect of appropriate technology which has received widespread attention, particularly since the oil crisis of the 1970's, is renewable energy technologies. Amory Lovins is perhaps the most well known advocate of the soft energy path. The soft energy path "combines a serious committment to energy conservation and to the rapid development of diverse, renewable, relatively flexible energy sources matched in scale, geographic distribution and energy quality to end use needs." (Elder, 1984) In contrast, the hard energy path "stresses the continued vigorous expansion of centralized high technology to exploit non-renewable energy sources. It is oriented toward increasing supply, especially of electricity." (Elder, 1984) Lovins, along with many renewable energy advocates, argues that because of the large amount of resources which have to be devoted to energy development, as well as the implications for society of the hard energy path versus the soft energy path, a choice has to be made for one or the other.

Lovins argues similarly to Schumacher that there are social, cultural, political and environmental reasons for choosing the soft energy path. He also argues that it is more conducive to democracy, less environmentally damaging, promotes self-sufficiency, and is better suited in scale and quality to the energy needs of society.(Lovins, 1977, 1982, 1989)

However, he also shows that there are compelling economic and technical arguments for choosing this path.(Lovins, 1982, 1989) For Lovins, "the energy problem is where to get the amount, type, scale and source of energy that will provide each desired service in the cheapest way. 'Services' are the physical end-uses sought (comfort, illumination, mobility, torque...). 'Cheapest' can refer only to internal costs or also to environmental and other external costs."(Lovins, 1989)

Just as an ecological system is less wasteful and more stable if it is diverse, so too, Lovins argues, a system of energy use is less wasteful and more stable if it is diverse.(Lovins, 1977) Lovins argues that renewable energy is end use oriented and therefore ultimately more efficient. It "circumvents the clumsiness of large scale single source strategies which have been likened to using a bulldozer to kill a fly or a chainsaw to cut butter." With the soft path, "each particular energy need is analyzed carefully before the possibilities are decided upon." (Todd and Todd, P.59, 1984)

The support for renewable energy alternatives has found application to the particular problems of energy development in developing countries also. As Flavin points out "the world's poor confront energy problems in immediate human terms - as a daily scramble to find fuel to cook the family's meal or heat it's home. The world's rural peasants and villagers use only a tiny share of the world's energy, and small additional amounts could provide large benefits."(Flavin, P. 245, 1983)

Much of the work of the Brace Research Institute is in the area of renewable energy alternatives for the developing world. According to Lawand of the Brace Research Institute, appropriate renewable energy technologies should be introduced to rural areas of developing countries through a program which includes funding of "interdisciplinary research efforts at the national and academic levels combining agricultural, engineering and social sciences skills in the development and enhancement of appropriate renewable energy systems for rural areas."(Lawand, n.d.) Furthermore, in a worldwide survey of village projects using renewable energy sources it was concluded that "what appears to be the greatest need is to develop a standardized, flexible, appropriate methodology of approach."(Alward, Lawand and Coffin, n.d.)

Specifically in Latin America, Szekely reports that in the rural sector of Latin America "a reasonable increase in the availability of energy could play an important role in improving the quality of life of rural inhabitants and in affecting agricultural productivity. It is in this sector that the greatest deficit of energy is found. ... and it is here that decentralized [renewable] energy systems could be widely used." (Szekely, P.2, 1983)

2.1.4 Participation and Education as Requirements for Development

The post-second world war development mentality which dictated that in order for development to take place, underdeveloped countries should follow the blueprint of the developed countries and become "westernized", was inherently a top down model. (Harrison, 1983) Theorists such an Rostow believed that developing economies would eventually reach a point of "take-off into sustained growth". (Harrison, P.23, 1983) Gradually, since the seventies, the bottom up model of development, emphasizing a basic needs approach to development and genuine participation, has gained legitimacy.(Brown, 1985; Harrison, 1983; Humphrey and Buttel, 1982) The national, bi-lateral and multi-lateral development organizations' continual increase of support to small, Non-Governmental Development Organizations(NGO's), which use a participatory approach to development, is acknowledgement of this fact.(Durning, 1989)

Perhaps the most well-known work concerning public participation and education is that of Paulo Freire of Brazil. His concept of conscientization was applied originally in Latin America and is now used throughout the world. (Mackie, 1981) It is particularly relevant to Nicaragua because Freire used the technique to develop the country's award winning literacy programme.(Miller, 1985) His concept of 'conscientization' is a 'dialogical'1 process of teaching people to read and write by having them reflect upon their reality in order to gain the confidence and understanding to change that reality. According to Freire any development process must involve "not psuedo-participation but committed involvement".(Freire, P.56, 1970) Freire believes that "every human being is capable of looking critically at his world".(Freire, P.82, 1970)

According to Freire, the development worker's role is to present an "organized, systematized and developed re-presentation to individuals of the things about which they want to know more."(Freire, P.82, 1970) In later work Freire expands some of these ideas on the importance of listening to the people. He believes that "attempting to understand peasants' discourse will be a decisive step in overcoming that narrow view of problems typical of the specialist."(Freire, P.70, 1985)

Following Freire's thought, Zachariah states that development workers "should resist the temptation to be benign technocrats who impose solutions on the people".(Zachariah, P. 74, 1986)

In simple terms, participation can be defined as a way "to make ordinary people responsible for their own well-being". (Goulet, 1989) Goulet recognizes a typology of participation which entails four aspects: (1)is participation a goal in itself or a means to a goal; (2)does it operate at the micro community level or the macro level regionally or nationally; (3) is the process initiated by government, a facilitator, or the community itself; and (4) at what stage of the process is the participation introduced? Goulet identifies three functions of participation. First, it guarantees the ethical treatment of the people for whom development is sought. Second, it mobilizes, organizes, and promotes grassroots action towards communities solving their own problems. Third, it is a channel to gain access from micro to macro arenas of influence. Goulet concludes that "participation is no panacea for development" but is "an indispensable feature of all forms of development". (Goulet, P.175, 1989)

There are hundreds of examples where grassroots groups, with membership perhaps in the hundreds of millions, have been able to achieve development at a community level. (Durning, 1989) Some of the more successful of these movements are Sarvodaya in Sri Lanka; the Base Christian Communities of Brazil;(Durning, 1989; Zachariah, 1985) the Kenyan Harambee (let's pull together) Movement; the Small farmers groups of Zimbabwe; The Chipko, or tree huggers of Uttar Pradesh, India; the Naam Movement of Burkina Faso, and the community organizations of Villa El Salvador in Lima, Peru.(Durning, 1989) The most important ingredient of these groups is the local momentum, initiative and control which organizing generates.(Durning, 1989) Durning concludes that "grassroots groups have capacity to tap local knowledge and resources, to respond to problems rapidly and creatively, and to maintain the institutional flexibility necessary in changing circumstances. Their agendas often embody sustainable development. They want economic prosperity without sacrificing their health or the prospects of their children". (Durning, P. 155, 1989)

In agreement with Goulet and Durning, The World Conservation Strategy also lists as one of its priority requirements "greater public participation in decisions concerning living resources". (IUCN, 1980)

2.1.5 Sustainable Development

These four preceding concepts were synthesized to some extent in the World Conservation Strategy (IUCN, 1980) and refined in Our Common Future (WCED, 1987). Our Common Future, represents a convergence of the major themes of environmental conservation and development into the concept of sustainable development. Sustainable development is defined as development which meets the needs of the present without compromising the ability of the future generations to meet their needs. The Commission's chairperson, Gro Harlem Brundtland, connects the concepts of environment and development very simply when she states in her foreword to the report that "the 'environment' is where we all live; and 'development' is what we all do in attempting to improve our lot within that abode". (WCED, P. xi, 1987)

The Commission recognized that "a safe, environmentally sound, and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative". (WCED, P. 15, 1987) The Commission was also very emphatic in its belief that for sustainable development to occur there is a need for "community knowledge and support, which entails greater public participation in the decisions that affect the environment...and giving communities an effective say over the use of these resources. It [sustainable development] will also require promoting citizen's initiatives, empowering people's organizations, and strengthening local democracy".(WCED, P. 63, 1987)

To summarize the above discussion, the methodology for this study is premised on the need to develop a sustainable energy strategy for a rural community based upon the following assumptions:

1. The concepts of conservation (i.e. diversity, self-reliance and sustainability) must be applied to renewable energy resource utilization.
2. Any applied technology has to be appropriate (i.e. consider the social, cultural, environmental, political, technical and economic reality within which it will operate).
3. Renewable energy resources must be developed to meet the objective of sustainability.

4. Meaningful public participation and education must be incorporated into the methodology to ensure the greatest opportunity for success.

2.2 OBJECTIVES

From the preceding discussion of the conceptual framework, the following specific objectives were outlined to address the stated problem.

1. Identify the basic energy needs of a selected rural Nicaraguan community.
2. Evaluate the renewable energy resources available to the community.
3. Match the basic end use energy needs of the community with the available renewable energy resources.
4. Select the viable renewable energy technologies to satisfy the community needs, utilizing the concepts of appropriate technology (i.e. sustainable development, self-sufficiency, social, cultural and political compatibility)
5. Facilitate public participation in the above process.
6. Incorporate an education process into the achievement of the above objectives.

2.3 METHODOLOGY

The study team consisted of the study co-ordinator and a Canadian field assistant, Linda Grandinetti. Linda has an education degree. She acted as interpreter for the first two months of the study and also brought experience in adult education to the study. It was hoped originally that one or two Nicaraguans would be available to work along with the study team, preferably students. However, due to the shortage of labor in the rural areas, it was impossible to find suitable people to participate. The study was carried out under the sponsorship of The Center for Education and Agrarian Promotion (CEPA). CEPA is a Nicaraguan NGO involved in human resource and agricultural development in rural areas.

The key element of the public participation process was the interaction of the study team with a commission made up of the study team and representatives of each of the five comarcas within the study area. Comarcas are the smallest political division in rual Nicaragua.(Klein, 1986)

The energy evaluation of this study utilized two energy evaluation tools. They were the Soft Energy Paths model developed by Amory Lovins and Friends of the Earth(Brooks, et al., 1983; Lovins, 1977) and the Integrated Rural Energy Systems model developed by INRESA members throughout the developing world, the United Nations University and the Brace Research Institute.(Kandpal, 1987; Lawand, 1986; Alward, Coffin, Lawand, n.d.)

The Soft Energy Paths model is a model employed to predict future energy requirements. Three aspects of this analysis make it unique. First, instead of energy forecasting, energy backcasting is employed. This means that the future goals of society are selected and from this, the quantity and quality of energy required is calculated. Second, energy needs are matched not just in quantity but also in quality, scale and geographic distribution to ensure an efficient use of the available sources of energy. Third, this analysis relies upon renewable resources and the use of sustainable sources of energy as opposed to the consumption of the energy capital, which the use of non-renewable resources entails.(Brooks et al, 1983)

The Integrated Rural Energy System was developed specifically for developing countries. This approach recognizes that there are more considerations for the suitability of an energy technology beyond the technical and economic considerations.(Ives, 1986) At least as important are the considerations of the appropriateness of the technology in terms of the cultural, social, and political fit of the technology to the society where it will be used. As well, this approach takes into consideration the effect of the technology on the environment and the degree to which a technology can enhance the self-reliance of a community.

This study is an opportunity to investigate to what extent these two energy analysis models can be combined, in a participatory process, to arrive at a valid community energy analysis. The INRESA model provides a framework for the inclusion of external, site specific factors in the selection of energy technologies. The Soft Energy Path model provides a rigorous energy analysis tool matching energy needs and available renewable energy resources.

The study was carried out in 6 steps. The following is an outline of those six steps.

1. Select the Study Location - The site was selected from the evaluation of various criteria which included stability of the area in relation to the war, isolation from the main electrical power system, strength of community organization, availability of data, and input from relevant development agencies.

Once the site was selected, there was a detailed inventory of the area. This included outlining the physical and natural environment in which the area is located.

2. Identification of the Basic Energy Needs of the Community - This was carried in consultation with the individuals and groups within the community. In particular it involved the representatives of the five comarcas within the community (The Commission). First of all the study team presented the proposal for the study to the community. The community was willing to form a partnership to go forward with the study, and work began. The study team was introduced and acclimatized to the community. Working with the Commission, the mechanics of the consultation process were elaborated.

A list a basic needs was derived from a community consultation involving individual interviews and general assemblies. This consultation was carried out with the aid of a questionnaire. A screening process, involving the Commmission, was used to develop a final list of needs for which energy was the critical factor in their acquisition.

3. <u>Identify and Analyze the Human Resources and Physical Infrastructure of the Study Area</u> - This information was important in the evaluation of the potential technologies for the community. It was collected predominantly at the local level through conversations with government officials, farmers, aid organizations, and other community organizations.

This included a demographic analysis including population, occupational profile and education levels; a profile of economic activity in the community, and the transportation and communication infrastructure of the community, and identification of educational institutions and educational opportunities available to the community.

4. <u>Identify Present Energy Use, Availability and Requirements</u> - The present energy use in the community was important to establish a base from which to work. This inventory included animal and human energy, fuelwood and electricity.

The available renewable energy resources had to be calculated in order to evaluate the potential technologies the community would be able to employ. The sources investigated included wind, solar, biomass, and water. This data was compiled from two sources. First, historical data on the site in question was available from government sources, aid organizations within the country, and international aid organizations. Second, data from similar sites was extrapolated to the study area. The basic energy requirements were calculated using the list of basic energy needs. The quantity of energy required to meet each need was calculated and the quality (i.e. low grade heat, mechanical, electrical, etc.) of that energy was also identified.

5. Selection and Evaluation of Alternative Energy Technologies - In this step the available renewable energy sources and technologies were matched with the end use needs. First of all the potential technologies to meet the energy needs were selected based upon their technical and economic feasibility. Second, these technologies were then evaluated to select those technologies for which technical assistance was available within the country. Third, using a list of criteria drawn up by the study team and the Commission, the remaining technologies were evaluated and they were assigned priority by the Commission. Fourth, the study team and the Commission outlined a strategy for acquisition of the technologies. This included identification of the sources of technical support within the country, related government agencies, and funding sources. It also included a discussion of the follow-up

tasks the community will have to undertake to further investigate various alternatives in consultation with the technical assistance agencies within the country.

6. Proposal of A Village Level Integrated Renewable Energy Development Methodology - Finally, a methodology was proposed for village level renewable energy resources development based on the experience gained in the implementation of this study. This methodology was based upon the work of the Integrated Rural Energy Systems Association developed by the United Nations University, the Brace Research Institute and the many Integrated Rural Energy programs operating throughout the world.

Footnotes

1. The words conscientization and dialogical are adapted from the Portuguese language of Freire's original writings in Pedagogy of the Oppressed.

CHAPTER 3: STUDY LOCATION SELECTION AND DESCRIPTION

In this chapter the process by which the Marcellino Guerrero Cooperative and its community were chosen for the study will be presented. First, an overview of the country will be presented. This will describe, in general terms, the three major ecological areas of Nicaragua. Second, details of the process by which the study location was selected will be discussed. This will include a review of the criteria used and the alternative sites considered. Third, the region in which the study area is located, will be examined in some detail. The ecological characteristics of the watershed in which the cooperative is located will be discussed. In addition, there will be a brief overview of some of the area's ecological problems which were relevant to this study. Relevant information concerning the human resources and infrastructure of the community, the department, and the country, will also be presented. This information will be used to evaluate the appropriateness of the potential energy technologies available to the community.

3.1 OVERVIEW OF THE COUNTRY

Nicaragua is the largest country in Central America. It has an area of 120,254 square kilometres. It is the least populated of the Central American countries, with a 1988 population of about 3.6 million and an annual growth rate of 3.3 percent. (CAHI, Vol. 8, 1989)

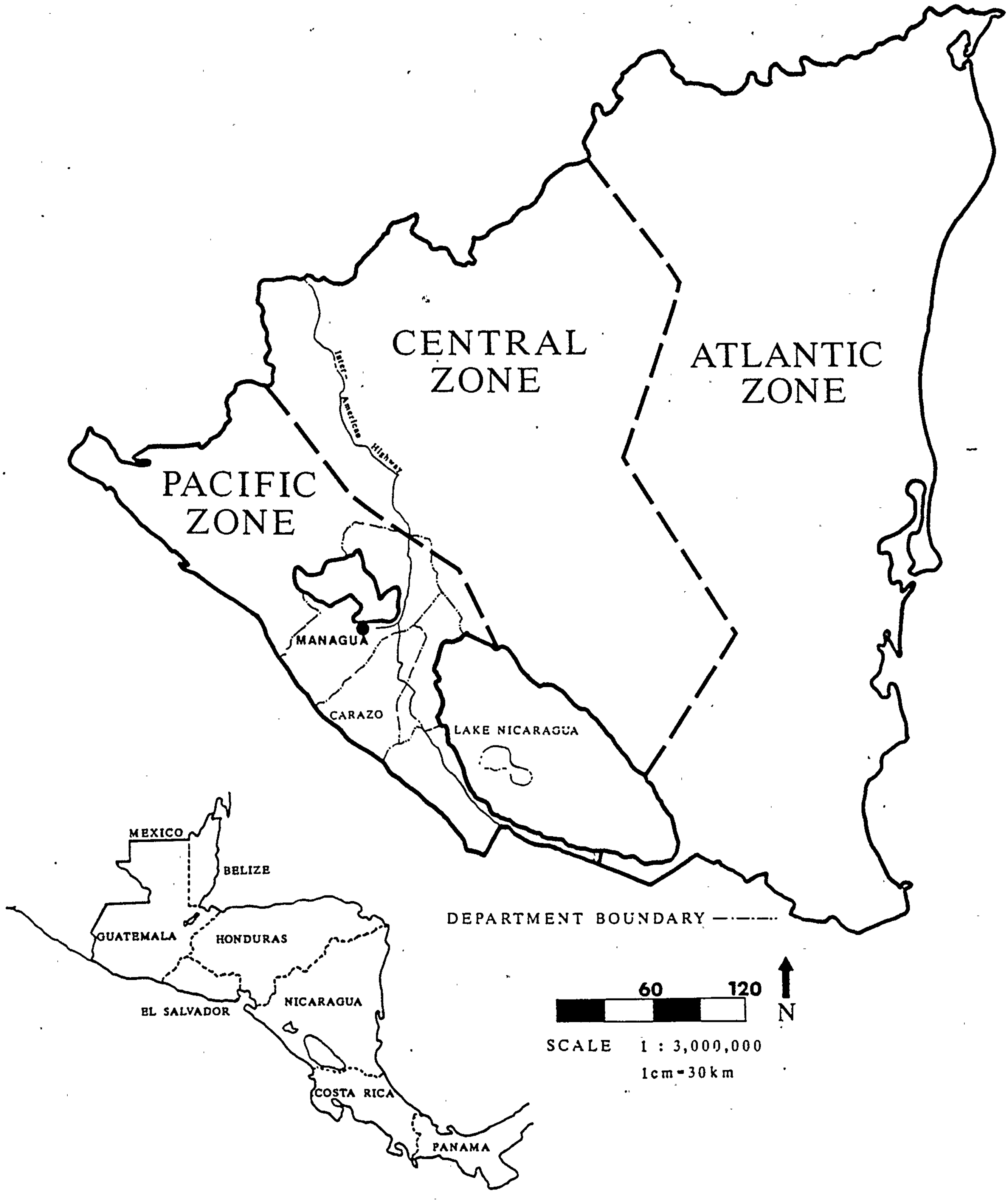
The country is comprised of three distinct zones.(Figure 1) The majority of the population lives in the Pacific Zone. With 63 percent of the population, it contains only fifteen percent of the national territory. The main products of the region are cotton, coffee, sugar cane and basic grains. The second zone, the Central Zone, contains 35 percent of the territory and 30 percent of the population. This zone's main products are coffee, basic grains and cattle. The third zone is the Atlantic Zone. This area contains 50 percent of the territory but only seven percent of the population and has remained relatively unexploited.(CATIE, 1986)

This study was undertaken in the Pacific Zone in a community approximately 70 kilometres southeast of the capital city of Managua, in the Department of Carazo (Departments are roughly equivalent to Canadian provinces). Refer to Figure 2 to locate the study area.

3.2 STUDY LOCATION SELECTION

The selection of the location for the study was based on a number of factors. The selection was made in consultation with CEPA. Six criteria were established for a suitable location. In the final analysis, all three potential locations satisfied three of the criteria. Evaluation of the remaining three criteria determined the final selection.

FIGURE 1: ECOLOGICAL ZONES OF NICARAGUA



First of all, within the chosen community there would have to be a perceived need for new sources of energy. Particularly in the short time frame of this study, it was felt that this was an important prerequisite. Otherwise, valuable time would be wasted attempting to point out to the community its need for energy. On a more basic level if there were no awareness of the problem in the community, it would be due to the fact that the community was focused on other more pressing needs and getting cooperation for some peripheral need would have proven very difficult.

The second criterion for location selection was that there be a strong community organization within the area. The objective of the study was to work closely with the people in identifying energy alternatives which could meet the basic needs of the community. It was considered beyond the scope of this project to work towards building the necessary community organization to cooperate with this project. An already established community organization was considered essential.

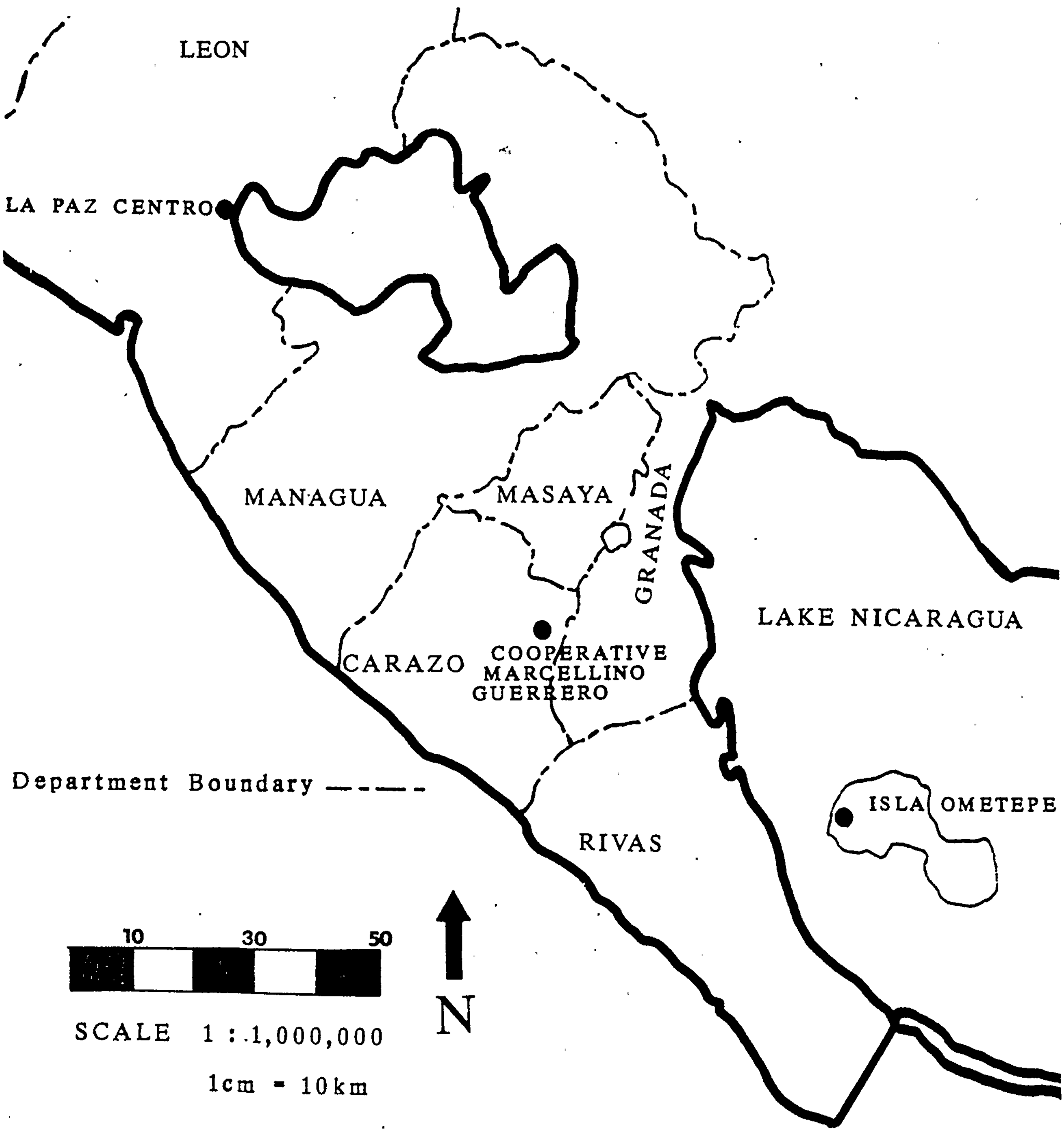
Isolation of the community from the main electrical grid was a third consideration for selection. It was felt that areas remote from the electrical grid generally have a greater need for energy development. As well, any area without electricity presents a more open disposition to accepting alternative forms of energy development. The areas of Nicaragua now without electricity from the grid also face long waits for possible connection because of the economic constraints on expansion brought on by the devastation of the war and priority needs of maintaining and re-equipping the present electrical capacity.

A fourth consideration was the accessibility of the area. With the constraints on the economy and infrastructure of the country, accessibility to many parts of the country is very limited. The study team would have to rely on public transport to travel between the study location and national government offices in Managua, and regional offices in other locations. In many areas of the country transportation is severely limited by the availability of buses, or road conditions. This is particularly true in the rainy season. Locating the study in an inaccessible area would severely curtail progress on the study.

With the reality of the war in Nicaragua, and particularly a war in which development projects are primary targets and foreign workers are not immune to attacks, the study would have to be located in an area removed from the danger of attack. Besides the obvious danger to people working in the area and residents collaborating with the study, transportation in and out of the area would be very difficult. There would be difficulty obtaining government data on the area. Also, the community would understandably be pre-occupied with more urgent matters.

Finally, the availability of data was considered in site selection. This included data on renewable energy resource potential as well as more general ecological and economic data of the area. Extensive measurement of parameters such as solar insolation, wood biomass density and river flows, was not feasible.

FIGURE 2: POTENTIAL STUDY SITES



These six criteria were used to select and later to evaluate three alternative locations for the project. The three alternatives were the island of Ometepe, in Lake Nicaragua, the Cooperative Marcellino Guerrero, in the Department of Carazo and the community of La Paz Centro, northwest of Managua. (Figure 2) All three communities were located in the Pacific Zone of the country. This zone is generally the least directly affected by the war and there has never been any fighting near any of the three locations.

In all three areas there was a perceived need for energy. The cooperative and La Paz Centro are both located in the region of the country most affected by deforestation and there is a consequent shortage of firewood. (Whelan, 1988) The island of Ometepe, does have a diesel electric plant. However, it is very old and in disrepair. The community has been actively seeking assistance to guarantee its electrical supply.

Differences were evident in the level of community organization. Ometepe and La Paz Centro both had strong leadership from government representatives but the base level community organization seemed to be lacking. The cooperative on the other hand, by virtue of being a collective, had a solid base organization. Unlike the other two alternatives, CEPA also had strong ties with, and knowledge of, the region where the cooperative was located.

Both the cooperative and La Paz Centro were quite easily accessible. They were close to Managua and their regional capitals where government offices are located. The transportation infrastructure of both areas was generally superior to that in most other parts of the country. It was possible to travel from either location, to Managua, any day of the week, within two and one half hours. In contrast, Ometepe was isolated because the ferry service to the mainland was unreliable. At times it would be a two day trip to Managua. Finally, all three locations were comparable with regard to data availability. Meteorological stations operate near each location and government sources of economic and biophysical data were available.

Based on evaluation of the criteria, the Cooperative Marcellino Guerrero was chosen as the best alternative for the study. Its main strengths were its level of organization and CEPA's familiarity with the area. The cooperative was a production cooperative. Ninety percent of the production of the cooperative was corn, with the bulk of the remainder being beans. Approximately 40 percent of the production of the cooperative was for local consumption. The rest was sold, usually to the state. The cooperative was formed in 1981 under the Agrarian Reform Law of the new government. It operates with approximately 40 members. The land is owned collectively, and credit and inputs are obtained collectively. However, each member farms, and receives the benefits of, his own plot of land.

3.3 STUDY LOCATION DESCRIPTION

To better locate the study area we can refer to a division of the country used by the Nicaraguan Natural Resources Ministry, IRENA. For planning purposes, the country has been divided into 24 major watershed areas. The study area is located on the western border of watershed seven, on the eastern slopes of the pacific mountain range. (Figure 3) This watershed encompasses approximately 125,000 hectares.

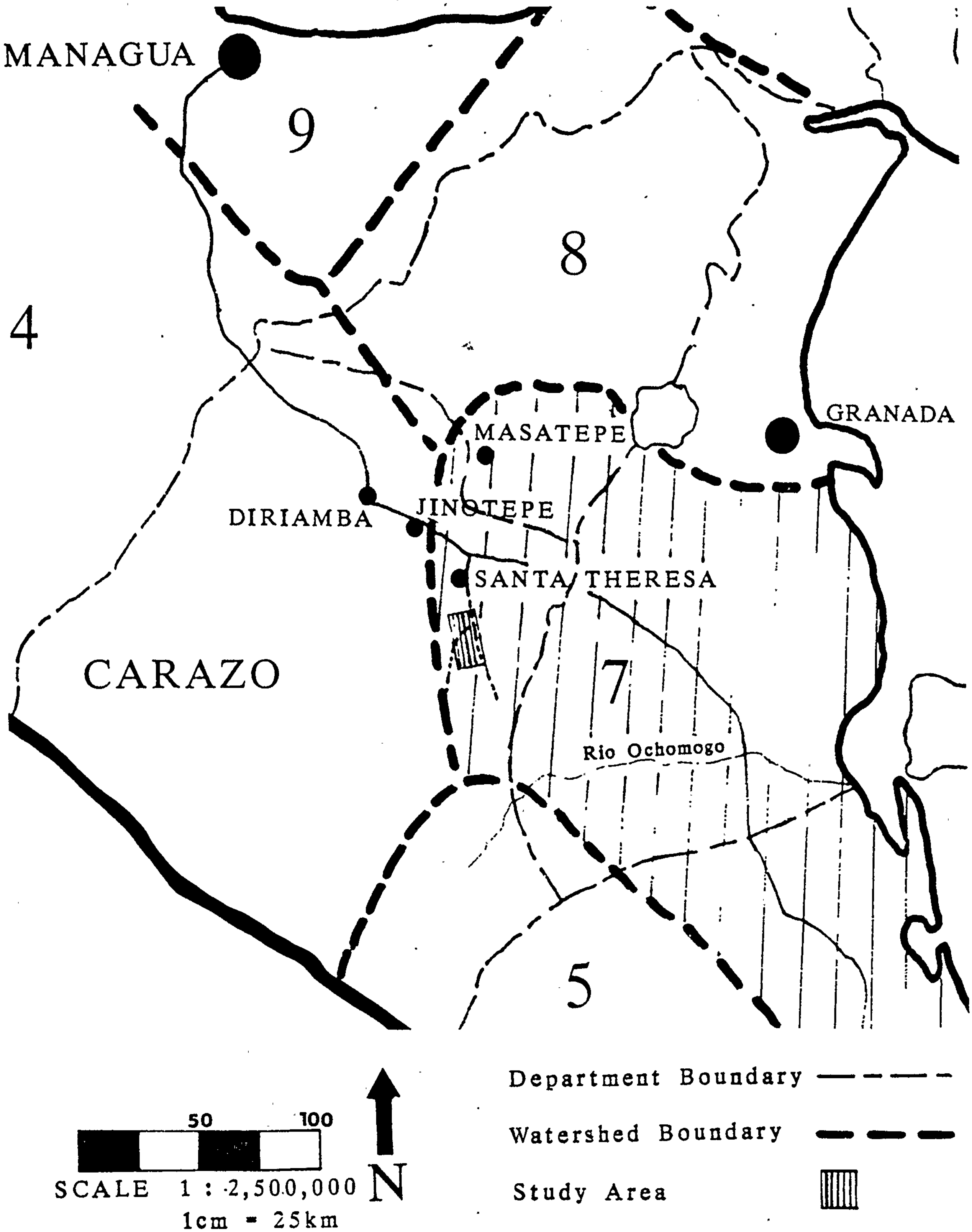
A further ecological classification of the country is one developed by L.R. Holdridge known as the Zones of Life. (Holdridge, 1982) These zones are classified according to mean temperatures, average rainfall and elevation above sea level. The study area has an annual average rainfall of 1,460 mm, an average temperature of 24.4 degrees celsius and is 200-300 metres above sea level. This puts the area into the zone known as Dry Tropical Forest.

3.3.1 Ecological Problems

The waters of watershed seven flow to the largest lake in Central America, Lake Nicaragua. (Figure 1) The major river of the watershed is the Rio Ochomogo which stretches 45 kilometres to Lake Nicaragua. (Figure 3)

The watershed has an alarming rate of erosion which deteriorates soil and water quality, and affects vegetation and fauna. Major regional studies of the watershed system have

FIGURE 3: WATERSHED 7 AND SURROUNDING COMMUNITIES



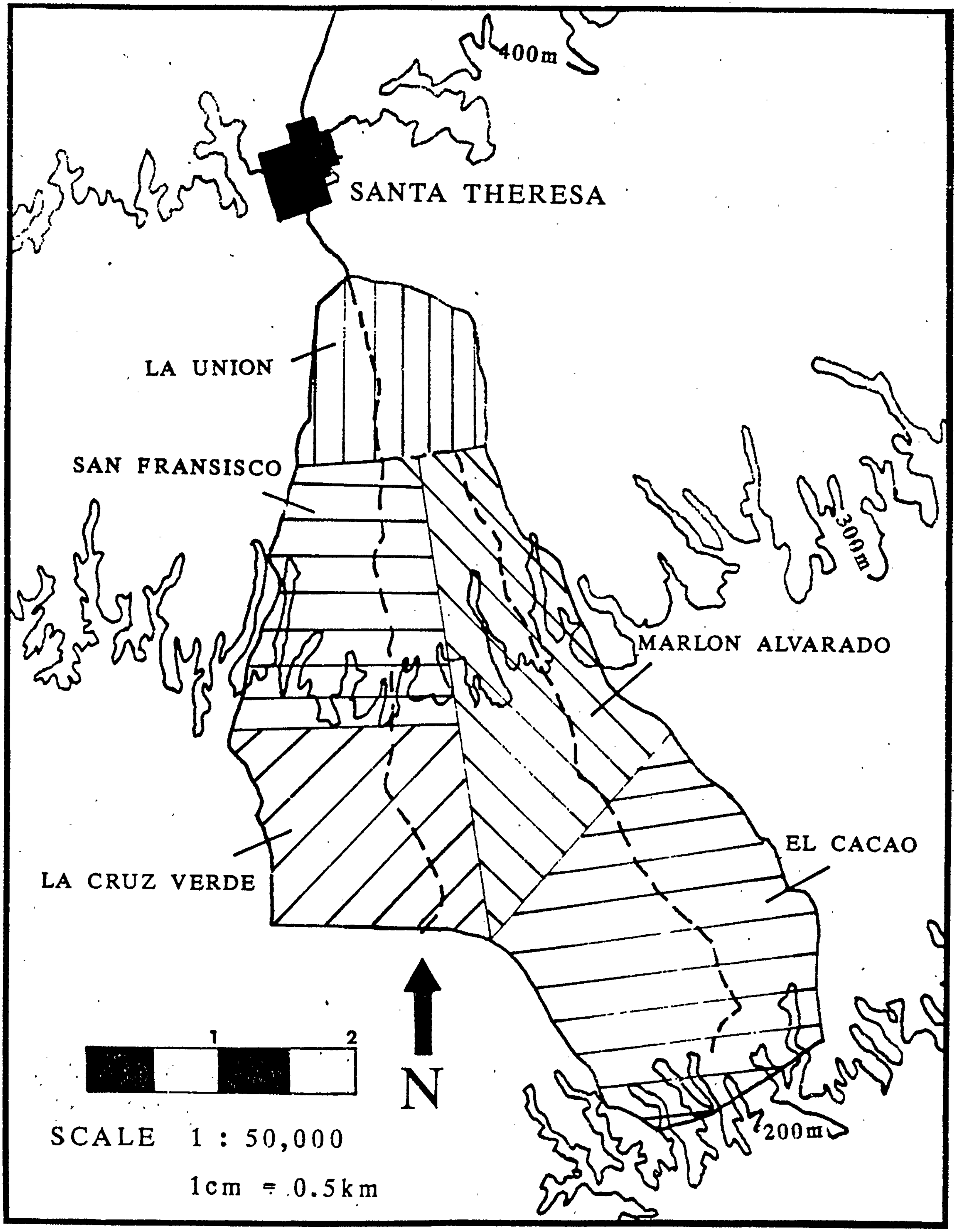
been carried out. (Whelan, 1988; IRENA, 1981; Schweibert, n.d.) One of these studies was completed on watersheds seven and eight. These two watersheds have a population of about 407,100 inhabitants and cover an area of 223,100 ha. Presently, within watersheds seven and eight, there are 170,000 ha without permanent vegetative cover. Half of this area is inclined greater than fifteen percent and one quarter is inclined greater than 25 percent.

The seriousness of the lack of cover is illustrated by studies which show that, where the inclination is greater than fifteen percent, the rate of groundwater drainage increases 60 percent with a change from forest to pasture and 40 percent with a change from forests to agriculture. (Schweibert, n.d.) The report estimations suggest that fertile land is eroded from these two watersheds at a rate of five million cubic metres per year.

Only fifteen percent of the surface area of these two watersheds remains forested. Thirty`two percent is now under intensive agriculture and 42 percent is pasture. This information helps to highlight the serious ecological problems of the area in which the study will take place. As will be shown, potential solutions to the fuelwood crisis of the study area will have a positive effect on these ecological problems.

Figure 4 contains a map of the study location itself. The boundaries of the study area will be the boundaries of five Comarcas where members of the cooperative live.

FIGURE 4: DETAILED MAP OF THE STUDY LOCATION



The five Comarcas which make up the study area are La Union; San Fransisco; La Cruz Verde; Marlon Alvarado and El Cacao. The total area of the study area is approximately 20 square kilometres.

3.3.2 Human Resources and Infrastructure

The human resources and infrastructure available within the Department of Carazo, as well as the major industries of the country are important to this study. Knowledge of what is available within the country will enable a better evaluation of energy technologies. Are they compatible with the structure of the community? Are there skills within the community to assist in the introduction and maintenance of these technologies? Are there capabilities in the Department, or nationally, to fabricate and maintain these technologies?

This section will include an outline of the demographics of the community where the study takes place. It will also include a discussion of the economic base of the community, education levels and the transportation and communications infrastructure available to the community. Finally, the relevant industrial infrastructure of the Department of Carazo and of the country will be reviewed.

3.3.2.1 Demographics

The Marcellino Guerrero cooperative is located in the Department of Carazo. The Department has a population of approximately 121,000. (CAHI, Vol. 4, 1985) The major city in the area is Jinotepe with a population of 40,000 people. It is approximately ten kilometres from the cooperative. The nearest urban center is Santa Theresa with a population of approximately 3000 people. It is approximately two kilometres from the cooperative. Figure 3 shows the region.

The rural area included in the study consists of five Comarcas from which members of the cooperative come. Table 2 shows the breakdown of the households and inhabitants of each of the Comarcas as well as the total for the five together. No data of the annual rate of population growth is available for the region but the national rate is 3.3 percent. (CAHI, Vol. 8, 1989)

TABLE 2: STUDY AREA POPULATION

Comarca	Households	Population
La Cruz Verde and San Fransisco	70	422
La Union and Marlon Alvarado	92	488
El Cacao	59	345
Total	221	1255

Source: Jinotepe Municipal Government

Age distribution data was not available. However, the study team observed that there was a higher average age in the countryside than in the nearby urban centers or the capital city of Managua, due to the migration of young people to the cities. The working age group of most Nicaraguan communities has been reduced because of Patriotic

Military Service, (SMP) or draft, to fight the war. This is true of the study area. Almost every family in the study area had one young person in the military at the time of the study.

3.3.2.2 Education

No hard data was available on the level of education for the community or the department. However, national figures can be used as an indicator of the education level. Table 3 shows the numbers participating in some form of formal education nationally.

Within the community of La Union there exist two primary schools (primary school is approximately equivalent to grades one to six in Canada) which provide instruction covering the first six years of schooling. Students have to travel to Santa Theresa to receive secondary schooling. Some of the members of the community are completing the final two years of secondary education (secondary education is equivalent to approximately grades seven to ten in Canada).

TABLE 3: PARTICIPATION IN EDUCATION

Education Level	Students
Pre-school	41,215
Primary	530,000
Middle	151,012
Higher	33,702
Special	1,587
Adult	242,587
Total	1,000,103

Source: Miller, 1985

Very few people have completed secondary school and there are no members of the community who have any formal education beyond secondary.

There is however a good opportunity to introduce the topic of energy into the schools. The study team review of some of the primary school text books indicated that the curriculum is geared toward the local rural agricultural community and the realities of life in Nicaragua.

3.3.2.3 Economic Activity

Once again there are no hard data on the occupational profile of the community. However, it is possible to make some generalizations from observations. The vast majority of the active male population is of course involved in agriculture. Occasionally women are involved also, but this is very rare. The majority of women work in the home. Their daily activites include childcare, cooking, washing and gathering firewood.

There are also peripheral economic activities within the community. Usually, within each Comarca there is a person who bakes and sells bread and other baked goods. There are also two supply posts; one in La Union and the other in El Cacao. These stores are run by women, out of their homes. They supply the basics consumed in the community including beans, rice, cooking oil and cigarettes. Occasionally, a selection of clothing will be purchased from the nearby towns and resold by the operators of the supply posts. Alternative crops such as vegetables are not commonly grown in the community. Some people do grow them however. At times there are surpluses sold within the community. Most of the men in the community are landowners but there are still agricultural workers whose only income is from working for another landowner.

In conversations with members of the Commission, people with two specific trades were identified within the community. These two trades are carpentry and masonry. Many of the members of the cooperative have carpentry skills, having built their own homes, storage buildings, etc. The Commission identified one mason in the community.

3.3.2.4 Transportation

The main modes of transportation are horse and ox-cart. Approximately 30 percent of the households have one or two oxen and approximately two-thirds of the households have a horse. There is bus transportation from the study area to Santa Theresa five times daily. A bus also serves the community for those who have to travel to Santa Theresa or Jinotepe. The bus makes five trips per day from La Union to Santa Theresa. Many people prefer to walk into town because they cannot afford even the minimal 70 Cordoba ($0.15CAN) fare for the bus. The trip from La Union to Jinotepe is approximately 45 minutes. Hourly bus service is available from Jinotepe to Managua, seven days a week.

3.3.2.5 Communication

There is no private telephone service in the community. The nearest telephone, telegraph and post office is in Santa Theresa. The service is very poor from the region and it is often difficult to call anywhere in the country.

3.3.2.6 Industrial Infrastucture

With Nicaragua having an almost exclusively agricultural economy, most of the industry which does exist is related to agriculture. As already mentioned there is no industry in the study area. Similarly, in Santa Theresa there is no industry at present.

Jinotepe does have some industrial activity serving the region and the country. In conversations with the regional representative of IRENA, and the municipal government, several industries were identified which could offer support to the development of renewable energy technologies in the study area.(Personal Contact, Aristides Rojas, Municipal Government of Jinotepe; Personal Contact, Pedro Marcenaro, IRENA, Jinotepe) Appendix 1 contains a review of the relevant industries identified within the Department of Carazo.

The survey of industrial infrastructure also included a more general survey of the largest industries throughout the country. This information was gathered from INE (The Nicaraguan Energy Institute). INE recently completed a survey of the largest companies in the country which together account for 80 percent of the country's industrial production. (Personal Contact, Silvio Teran, INE, Managua) This survey was done as part of a project to evaluate the energy conservation potential in Nicaragua's industrial sector. (Manwell, 1986) Analysis of this study revealed that the major industries within the country represent six of the International Standard Industrial Classifications. These classes are:

31. Food, Beverage and Tobacco Products.
32. Textiles, Clothing and Leather Industry.
33. Wood.
35. Chemical Substances, Basics, Soaps and Perfumes.
36. Cement and Concrete.
38. Metal Structures Products.

Classes 32, 33, 35, 36 and 38 represent the industrial infrastructure, within Nicaragua, which is available to support development of renewable energy technologies. Appendix 1 also contains a partial list of these industries.

CHAPTER 4: IDENTIFICATION OF COMMUNITY BASIC ENERGY NEEDS

The most important aspect of the methodology employed in this study was the participation of the community. The most important aspect of that participation was the identification of the basic needs. The approach taken in this study to identify the basic needs was based on the assumption that without a realistic, reliable identification of what the community believed to be its necessities, it would be very difficult to successfully introduce renewable energy technologies. Of the six community selection prerequisites, the requirements that there be a recognition of the problem to be dealt with and, that there be some level of community organization, were key to mobilizing community participation.

In this chapter, three stages of the search for the basic energy dependent needs of the community will be highlighted. First of all will be the review of how the project was introduced to the community. Second, the community consultation process will be explained. This consultation included the development of a questionnaire used to identify the needs of the community. This second stage will also include a discussion of how the consultation was carried out. Finally, from the needs list identified by the community, the process of analysis of that list, to arrive at a short list of energy dependent needs, will be explained.

4.1 INTRODUCTION TO THE COMMUNITY

Once the Marcellino Guerrero cooperative was chosen it remained for the study team to contact the cooperative and seek its interest. The introduction to the community was established through UNAG, the largest farmers and cattlemen's union in the country. UNAG has been a major catalyst to development of rural Nicaragua since the revolution. It is well respected by the cooperative movement. The UNAG delegate is also a member of an adjacent community and has a good working relationship with the cooperative. The contact with UNAG was facilitated by CEPA, which has worked with UNAG in the past.

It was considered vital to have the opportunity to carry out this study while living in the community. The project co-ordinator felt that two key objectives of the study team were first of all to establish a rapport with the people, and secondly, to gain the greatest possible understanding of the community. Given that the site visit would only be for four months, it was felt these two objectives could be accomplished only by living with a family and becoming involved in the community life beyond just carrying out the study (e.g. helping out with the planting and harvesting). The UNAG representative introduced the study team to the community and arranged accommodation with a family.

The next step was to present the project to the cooperative. It was suggested by the UNAG delegate that the most appropriate way to do this would be to speak to the total co-op membership at its bi-monthly meeting.

A presentation was made to the membership and after some discussion and clarification the co-op (with 30 of 37 members present) decided to accept partnership in the project. The study team presented the following objectives which were accepted by the membership.

1. Involve the community in the planning for its energy needs to enhance the possibility of success for the study.

2. Enhance community self-sufficiency and identify alternatives which make full use of the human, natural and infrastructural resources available within the community.

3. Plan to use the natural resources in a sustainable manner.

4.2 COMMUNITY CONSULTATION

Having initiated a partnership with the community, the next step was to design a consultation process to identify the most basic needs as perceived by the community. There were two distinct aspects to the consultation process. These were; (1)the household interviews; and (2)the Comarca general assemblies.

4.2.1 Household Interviews

Originally, the study team had anticipated that the Commission from the community would be set up at the initial meeting with the cooperative. This Commission would be the liason between the study team and the community. Then, through a consultation process with the Commission, the needs of the community could be identified.

However, it was acknowledged at the first meeting with the co-op that the time each member had available was restricted because, with the start of the planting, the time period of the study was the busiest part of the year for the members. It was agreed that the duties of liason of the community with the study team would be on an ad-hoc basis with each co-op member supporting the study with his time when necessary.

The president of the cooperative suggested that the best way to begin to investigate the needs of the community and introduce the project would be to meet as many people as possible in their homes. In this way the study team and the project could be introduced and the perceived necessities of the community could be discussed in an informal setting. The co-op members were also very interested in this approach as a path to greater community involvement, beyond the 37 families of the cooperative. A schedule was drawn up to visit two of the five Comarcas represented in the cooperative, over a two week period. Members of the co-op were chosen to accompany the study team on these visits.

A questionnaire was used during the household interviews. It was used as a tool to begin to understand the community and to gather as much relevant information as possible about the community. The study team felt it was necessary to find out about patterns of land ownership and crop types; how energy is used in the community; how work was divided among the family members, and what level of participation there was in the community and the cooperative. Therefore, the study team compiled the questions under the following four topic areas:

1. The land.
2. Use of energy.
3. Household chores and needs.
4. Participation in the community.

The first day of household visits was a trial period. The study team assumed that the interviews at each household were predominantly to introduce the team and the project to the members of the community. The questionnaire itself was designed more for the co-op member who accompanied the study team. However, the co-op members assumed that a more extensive interview in each household was planned.

Eventually these communication problems were ironed out and two questionnaires were used; one for the co-op member and one for the members of the households which were visited. The co-op member answered the more general questions about the comarca as well as the specific questions about his household. The members of each household were asked questions specific to their situation. During the first week of visits, as the study team gained experience, revisions were made to the questionnaires. Table 4 contains the final make-up of the questionnaires.

Table 4: Household and Coop Member Questionnaires

Questionnaire #1 - For Households

1. The Land
   - How do you dry your crops?
   - How many manzanas (1.431 manzanas/hectare) do you have cultivated?
   - What percentage of your crop do you lose because of insects, moisture, or fungus?
   - What type of crops do you plant?
   - How do you store your crops?
2. Fuelwood
   - How many people live in the house?
   - Do you cut your own wood?
   - If you cut your wood, where does it come from?
   - If you do not cut your own wood who do you get it from?
   - Where do you get your wood?
   - If you buy your wood, how much does it cost?
   - What type of trees do you use for firewood?
   - Do you plant trees yourself? For what purpose? What type?
3. Other
   - How do you spend a typical day?
   - What type of tools do you have available to you?
   - How many and what type of animals do you have?
   - What type of transportation do you have?
   - What are the biggest problems you have here in the community?

Questionnaire #2 - Additional Questions for the Coop Member

- Do you have a system of irrigation?
- What are your responsibilities as a member of the co-op?
- How many people live in the Comarca?
- Are there any workshops in the cooperative?
- What do you think you can do about the problem of firewood?

Through these visits the questionnaires were completed for each household and for each co-op member. A total of 40 households were visited over the two week period. A summary of the results of the questionnaires is presented in Appendix 2.

The study team was introduced to the family by a co-op member. The study team then explained the proposed project to the family. Before proceeding with the questionnaire, the respondents were asked if they would mind answering some questions related to the project. The questions were asked orally and in as informal a manner as possible to avoid intimidation. As much as possible, the questions were worked into the conversation and answers recorded afterwards.

4.2.3 General Assemblies

After the first two weeks of the consultation, most of the households in the Comarcas of La Union and San Fransisco had been visited. The study team felt that visits to every household were both too time consuming and unfruitful because not all members of the community were interested in the study. It was suggested at the second bi-monthly co-op meeting that only a sample of households be visited in the remaining three Comarcas. The members of the co-op still felt it was important to speak to all of the members of the community. The compromise arrived at was to hold general assemblies in each of the three remaining Comarcas.

The general assemblies were held over the second two weeks of the investigation. As time went on it became evident that the co-op member selected to organize the assembly in El Cacao was not interested in participating in the process due to poor health and a disinterest in the study. Therefore, only two assemblies were held in Marlon Alvarado and in La Cruz Verde. Both assemblies were well attended with representation from almost every household.

The assembly in La Cruz Verde was held in a recently built school which was vacant. After being introduced by the past president of the cooperative the study team and the project were explained to the assembly. A lively discussion of the problems in the Comarca followed.

It appeared that the major problem most people saw was the need for potable water. Two of the homes in La Cruz Verde had wells installed which supplied water daily but not enough for all of the Comarca. The closest source of water for most of the residents was in La Union, about two kilometres away. Due to a road rendered impassable because of heavy rains, this round trip could take up to two hours some days. The Comarca has tried to organize to obtain the materials to extend the water supply to La Cruz Verde but faced problems of poor organization, lack of funds and lack of materials (plastic pipe used to be manufactured in the country but with the war it was no longer possible).

Another problem cited by a majority of the people was the need for a teacher for the local school. A pre-school teacher was required for the more than 50 pre-schoolers in the Comarca.

A related problem was the aforementioned inadequate road. With the rainy season the road is often impassable, particularly for children. During the rainy season the road can also be a safety problem with the heavy flow of water making it very dangerous for young children. School days are often missed due to the condition of the road.

Also in this Comarca, probably the poorest in the community, malnutrition was more evident and the lack of food was seen as a problem. This problem is due in large part to the fact that there had been a drought in the past two years and to the affects of the war draining emergency resources (e.g. surpluses of grains usually available were depleted because much of the arable land in the war zones cannot be planted).

Finally, the fuelwood supply was also seen as a problem in La Cruz Verde, although less so than in other Comarcas. A greater percentage of people still have access to wood supplies but all believe that situation will change for the worse within one to two years. Three species of wood were reported as the most favourable for firewood: acetuna (scientific name not available), madero negro (Gliricidia sepium), and malinche (Delonix regia)

In the second assembly in Marlon Alvarado there was also representation from the majority of the households. Once again it was a lively discussion. Most of the attendees participated and were very interested in understanding the project. At times the discussion was not directed specifically to the question at hand, but to other topics of concern within the community. The community members appeared to enjoy the opportunity to discuss the issues. There were many questions of clarification of the project objectives and the concept of renewable energy. It was interesting to note that once some of the more astute members of the community grasped the concepts, they took on the role of explaining the concepts to the other members of the community more effectively than the study team, due to the language and cultural barriers.

The concerns expressed at this assembly differed from those of La Cruz Verde. Marlon Alvarado is lucky enough to have a supply of potable water and a good road to Santa Theresa. However, the firewood situation in this Comarca is much more critical, with practically no trees available to cut. It appeared to be the number one priority. Depending on the size of the family, estimates of usage ranged from two to six carretas annually (one carreta is approximately three cubic metres of wood). The species named as good firewood included Guacimo (Guazuma ulmifolia), Chocagua (scientific name not available), and Teca (Tectona grandis). The members of the community also pointed out alternative uses of some of the species. For example Teca leaves can be used to make a red dye. Finally, the people at this assembly were concerned about obtaining a school and teacher for primary and elementary grades.

4.3 SELECTION OF ENERGY DEPENDENT BASIC NEEDS

Through the consultation process, an original list of community basic needs was identified. Eventually, this original list was reduced to the final energy related needs. In this section the process employed to arrive at the final energy related needs will be outlined. First of all formation of a Commission which carried out the process will be discussed. Second, the original basic needs list garnered from the community consultation will be presented. Third, the analysis which was applied to arrive at the final energy dependent basic needs list will be reviewed.

4.3.1 The Commission

Following the first two weeks of consultations with individual households in La Union and San Fransisco the study team recognized two problems. First of all was the crossed communications between the study team and the cooperative. It proved difficult to co-ordinate activities with members of the co-op on an ad-hoc basis. Second, was the difficulty in reaching a concensus among the entire membership of the cooperative. At the general co-op meetings it was difficult for all members to come to agreement on any decisions regarding the study. The study team judged that it would be better to set up a small group representing the community which could work closely with the study team.

The study team suggested that a Commission consisting of the study team and three members of the community be formed to oversee the project. The three members should be from the household sector, the farming sector and the past or present president of the cooperative. The co-op members suggested the Commission include two members from each of the five Comarcas. A concensus was reached for the Commission to be made up of the study team, one community member from each of the five Comarcas and the past and present presidents of the cooperative with at least two of the five Comarca representatives being women. The request for participation for women was made by the study team to ensure that the perspective of the homemakers was considered. This was important because so much of the energy usage was related to women's duties in the home. This was readily accepted by the co-op membership.

It was agreed that the Commission would serve to:

1. Discuss the progress of the investigation and matters relating to the study in a formal and regular manner.

2. Give the members of the community the opportunity to question the study team about the progress of the investigation.

3. Be a group which the study team could consult on questions which arose concerning the study, and for decisions which would have to be taken.

The Commission representatives were chosen at the meeting. Two female representatives from La Union and San Fransisco were later asked to join the Commission and they agreed. It was agreed that the Commission would meet every two to three weeks.

4.3.2 Make Up of The Commission

Pablo Jiron Cortez, the past president, is 22 years old. He organized the community to take advantage of the agrarian reform in 1980 when he was fourteen. He has more knowledge of the operation and history of the cooperative and the agrarian reform than any other member of the community. Pablo also takes a strong position supporting the attempt to diversify involvement in the project - not to restrict it to co-op members. This is important, given the objective of the study to involve all of the community.

Antonio Lopez Vega, the current president of the cooperative is also very young, in his late twenties. He has the most expertise of any member on the current operation of the cooperative. He is also one of the better educated members. He is enrolled in the last year of high school. It was important for the credibility of the study that Tono and Pablo were supportive of the study.

Fransisco Cortez Delgado was the representative from Marlon Alvarado. He does not have the formal education of some of the other members of the Commission. Through his participation in the cooperative he has shown a strong interest in and committment to the cooperative. He also showed an interest in the project, particularly the issue of reforestation.

Anselmo Cortez and Jose Felix Munoz were the representatives from El Cacao and La Cruz Verde respectively. They are more senior members of the community. They were among the more outspoken members in the regards to the functioning of the cooperative. In particular, they were very involved in the discussions of the study. At times they expressed valuable critique of the study during discussion of the process of the study. (e.g. how to conduct the community consultation process)

Ayaleht was the representative from San Fransisco. She has been one of the most involved members of the community over the past ten years. Since the age of nine she has worked in the revolutionary movement. Therefore, she has experience dealing with many of the regional government departments and mass organizations. Her knowledge of all of these groups was very valuable.

Finally, Nora Jiron Cortez, the representative from La Union, is nineteen years old. She is also one of the better educated members of the community, presently completing her final year of studies before university. She has an interest in the sciences and was able to understand quite readily the concept of renewable energy and the measurement techniques used in the study. Ayaleht and Nora are also non-members of the cooperative and thus represent wider interests of the community outside of the cooperative.

The Commission thus represented a wide cross-section of the community. Age groups from late teens to fifties were represented, as were all five Comarcas; men and women and members and non-members of the cooperative.

4.3.3 Generation of the Basic Needs List

With the information obtained from the individual interviews and the general assemblies, the study team compiled a list of the basic needs as identified by the community. At this stage there was no preliminary elimination of needs. All of the needs expressed through the consultation process were included. The following is the list which was compiled.

1. Storage of Crops.
2. Drying of Crops
3. School and teacher for Marlon Alvarado.
4. Electric lights.
5. Health Centre.
6. Transportation to Santa Theresa.
7. A Business to Create Work.
8. Potable Water for San Fransisco and La Cruz Verde.
9. Fuel for Cooking.
10. A Teacher for La Cruz Verde.
11. Food.
12. Child Care Facilities.
13. An Upgraded Road for La Cruz Verde and San Fransisco.

4.3.4 Commission Review of the Basic Needs List

The original basic needs list was presented to the Commission for review. Each of the thirteen needs was reviewed and all were accepted as valid by the Commission. In addition, two other points were raised. First of all was the question of transportation. This was raised in relation to the operation of the cooperative. The point was made that the co-op needed a small truck for transportation of seeds, produce and people for co-op business in Santa Theresa and Jinotepe.

The second point raised was the need for agricultural machinery for the cooperative, specifically, a tractor. The members felt that with a tractor the work load could be decreased and more available land could be cultivated to boost production. The final list of the basic needs of the community now included fifteen points.

4.3.5 Selection of the Energy Dependent Basic Needs

The study team then analyzed the list of fifteen basic needs. While most of the items were in some way dependent upon energy, it was evident that energy was not the critical factor for the acquisition of many of these necessities. The study team divided the list into three categories. There were those needs for which energy was a critical component, those with which energy was a contributing factor but some other factor was critical, and those which were basically unrelated to energy. Table 5 shows the categories. Only those basic needs where energy was the critical factor were considered for the final list of energy dependent needs.

Table 5: Relation of Basic Need to Energy

CRITICAL	CONTRIBUTING	UNRELATED
crop drying	crop storage	health centre
cooking	transportation	schools
electric lights	industry	child care facility
potable water	road upgrading	agricultural equip.
	food	teachers

The most obvious points which were eliminated were the teacher and school for Marlon Alvarado, the teacher for La Cruz Verde, and the health centre. Energy is useful or even necessary for schools and health centres, but the labour and materials required are the critical components. Finding a teacher has very little to do with energy. Similarly, the upgraded road for La Cruz Verde and San Fransisco is more dependent upon equipment and labour than energy.

The creation of secondary industry is also a much bigger question than simply a supply of energy. Although energy is a very important component for secondary processing, for example, there are many more inputs required which put this need outside the scope of the study. The provision of transportation and agricultural equipment is essentially a question of the necessary capital to purchase the equipment. These needs were also dropped from the list.

The problem of crop storage is one which is very dependent upon energy sources. However, it was felt by the study team that there were also other substantial components to a crop storge system which could not be dealt with through this study. Hence, it was also dropped from the list.

The need for more adequate supplies of food is a multi-faceted problem. However, one aspect of food supply which was within the scope of the study was the improvement of drying techniques. Thus, food does not appear on the final list but is considered to be partially dealt with under crop drying.

Finally, the need for potable water was dropped from the list. While energy can certainly be a critical factor in the acquisition of water supplies (e.g. wind turbine pumping of sub-surface water reserves) the study team judged that in this case the most economical alternative to bring water to La Cruz Verde and San Fransisco was to make use of the artesian well in Santa Theresa with an extension of the pipeline. Hydrological data from the area indicated that the present well in Santa Theresa had sufficient excess capacity to service La Cruz Verde and San Fransisco.(Personal Contact, Luis Campo, Nicaraguan Institute of Aqueducts and Sewers(INAA), Jinotepe)

The final list of energy dependent basic needs is shown in Table 6.

Table 6: Final List of Energy Dependent Needs

Need	Type of Energy Required
1. Crop drying.	low grade heat
2. Electric lighting.	electricity
3. Fuel for Cooking.	low grade heat

4.4 EVALUATION OF THE CONSULTATION PROCESS

Overall, the consultation process worked well. Through the visits to individual households and the general assemblies the study team was able to get high degree of participation and input from the whole community. However, there were problems which arose in the process.

First of all, after the first day of visits to individual households it became evident that the word 'energy' ('energia' in Spanish), meant electric lights to the majority of the people interviewed. The study team adjusted its approach in an attempt to better explain the concept of renewable energy in terms of where the energy source originates and the possible technologies which could be used to harness it. Given the communities' understanding of 'energy', the study team elected to clarify very strongly that it was beyond the scope of this project to bring lights to the community. To avoid undue expectations of the study, the study team decided to avoid the topic of electricity during the field portion of the study. That topic was only considered from a technical and economic viewpoint in this final document.

A second problem encountered was the difficulty in designing a questionnaire at the start of the study. This difficulty was mostly due to the fact that the study team was new to the community and was still at the stage of learning about the community when the questionnaire was administered. As a result, the questionnaire was not as valuable as it might have been if employed when the study team had a better understanding of the community.

A third related problem was that it was not possible to hire a member of the community to work full time with the study team as had originally been hoped. The situation in Nicaragua is such that with the war, many of the able bodied people of the community are serving in the army. Thus, there is a shortage of labour in the rural areas. Having a member of the community on the study team would have made acclimatization to the community much easier. In particular it would have helped in developing and administering a questionnaire.

Fourthly, the visits to individual households were productive but the general assemblies were necessary to obtain some kinds of information. Visiting individual homes proved to be time consuming. It was also difficult to command the attention of the members of the households at times because they were busy with other chores. Also, with daytime visits, one or more adult members of the household were often not available. The general assemblies were a less intimidating atmosphere for the people. They appeared much more willing to express opinions in the assemblies. Finally, in the household visits it was much more likely that the women of the household were at home during daytime visits. This provided an unbalanced sample for the questionnaire.

CHAPTER 5: PRESENT ENERGY USE, AVAILABILITY AND REQUIREMENTS

In this chapter, the energy data which will be required to evaluate the potential technologies available to the community will be presented. First of all, the survey of energy use in the community will be reviewed. Second, the available renewable energy resources will be presented. From various data sources information was gathered which allowed the calculation of estimates of the total renewable energy available to the community from all sources. Third, this chapter will present the calculations of the community basic energy needs. From the previous chapter the energy needs of the community were identified descriptively. In this chapter the quantity of energy required to meet those needs will be calculated.

5.1 ENERGY USE AT PRESENT

One of the main tenets of the Integrated Rural Energy System model is that you must obtain a base from which to evaluate the energy needs of the community. (Lawand, 1982) That base is an evaluation of present energy use. With this information the level of resource use can be ascertained, present technologies can be identified and conservation measures can be proposed. Table 8 contains a summary of the present energy use in the community.

5.1.1 Human and Animal Energy

This primary source of energy is often overlooked, but in the many Nicaraguan communities near the subsistence level, this form is of vital importance. Without any mechanization in the community, human and animal energy is

TABLE 8: SUMMARY OF PRESENT ENERGY USE FOR THE COMMUNITY

		Energy Output				
Energy(1) Source	Power(6) Available (watts)	Daily Individ. (MJ/day)	Yearly Individ. (MJ/year)	Yearly Community (GJ/year)	Yearly/ Adult (MJ/year)	Percent Yearly (%)
Humans(1)	100.0	1.8	540.0	358.0	540.0	1.7
Oxen(2)	200.0	3.6	900.0	66.6	100.5	0.3
Horses(3)	500.0	3.6	900.0	132.3	200.0	0.6
Sun(4)	400.0	--	--	1,146.0	1,730.0	5.3
Wood	--	241(7)	87,965(7)	19,440.0	29,321.0	90.2
Diesel(5)	10,000.0	1,126(8)	--	411.0	619.0	1.9
Total				21,553.9 (6.00 Gw-hr)	32,510.5 (9050 kW-hr)	100.0

Industrial Economy/Capita Consumption 61,320 kW-hr(9)

(1) Assumes 3 adults/house, each adult human works 5 hrs/day, 300 days/yr

(2) Assumes 74 Oxen. Oxen work 250 days/year, 5 hrs/day.

(3) Assumes 147 horses. Each horse works 250 days/year, 2 hrs/day.

(4) Assumes an average of 400 W/m2, a 12 hour day, with the bean crop drying for three days over a 100m2 area per household.

(5) Assumes 5 trips/day for one bus, 30 km round trip, at 4.25 km/litre, operating 365 days/year.

(6) Source: Steinhart, 1974 (7) per household (8) MJ/community/day

(9) Source: WCED, 1987

the only energy source available to maintain the agricultural system. The people plant the seeds, hoe the weeds and pick the crops with the help of animals.

The study team observed that many households, perhaps one-third, have one or two oxen to help prepare the fields for planting and to assist in the gathering of the harvest.

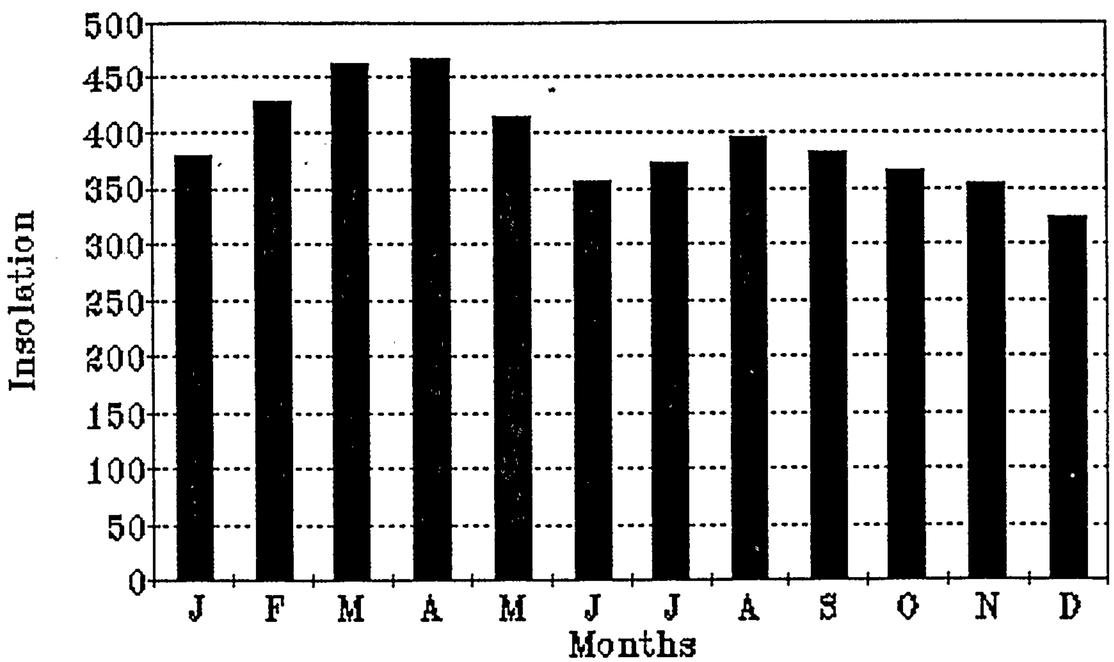
In the transportation sector, horses are the most common form of transport for travelling to and from the fields and back and forth to town. The study team estimated that two-thirds of households have a horse. Ox carts are also used for this purpose, particularly when there are heavy loads to be transported.

Bicycles are visible in the community and their use is being promoted. (El Nuevo Diario, June, 20, 1988) The study team observed two people using bicycles for transportation to and from Santa Theresa on a regular basis. One other person uses a bicycle with a portable cooler to travel through the community selling ice cream. However, to date bicycles are a minor contributor to the transportation picture.

5.1.2 Solar Energy

At present solar energy is used in its most basic form. The bulk of the crops are sun dried. No technologies for enhancing energy from the sun are employed. The corn crop is dried in the sun on the stalk before harvesting. The bean crop is harvested and dried by spreading it on the ground, initially right in the fields and later patio style nearer the homes. Figure 5 shows the available energy from the sun ranges from 323 J/square metre/sec in December to 467 J/square metre/sec in April. During the important periods for drying crops in August and November the solar energy available averages 396 J/square metre/sec and 353 J/square metre/sec respectively.

FIGURE 5: AVAILABLE SOLAR ENERGY
(Watts/metre square)



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5.1.3 Wind Energy

Wind energy was not used in the study area. However, there was an installation of a water pumping wind machine in the nearby community of El Sol which was not operating at the time of this study. It was built to provide water to a school and health clinic. Hundreds of imported windmills are currently operating throughout the country although many others are presently in disrepair. (Alberts, 1984)

5.1.4 Biomass

The most important source of energy for the community presently is biomass. All houses in the community burn firewood for cooking. Of all forms of energy used in the community, this is also the most easily quantifiable. In order to get an accurate estimate of fuelwood usage a measurement procedure was devised and carried out over a six week period. The objectives of the fuelwood measurement went beyond simply measuring consumption. The measurement also was to serve as a demonstration and awareness building tool for the community. In addition, an experiment was carried out to estimate the efficiency of the open fire method of cooking.

5.1.4.1 Fuelwood Consumption Measurement

In consultation with the Commission it was decided to test at least two households in each neighbourhood and to test a total of twelve households. The length of the tests would be one week.

Individuals were approached by the study team and a member of the Commission. The procedure was explained and they were asked if they would participate. If they agreed they were then asked to estimate the quantity of wood from their woodlots which they would use over a ten day to two week period. This was to give a margin of error to ensure enough wood was measured to last the week. The wood was measured with a 30 kilogram scale and piled in a convenient location for use. After one week the remaining wood was measured, and an estimate of usage obtained. The number of people in the household was also recorded.

In the first week of measurement one problem arose because the woodpile did not have a shelter. Due to the rains the wood had become very wet and thus was not used. The family had to scavenge for scraps of wood, branches, and crops residues such as corn cobs. It became evident, then, that additional criteria for selecting households was that the wood be relatively dry and that there be a shelter to protect it. If these criteria were met, the study team could be confident that the individuals would use only the measured wood during the testing period.

Table 7 shows the results of the testing. Twelve households were selected but only eleven tested. At least two houses in each neighbourhood were tested except El Cacao. Being at a lower elevation than the other neighbourhoods, El Cacao was generally wetter and the woodlots were wetter. Only two households were identified with a roof for protection of the wood. One of these households refused to participate.

TABLE 7: RESULTS OF WOOD CONSUMPTION MEASUREMENT

Household	Children (under 12 yrs)	Adults	Consumption (kg/week)
1	2	8	117
2	2	2	96
3	4	4	102
4	-	-	-
5	3	2	71
6	2	6	60
7	-	-	-
8	3	5	68
9	1	5	106
10	2	4	69
11	4	3	70
12	-	-	-
Total	23	39	759

The data for one other household were discarded because the obvious low value of wood consumed was only 25 percent of the average of the other households. The study team judged that this family had used wood other than that which was weighed.

The burning of wood for baking was not included in the survey of wood consumption. It was felt that this use of wood would not add significantly to the total. Generally only one family per Comarca bakes and sells bread once every two to three weeks. Other households use the ovens perhaps once every two months to bake "cosas de orno" (baked sweets).

With a consumption of approximately 30 kilograms of wood for each bread baking, twice a month, the average consumption of wood per household for baking would be 0.34 kg/week. This is less than one percent of the total measured wood consumption.

It should also be stated that this value does not account for what could be called special community events, where large amounts of wood are consumed. These include Mother's Day, birthdays, holidays, births and deaths. No estimate of the value of this consumption can be found in the literature. Since the numbers from the survey are comparable to the literature no allowance was made for this consumption.

With the data from the nine households the average consumption over one week was 84.3 kg/house. The average consumption per person was thus calculated at 12.24 kg/person/week or 1.75 kg/person/day. In terms of joules of energy consumed these figures translate to 1686

MJ/house/week, 244.8 MJ/person/week and 35 MJ/person/day respectively. These conversions are based on an average energy of 20 MJ/kg of wood. (Centro Agronomico Tropical de Investigacion y Ensenanza(CATIE), 1986)

5.1.4.2 Other Consumption Literature

The above figures of energy consumption compare favourably with the numbers obtained from the literature. In a study carried out by the Nicaraguan Energy Institute(INE) in 1985, fuelwood consumption was measured in 2600 homes throughout the country in both urban and rural areas (CATIE, n.d.) This study found a daily consumption of 2.5 kg/person/day or 50 MJ/person/day. However, this survey most likely included data from the colder mountainous areas of the country.

The Brace Research Institute has also reported on fuelwood consumption surveys which estimate daily consumption to be between 0.42 and 1.35 kg/person/day or 8.4 MJ/person/day and 27 MJ/person/day (Brace Research Institute, 1986) Foley has also reported on fuelwood consumption in developing countries. He estimates an average consumption of 700 kg/person/year or 1.92 kg/person/day. (Foley, 1985).

5.1.4.3 Open Fire Cooking Efficiency

An experiment was also performed at one of the households in the community to estimate the efficiency of the open fire cooking methods employed by the majority of the homes in the community. A large iron pot of water was made to boil over a period of six hours 45 minutes. Wood was added to the fire to simulate actual cooking procedures. The efficiency of the open fire was then calculated to be about ten percent.(See Appendix 3) The remainder of the energy consumed is wasted energy. It is dissipated to the surrounding air, or still locked in the charcoal produced from the fire. This experiment demonstrated that in reality, only 3.5 MJ/person/day is required to cook and there is great opportunity to conserve energy in the kitchen.

5.2 AVAILABLE RENEWABLE ENERGY RESOURCES

The first step in the investigation of energy alternatives is to estimate the renewable energy potential available to the community. The renewable energies to be evaluated are solar, wind, biomass and hydraulic.

Each source was evaluated separately using the best available data. The quantity and quality of energy from each source was identified using units most appropriate for the source and the probable end use.

5.2.1 Solar Energy

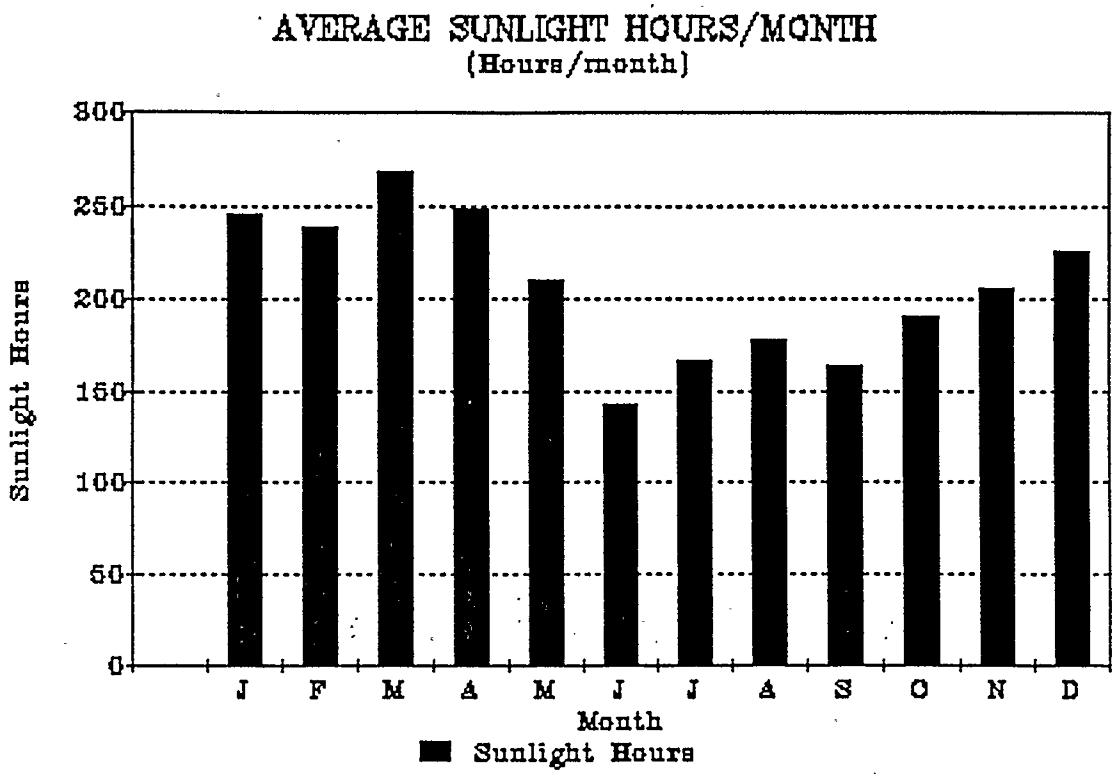
The best measure of available solar energy is the level of solar radiation. Solar radiation data was obtained from the Masatepe meteorological station, fifteen km northeast of the study area. (Figure 3) As can be seen from the bar chart of Figure 5, incident solar radiation for the Masatepe station ranges from 323 W/square metre in December to 477 W/square metre in April. Details of the manner in which these measurements were taken was not available. From other documents reporting on solar dryer experimentation in Nicaragua, it appears that the values of solar insolation given in Figure 5 are averages of measurements taken over twelve hours per day. (Gustafsson, 1982)

Other parameters describing the solar resource which are useful for evaluating the applicability of solar technologies include the mean hours of sunlight per month and the median monthly temperature. The bar charts of Figure 6 show the hours of sunlight ranging from 267 hours/month in May to 143 hours/month in June. The median temperature/month is greatest in May at 25.9 degrees celsius and least in January at 23.1 degrees celsuis.

Table 9 is a summary of the calculated solar heat energy available in the community per square metre on a daily and monthly basis, derived from the meteorological data. The estimate of the total solar energy available for the year is also given. The minimum and maximum available over a one month period are 426 MJ/square metre and 608 MJ/square metre for December and April respectively.

FIGURE 6: SUNLIGHT HOURS AND MEDIAN TEMPERATURE/MONTH

FIGURE 6: SUNLIGHT HOURS AND MEDIAN TEMPERATURE/MONTH



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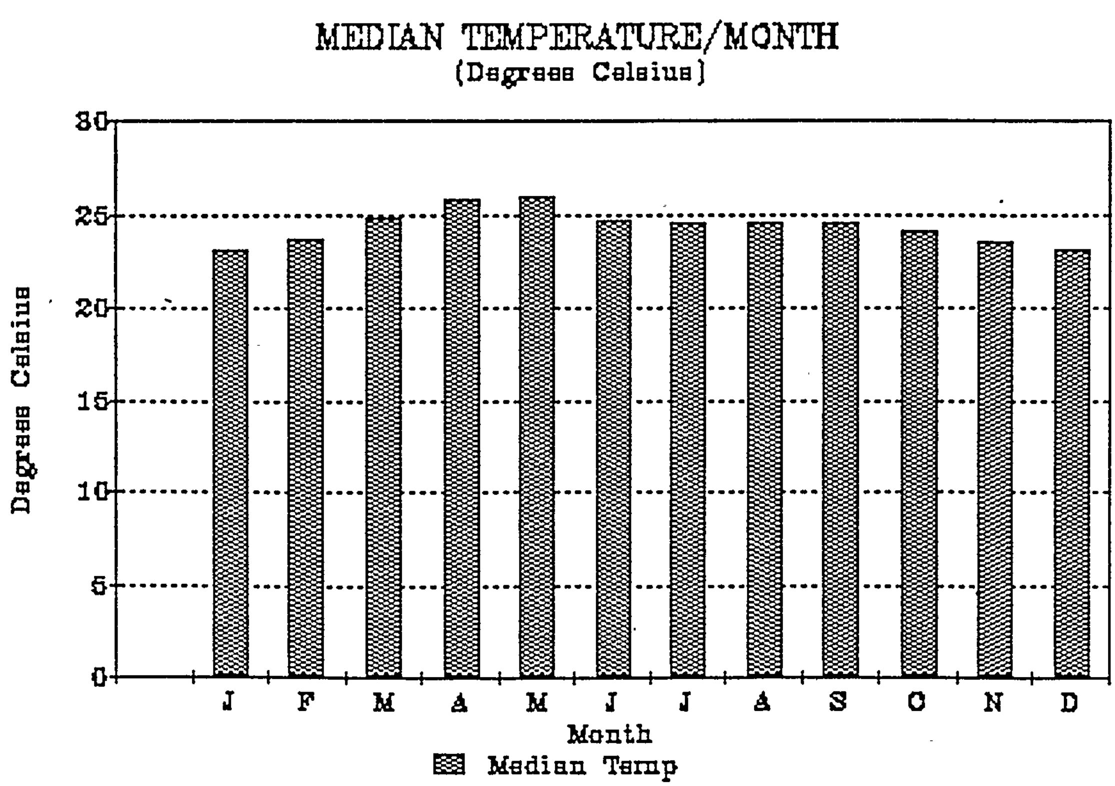

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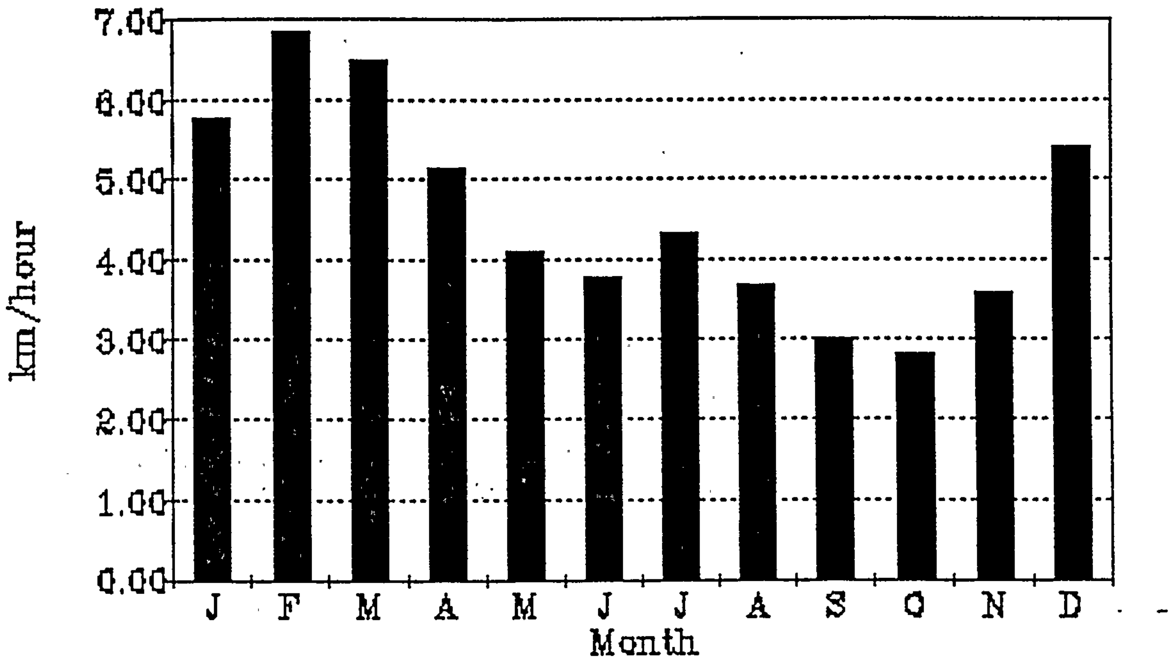
TABLE 9: AVAILABLE SOLAR HEAT ENERGY

Month	Measured (J/M2/s)	Daily Total (MJ/m2/day)	Monthly Total (MJ/m2/month)
J	378.5	16	497
F	428.3	19	563
M	461.6	20	607
A	466.9	20	614
M	413.4	18	543
J	356.5	15	468
J	372.5	16	489
A	395.5	17	520
S	380.3	16	500
O	365.9	16	481
N	352.9	15	464
D	322.9	14	424
Average	391.27	17	514
Yearly Total			6169

the wind resource evaluation was that other sources of information, discussed later in this section, conflict with the Masatepe data.

From the monitoring station at Masatepe it would appear that the potential for harnessing energy from the wind is minimal. From the chart of Figure 7 it can be seen that the wind velocity fluctuates between 6.84 km/hr in February and 2.81 km/hr in October. It is generally accepted that speeds above 4 m/s (14.4 km/hr) are sufficient for wind machine installations. (Manwell, 1986) Visual observations at the study location (i.e. flagging of trees and wind induced deformation of vegetation) indicates that there is a significant, consistent wind velocity. This observation is consistent with evidence of residents that the wind speed in dry season months (November to April) is significant; enough to damage fruit trees in the area.

FIGURE 7: AVERAGE WINDSPEED/MONTH
(km/hour)



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According to Manwell (Manwell 1986) the western shore of Lake Nicaragua generally shows potential wind velocities high enough to make use of wind energy technologies for mechanical power and possibly electrical power. (Manwell, 1986) Manwell found that western shore areas could have winds between 16.2 km/hr and 25.2 km/hr.

Other data gathered by the Nicaraguan Institute for Territorial Studies, INETER, indicates that at a site five kilometres from the study location, windspeeds are estimated at 14.4 km/hr. (Personal Communication, Luis Campo, Nicaraguan Institute for Aqueducts and Sewers, INAA, Jinotepe)

Table 10 shows the results of calculations of the gross amount of energy available, on a per square metre basis,

TABLE 10: POTENTIAL WIND ENERGY

Month	A.W.S. (km/hr)	A.W.P. (W/m2)	T.M.W.P. (W/m2)	T.A.W.E. (MJ/m2/mon)	A.T.A.W.E. (MJ/m2)
J	5.76	2.52	1.49	3.93	
F	6.84	4.22	2.50	6.58	
M	6.48	3.59	2.13	5.59	
A	5.15	1.80	1.07	2.81	
M	4.10	0.91	0.54	1.42	
J	3.78	0.71	0.42	1.11	
J	4.32	1.06	0.63	1.66	
A	3.70	0.67	0.40	1.04	
S	3.00	0.36	0.21	0.55	
O	2.81	0.29	0.17	0.46	
N	3.60	0.62	0.36	0.96	
D	5.40	2.08	1.23	3.24	
Ave.	4.58	1.57	0.93	2.44	29.33
INETER	14.4	39.39	23.35	61.36	736.38
Manwell					
(Min)	16.2	56.08	33.25	87.37	1048.47
(Max)	25.2	211.08	125.14	328.88	3946.52

A.W.S.= Average Wind Speed; A.W.P.= Available Wind Power
T.M.W.P= Theoretical Maximum Wind Power (at 59.3% eff.)
T.A.W.E= Theoretical Available Wind Energy (at 59.3% eff.)
A.T.A.W.E.= Annual Theoretical Available Wind Energy (59.3%)

using the wind speed data from the various sources. The inconsistency of the data is evident with a range of 6.6 MJ/square metre/month of mechanical wind energy theoretically possible in the best month from Masatepe figures, to 329 MJ/square metre/month for the upper range of Manwell's estimates.

5.2.3 Hydro Power

The hydropower resource potential is negligible in the study area. The small waterways located within the study area have flows for only part of the year, during the rainy season, and even then the flows are very small.

The Rio Ochomogo is located in watershed seven, but it is well outside of the study area. (Figure 3) While there may be possibilities for utilization of its potential for the watershed, it is not within the boundaries of the study area and is not directly available to the people of the study area.

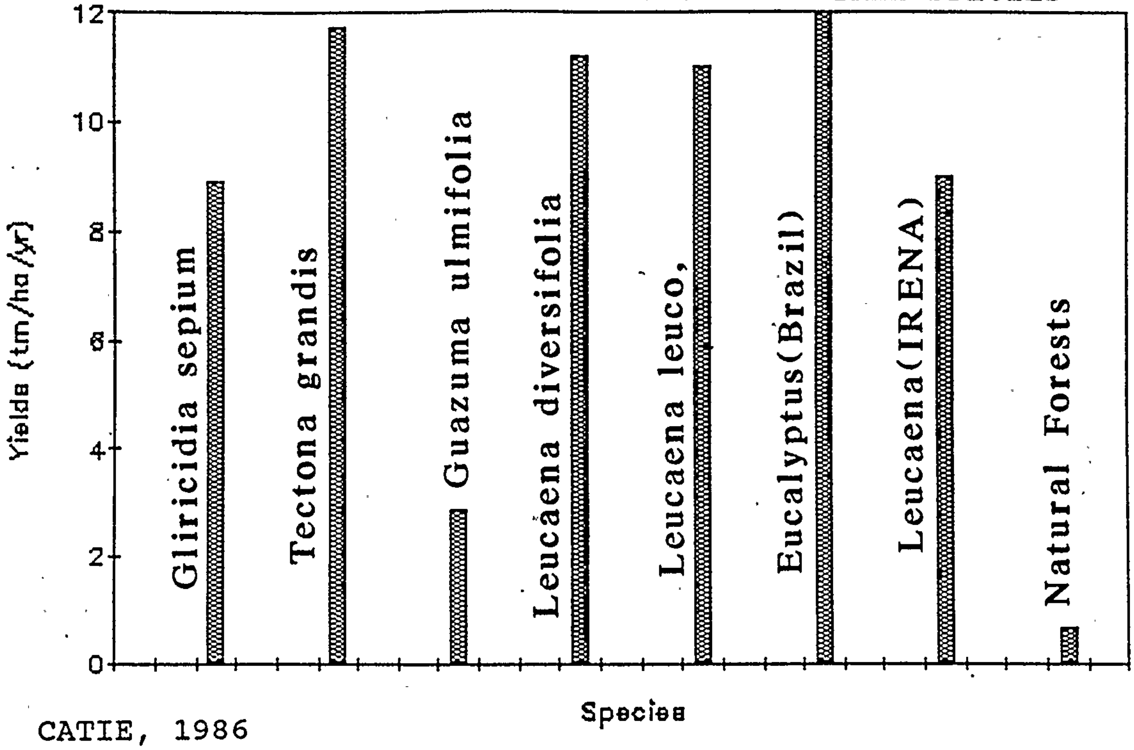
5.2.4 Biomass

Due to deforestation of the study area over many years there is very little forest biomass naturally available to the community. The Department is severely deforested and at present 60 percent of the wood cut is cut illegally. (Personal Communication, Pedro Marcenaro, IRENA, Jinotepe) However, the tropical climate is very productive and significant potential exists for growth of biomass.

The natural regeneration rate of forests in this area is about one to two tonnes per hectare per year (Food and Agriculture Organization(FAO), 1980). Studies undertaken throughout Central America suggest that it is possible to produce upwards of 21 tonnes of fuelwood per hectare per year in the study area. (FAO, 1980) The estimates vary according to the species planted. Figure 8 shows some of the accumulated data on growth rates of various types of trees which were among a group chosen for study because of their suitability in the region. (CATIE, 1986) The data were selected based on the similarity between rainfall, temperature, and elevation above sea level between the study area and at the project sites selected from the CATIE report.

This report also includes an evaluation of the growth rates over a number of years. This data is useful to give an indication of the time period for optimum growth. Figure 9 is an estimate of this data compiled by IRENA. The optimum time for cutting is when the trees have passed their fastest

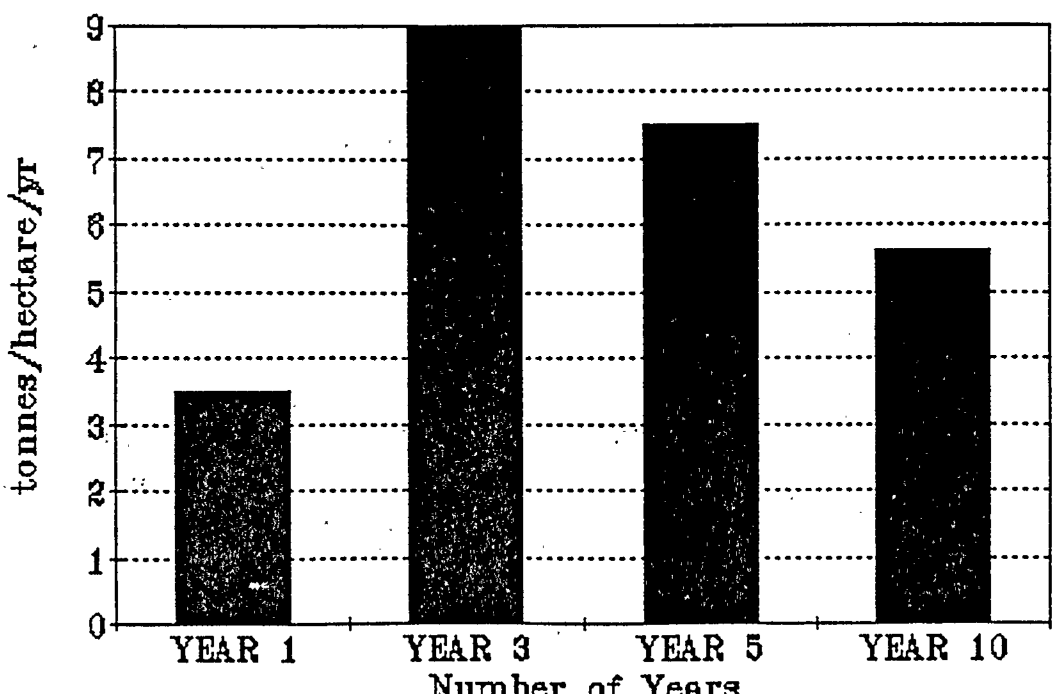
FIGURE 8: GROWTH OF VARIOUS TREE SPECIES



CATIE, 1986

growth rate. (FAO, 1981) Figure 9 shows that the optimum time for cutting of trees to obtain the greatest yearly average harvest would be three years.

FIGURE 9: LEUCAENA GROWTH RATES



UN, FAO, 1981

Table 11 shows estimates of potential yields from various species using the data from Figure 8 for selected species, data from eucalyptus plantations in Brazil (FAO, 1981), and IRENA's accepted growth rate for leucaena for its project planning. As well, there are yield estimates for natural growth for comparison.

The other form of biomass available is crop residues and animal and human waste. Biogas can be produced from these materials with nitrogen rich fertilizer as a by-product. Crop residues were not included in these estimates. It was assumed that, given the seasonal nature of the availability of residues, they would not contribute greatly to a biomass system. They can only be a supplement to manure and would not add greatly to the quantity of biogas produced. They are best left in the fields where they can return nutrients to the soil. There was no census of the animals in the community. However, the study team estimated animal populations per household from observations made during visits to households throughout the community. Those estimates are contained in Table 12 below along with calculations of the biogas available.

Table 12 - Estimates of Animal Populations and Biogas

Animal	Number /House	Wet Dung (kg/day)	Percent Recover.	Total Recover. (kg/day)	Total Biogas (lit/day)
Cattle	2	20.0	50	10.00	280-340
Horses	0.75	5.25	50	2.6	74-89
Pigs	5	25.0	50	12.5	700-850
Fowl	10	0.75	50	0.4	21-26
Humans	5	1.00	100	1.00	55-70
TOTAL		52.0		26.5	1119-1374

Sources: Fulford, 1988; Canadian Hunger Foundation, 1983; Instituto Centroamericano de Investigacion y Technologia Industrial(ICAITI), 1983.

Table 11: ESTIMATES OF POTENTIAL YIELDS FROM VARIOUS SPECIES

Species	Yield (t/ha/yr)	Dry Cal. Value(1) (kJ/kg)	Seasoned Cal. Value (kJ/kg)(2)	Avail. Dry Energy (GJ/ha/yr)	Avail. Seas. Energy (GJ/ha/yr)
Gliricidia sepium	8.9	20,500	17,220	183	153
Tectona grandis	11.75	21,000	17,640	247	207
Guazuma ulmi.	2.85	18,400	15,460	52	44
Leucaena diversi.	11.2	20,000	16,800	224	188
Leucaena leuco.	11	18,600	15,625	205	172
Eucalyptus (Brazil)	12	20,000	16,800	240	202
Leucaena (IRENA)	9	20,000	16,800	180	151
Natural Forests	0.66	20,000	16,800	8	11

(1) Dry Calorific Value @ 8% Moisture Content
(2) Seasoned Calorific Value @ 20% Moisture Content

CATIE, 1986

Because of the scattered nature of the homes in the study area, the best strategy for biomass use would probably be to construct units for the use of two to three families, because most of the houses were built in these small clusters. Table 13 shows the calculation of potential heat energy from the calculated quantity of biogas shown in Table 12.

The community as a whole has available to it approximately between 90,200 cubic metre and 109,300 cubic metre of biogas annually. This has a heat energy value of between 2,000 and 2,400 GJ annually. The single, double and triple house clusters would have 9-11 GJ/year; 18-22 GJ/year; and 27-34 GJ/year respectively of biogas available.

Table 13: Potential Heat Energy From Biogas

Number of Houses	Biogas (lit/day)	Avail. Energy (MJ/day)	Avail. Energy (GJ/year)
1	1,119-1,374	25.0-30.6	9-11
2	2,238-2,748	49.9-61.3	18-22
3	3,357-4,122	74.9-91.9	27-34
	(m3/day)	(GJ/day)	(GJ/year)
COMMUNITY	247-304	5.51-6.68	2,000-2,400

Sources: Fulford, 1988; Canadian Hunger Foundation, 1983. ICAITI, 1983.

Table 14 is a compilation of the estimated total renewable energy available to the community. These estimates will be used to calculate the quantity of energy which can be delivered by selected conversion technologies.

TABLE 14: ESTIMATE OF TOTAL RENEWABLE ENERGY AVAILABLE FROM ALTERNATIVE SOURCES

Energy Source	Annual Available Energy
Solar Energy	6 GJ/m2
Wind Energy	0.03 - 0.4 GJ/m2 swept area
Fuelwood Plantation	44 - 207 GJ/ha
Biogas	2,011 - 2438 GJ

5.3 BASIC ENERGY REQUIREMENTS OF THE COMMUNITY

Having identified the most important needs of the community and chosen those needs which are predominantly a problem of energy supply, we can now go on to quantify those energy needs. Recall that the needs identified through the consultation process were:

1. Drying of crops.
2. Electric lighting.
3. Cooking fuel.

Each of these needs will be addressed individually to calculate the approximate energy need.

5.3.1 Cooking Fuel

The energy required for cooking can be calculated from the estimates of fuelwood consumption for cooking which were obtained from the energy survey. Each household consumed 84.3 kg/week of wood or 393.7 kW-hr/week equivalent energy.(based on 16.8 MJ/kg of wood) However, the experiment to determine the efficiency of the open fire method of cooking revealed that this method is only ten percent efficient. Therefore the actual energy required to cook the required amount of food for a family is actually only 39 kW-hr/week or 2000 kW-hr/year. For the entire community of 221 households the equivalent numbers are 8700 kW-hr/week (31 GJ/week) and 452 MW-hr/year (1600 GJ/year).

5.3.2 Electric Lighting

The provision of electricity would make life easier in rural areas. More options would be open to everyone. Presently after dark most activity has to come to a halt. In many homes the use of kerosene candles is the only source of light at night. Students often spend the daylight hours working around the house or in the fields. Often night is the only time left over for studying. It is very difficult for students to study using kerosene light.

Lack of lighting is also a constraint to community organizing. After dark is a good time for meetings, especially during the busy harvesting season. In the cooperative, lighting would be a significant benefit, giving the community the opportunity to meet and take care of co-op business. Electricity would also provide greater access to the outside world by providing energy for radios and televisions. The provision of electricity would also provide an incentive for young people to remain in the community. There is a great attraction for young people to move to the towns and cities. From conversations with young people in the community, lack of electricity is one factor which works against their staying. The demand for electricity is not necessarily very high. The following is a list of the basic necessities for electricity in this community.

3 - 40 watt light bulbs in use 5 hours/day	= 600 W-hr/day
one television - 200 watts for 5 hours/day	= 1000 W-hr/day
one radio - 50 watts for 10 hours/day	= 500 W-hr/day
Total electrical energy required/household	= 2100 W-hr/day

This energy requirement translates to 14.7 kW-hr/week or 764 kW-hr/year per family. The respective daily, weekly and yearly values for the entire community are 464 kW-hr/day and 3249 kW-hr/week and 169 MW-hr/year.

5.3.3 Crop Drying

The bean crop represents the vast majority of the crop which has to be dried. There are normally two harvests of beans every year. The first harvest is in August and the second is in October. Because of the greater rainfall in the period when the first crop is maturing usually the August yield is substantially more than that of the second harvest.

To estimate the energy needed for drying, some assumptions have to be made. First of all, the co-op estimates that 40 manzanas of land are cultivated in beans yearly. For the first harvest they average fifteen quintales or 680 kilograms of beans per manzana. The second harvest yields about ten quintales or 454 kilograms per manzana. This is the approximate weight of the beans when they are sold to the state. At the time of sale the moisture content is unknown but it is assumed to be 25 percent. This is down from the original moisture content of 80 percent (Astrom, 1988). The final moisture content needed to preserve the beans is thirteen percent (Astrom, 1988). With these numbers the original quantity of water which has to be evaporated from the beans was calculated. These figures are 20,734 kg of water and 13,823 kg of water respectively for the first and second harvest. The heat of vapourization of the water in the beans is not simply the standard heat of vapourization of water. Because of the binding of water to the beans, as well as the physical and chemical properties of the beans, this heat of vapourization will be somewhat higher. This value for beans could not be found in the literature, so the value for corn is used as an approximation. (Astrom, 1988) The heat of vapourization of water in corn is 0.75 kW-h/kg of water. (Astrom, 1988)

Using this value and the estimates of water content of the beans, a requirement of 25,917 kW-hr/year of heat energy were calculated for both harvests together. Table 15 is a summary of the basic energy requirements of the community. These estimates, along with the estimates of available renewable energy resources, will be used to select appropriate energy conversion technologies.

TABLE 15: COMMUNITY BASIC ENERGY REQUIREMENTS

Need	Energy Quality	Energy Quantity
Cooking	Low grade heat	452 MW-hr/year
Crop drying	Low grade heat	25.9 MW-hr/year
Lighting	Electricity	169 MW-hr/year
TOTAL		647 MW-hr/year

CHAPTER 6: SELECTION AND EVALUATION OF ALTERNATIVE ENERGY TECHNOLOGIES

In this chapter the potential renewable energy technologies which were considered by the study team, will be presented. These potential technologies were chosen solely on their technical and economic feasibility. First, this chapter will include an estimate of the energy required by each technology so that after conversion to the required energy quality, the community's needs will be met. Second, the preliminary evaluation of the technologies will be reviewed. This preliminary evaluation was a pre-screening, carried out by the study team, based on the need to concentrate only on those technologies which could potentially be acquired in the near term. The key criterion for that determination was whether or not there was technical support within the country to assist the community with the implementation of the technology. Third, the evaluation and ranking of the final list of technologies, presented to the Commission, will be reviewed. Finally, there will be a discussion of the steps which have been initiated towards the implementation of the selected technologies.

6.1 Potential Renewable Energy Technologies

In Chapter five the point of delivery energy quantity and quality were calculated for each of the three community basic needs - cooking, crop drying, and electrical energy. Now, the various potential technologies which can meet those needs, along with the source energy required for each, will be presented.

6.1.1 Cooking Technologies

The predominant form of energy for cooking presently used in the community is the burning of wood on an open fire. As has been demonstrated, this method is very inefficient with only ten percent of the available heat being employed to cook the food. This form of cooking requires approximately 452 MW-hr/year (1627 GJ/year) for the entire community. In this section four alternatives will be presented. They include three alternative cooking technologies - biogas, improved wood burning stoves, and solar cookers, and one supply enhancing alternative - a fuelwood plantation.

6.1.1.1 Improved Wood-burning Stoves

This technology uses the same traditional fuel source, but attempts to apply conservation technology to the process. Improved efficiency stoves have held promise for many years but success rates of the various projects have been scattered.(Krugmann, 1987) However, the higher efficiency stove is a proven technology. In recent years success rates have been improving due to better design and introduction strategies.(Krugmann, 1987; Baldwin, 1985)

Still, it is difficult to accurately predict an efficiency. There remain wide discrepancies in the performance claims of the many designs. Reported efficiencies range from thirteen percent to 50 percent.(WCED, 1987; Krugmann, 1987; Kristoferson, 1986; Baldwin, 1985; Eckholm, 1975) The literature suggests that more recent designs of lightweight, metal cookstoves perform better than the older, high mass, sand and clay designs.(Baldwin, 1985) For the purpose of this study I have chosen efficiency estimates based upon the work at the Brace Research Institute. Its testing suggests that efficiencies of conversion from wood energy to delivered heat, in the range of 30 percent, are feasible.(Brunet, 1987) At 30 percent efficiency, 5425 GJ/year of energy would be required for the entire community. Assuming that, in general, the wood will be air dried for a period of two to three weeks before use, the gross energy available from the wood will be the lower calorific value of approximately 16,800 kJ/kg(Merrill, 1978). Therefore, approximately 323,135 kg of wood would be required to meet the community's needs.

6.1.1.2 Solar Cookers

Solar cookers have been in development for many years. The most common type of solar cookers are those without energy storage. These include the parabolic cookers and the hot box.(Assets, March, 1983) The conventional hot box and parabolic type solar cookers have achieved limited field success up to now.(Flavin, 1983) Other, more recent designs are indirect type cookers which employ storage in the form of insulated containers which store heated water.(Mills and Mao, 1987) These designs have the advantage of being able to store solar energy to be used after dark when the evening meal is often prepared. It is difficult to assign efficiencies to these cookers because so much depends on the time and type of energy storage. The storage type cookers have been proven technically feasible in testing but have not been proven in field conditions. The main problem with all solar cookers is not the technical feasibility of the technology, but the cultural fit. These cookers demand adjustment of food preparation customs which have been followed for generations.

6.1.1.3 Biogas Cookers

Cooking with the heat from the burning of biogas is a proven technology throughout the developing world. This technology is particularly widespread in India and China.(Fulford, 1988) There is also a program for biogas development in Costa Rica.(Instituto Tecnico de Costa Rica, 1986) The efficiency of this technology varies according to the system employed. However, many biogas stoves can operate at about 55 percent efficiency of conversion of biogas to heat energy delivered to the food.(Fulford, 1988) At this rate the entire community would require approximately 822 MW-hr/year (2958 GJ/year) biogas energy from the source.

Approximately 132,646 m3 of biogas would be required to supply this quantity of energy, assuming a biogas energy content of 22,300 kJ/m3.(Instituto Centroamericano de Investigacion y Tecnologia Industrial, ICAITI, 1983)

6.1.1.4 Fuelwood Plantation

Fuelwood plantations are also a proven technology throughout the world. Using the present open fire cooking technology each household requires approximately 84.3 kg of wood/week or 968,776 kg/year for the entire community. Using improved cookstoves with an average efficiency of 30 percent that amount could be reduced to approximately 322,925 kg/year.

IRENA has estimated that it is feasible to harvest 27 tonnes each three years from one hectare of fuelwood plantation.(Personal Contact, Mario Duarte, IRENA, Granada, 1988) Therefore, with no improvement in the cooking efficiency, 108 hectares of fuelwood plantation would be required to sustain the woodfuel supply of the community. If stoves with a 30 percent efficiency could be introduced, the required area devoted to a fuelwood plantation could be substantially reduces - to only 36 hectares.

6.1.2 Electrical Energy Technologies

Presently, the community has no access to electicity. However, there is a desire in the community to obtain electricity. There are also many advantages which would accompany the introduction of this type of energy. Three technologies were considered for the introduction of electricity. They were photovoltaic cells, biogas used to fuel a generator and wind turbines. These technologies would have to deliver the required 168.9 MW-hr/year of electrical energy calculated in chapter 5.

These technologies were not among those presented to the Commission for evaluation because of the problems of unrealistic expectations and the improbability of obtaining these technologies in the near future. It was felt that discussion of these technologies would have a negative impact on the study.

6.1.2.1 Photovoltaic Cells

Sunlight can be converted directly to electricity by the use of photovoltaic cells. Unfortunately, these cells have an efficiency of about ten percent. Therefore, based on the calculations of community energy need for electricity, the cells would have to be large enough to intercept 1694 MW-hr/year or 6098 GJ/year of solar energy, ten times that required to fulfill household electricity needs. This amount of energy would require approximately 967 square metres of photovoltaic panels. This number itself is low because it assumes a 100% load factor.

6.1.2.2 Biogas Fueled Generator

Biogas can be produced in a digestor and used to fuel a diesel electric generator. Because the biogas has a lower energy density than diesel fuel, the efficiency of the generator will be lower when the biogas is used. Typical efficiencies of generators using the lower grade fuel are approximately 24 percent.(Fulton, 1988) Assuming 24 percent efficiency, the heat energy in biogas required to fulfill the needs of the community would be 704 MW-hr/year (2534 GJ/year). These numbers tanslate into 113,600 cubic metres/year of biogas, assuming the biogas energy content to be 22,300 kJ/cubic metres.

6.1.2.3 Wind Electric Generator

This is a proven technology in the developed countries. However, it has seen little application in developing countries.(Flavin, 1983) Typical efficiencies for conversion systems of wind to electricity are 35 percent (59.3 percent theoretical efficiency times 60 percent machine efficiency).(Merrill, 1978) What size of turbines would be required to deliver the required 168.9 MW-hr/year of energy? To estimate turbine size, the average capacity factor has to be taken into account. The best estimate of capacity factor available was 26 percent.(Trans Alta, 1987) This estimate comes from Pincher Creek, in Southern Alberta, and thus has to be considered optimistic for the study area. The wind data for the site is very scant. For the purpose of this calculation the INETER value of 4 m/s for average windspeed will be used. At this average speed, and an efficiency of 9.1 percent (26 percent average capacity factor times 35 percent conversion efficiency) a wind energy of 1856 MW-hr/year would have to be available. The total swept area of the wind turbines would have to be 5025 square metres. This value could be achieved, for example, with 40 turbines of 12.6 metres diameter each.

6.1.3 Crop Drying Technologies

Only one technology was selected for crop drying. This technology was a solar crop dryer. From testing performed on crop dryers in Nicaragua, the efficiency of solar dryers for hot, humid areas is estimated to be in the range of 35 percent.(Gustafsson, 1982) Efficiency is defined as the solar energy incident on the dryer surface divided by the heat energy delivered to the crop. Table 16 provides a summary of all eight of the selected technologies.

<u>TABLE 16: SUMMARY OF POTENTIAL TECHNOLOGIES</u>

Technology	Overall Conver. Efficiency	Energy Input (MW-hr/year)	Resources Required
Cookstoves	30%	1,506	323,100 kg of wood
Biogas Cooker	55%	822	132,700 m3 biogas
Solar Cooker			
Fuelwood Plant.		4,520	969,400 kg of wood
Photovoltaics	10%	1,694	967 m2 of panels
Wind Electric	9.1%	1,856	40 WECS/12.6 m ea.
Biogas Generator	24%	704	113,600 m3 biogas
Crop Dryer	35%	74.1	11 - 50 m2 dryers

6.2 PRELIMINARY SCREENING OF TECHNOLOGIES

From the previous section a total of eight different technologies were introduced as technically feasible for the community. In this section the preliminary screening of these technologies will be presented. This screening resulted in a final list of three technologies which the study team presented to the Commission for consideration. These were the fuelwood plantation, the crop dryer and the improved cookstoves.

The Commission felt that the highest priority for the community was the need for the project to continue after the departure of the study team and, that concrete benefits be seen in the short term. Thus, only those technologies which could conceivably be acquired in the short term were evaluated. Given the absence of technical expertise in the community, and the fact that the study team would only be in the community for a short time, one test was applied to the technologies to make that determination. That test was whether or not technical assistance was available within the country to assist in the implementation of the technologies.

The study team, together with CEPA, investigated the technical services which were available within the country. Three agencies were contacted. These were the Nicaraguan Energy Institute (INE), The Ministry of Natural Resources (IRENA), and the Italian funded aid organization Centro DINOT which operates in conjunction with the National

Engineering University (UNI). Due to the survival economy of the country, operations of many of the agencies working in alternative energy have been severely cut back in the last year. The study team's investigations revealed that three areas where support could be available to the community were reforestation, crop drying and improved stoves.

IRENA is presently involved in reforestation. It is co-ordinating three major reforestation projects in the Department of Carazo. These projects involve mainly the cooperatives in the Department. The purpose of the projects is to provide fuelwood for the communities, reclaim forest lands, erosion control and diversify the economy of the cooperatives by introducing fruit trees. The regional office of IRENA, located in Granada, expressed a willingness to provide technical assistance to the cooperative for a reforestation project.

Centro DINOT is an internationally funded agency. It has not been effected by the internal economic problems of the country as the government or indigenous agencies have. Centro DINOT has a division specializing in solar energy technology. The solar division's main project is the development of grain dryers. Centro DINOT is presently working with the state grain agency, ENABAS, to develop a large scale dryer which will operate in series with the diesel dryers in the regional facilities. Centro Dinot is also are testing a small scale dryer suitable for individual cooperatives and medium size farms. The capacity of the dryer is approximately eight to ten quintals of beans (one quintal = 45 kilograms) per day.

DINOT also has a newly formed division which is experimenting with improved cookstoves. In July 1988 the technical staff of DINOT were involved in a cookstove workshop. The workshop was put on by the Aprovecho Institute from Guatemala. The new cookstove division is eager to work with a community to introduce improved stoves in an effort to reduce fuelwood consumption.

With this information it was decided by the study team to present three alternatives to the community. These three alternatives were:

1. Introduction of improved cookstoves.
2. Construction of a solar grain dryer.
3. Development of a fuelwood plantation.

6.3 EVALUATION OF THE PROPOSED TECHNOLOGIES

The next step in the process was to present the final list of proposed technologies to the Commission for consideration. The technologies would then be evaluated based upon an agreed upon set of criteria. One list of criteria was prepared by the study team for presentation at the Commission meeting where the evaluation was to take place. Before these criteria were presented, there was an opportunity for discussion among the Commission members. The representatives of the community brought out several relevant criteria in that discussion. Other points were then raised by the study team for discussion. The following is the list of criteria, reached by concensus, which the selection was based upon.

1. Economic costs and benefits.
2. Availability of components needed to manufacture the technology.
3. Availability of expertise to construct the technology.
4. Availability of expertise to operate and maintain the technology.
5. Durability of the technology.
6. Probability of success of the technology.
7. Affects on the Environment.
8. Who will operate and who will benefit from the technology?

Table 17 is a summary of the evaluation of each technology based upon these eight criteria.

TABLE 17: EVALUATION OF THE THREE FINAL TECHNOLOGIES

Criteria	Improved Cookstoves	Fuelwood Plantation	Solar Crop Dryer
1	$60CAN/stove Yearly Saving	$85CAN/ha Yearly Saving	$1,200CAN Yearly
Saving	$12CAN Payback-5 yrs	$21CAN/ha Payback-4 yrs	$84CAN
2	Available locally	Most Avail. locally	Available locally
3	Available locally	Available locally	Available locally
4	Available locally	Available locally	Available locally
5	Fair	Very Good	Good
6	Good	Very Good	Fair
7	Positive	Positive	Neutral
8	Women	All members of community	Men

6.3.1 Discussion of Alternatives

In this section the three alternatives presented to the Commission will be discussed in relation to the criteria listed above. Except for the economic costs and benefits, the technologies were evaluated qualitatively. From this qualitative evaluation the Commission assigned priority to the three potential technologies.

6.3.1.1 Fuelwood Plantation

There are many advantages to a fuelwood plantation. Since this community is a farming community, practically everyone has the basic skills required to raise and care for crops: the knowledge of the soil; knowledge of the care required of plants during their growth; and an appreciation of the vigilance necessary to combat plagues and disease which plants are subject to. The technical expertise which will be required to assist the community with the particular nuances of the tree crops is available from IRENA technicians.

All of the most suitable species' seeds are available within the community, or through the IRENA seed bank in Managua. The seedlings can be planted using the same methods used for the present crops. Animal and human power is sufficient for the task although if funds are available the task can be made easier if a tractor can be rented to prepare the fields. If the in-vitro method is followed the plastic bags required for the seeds, and to protect the seedlings, are manufactured at Plastinic in Jinotepe. The in-vitro method involves raising the seedlings to a specified size in the protection of plastic bags. The chemicals needed to fertilize and protect against plagues are all readily available from IRENA. Some of them are manufactured in the country, others are imported.

No outside expertise will be needed for the operation and maintenance of the crop. There is sufficient assistance available through IRENA and research efforts of various university and technical schools within the country.

This alternative is very attractive because it is very durable. Once a mature plantation has been achieved very little care is needed to maintain the crop into the future.

The success rate of this type of project has also been shown to be very high.(CATIE, 1986) The advantage of this type of project is that its success is dependent upon the work of the community, not an outside force. The study shows that survival rates for the trees planted typically are in the 80% to 100% range.(CATIE, 1986)

All members of the community have the ability to participate in the maintenance and operation of the tree plantations. However, it is assumed at this stage that the men will take on this task, just as they have the task of production presently. Over time, as the tree plantations grow, the entire community will benefit. The women of the community will potentially benefit to a greater degree. The secure supply of firewood will eliminate the work they presently do gathering branches and twigs for firewood when the supply is scarce or, when there is no cash to purchase firewood. Who benefits will depend upon where the initial plantations are located. If they are located on co-op land (as they probably will be) the benefit would go primarily to co-op members. Other members of the community may also benefit if the surpluses of wood are sold at less than the market price by the cooperative.

Environmentally, the raising of tree plantations will help to turn the tide of deforestation which is so accute in this region. With trees planted in soils most vulnerable to erosion this problem can also be dealt with very effectively. By utilizing nitrogen fixing species, such as leucaena, the problem of soil replenishment can be dealt with.(Pilarski, 1988) However, the long term affects of continuous mining of the soil are not fully understood.(Baldwin, 1985; Anderson and Falk, 1984) This is a matter which should be part of future monitoring programmes.

IRENA has estimated that the costs associated with tree plantations are minimal. For a crop of two manzanas (2.86 hectares), including the seedlings, the plastic bags, the fencing to protect the plants and the chemicals required over a three year period, the cost would be approximately

40,000 Cordobas ($120CAN). IRENA estimates that it is possible to harvest 19 tonnes of wood each three years for each manzana planted. The Commission estimates the cost of wood at approximately 1,400 Cordobas per tonne. At this cost, assuming that two-thirds manzanas will be planted each year for three years, the investment could be recovered after five years and a savings of approximately 8,900 Cordobas/manzana ($30CAN) could be realized each year thereafter, minus minimal maintenance costs, compared to not planting trees and continuing to buy fuelwood. These cost estimates can be assumed to be conservative. With the growing shortage of wood in the region the price of firewood is rising compared to most other items. Furthermore, with each family averaging 4.4 tonnes of fuelwood consumption per year, approximately three-quarters of a manzana would be required to supply each household with its wood requirements on a sustainable basis.

6.3.1.2 Efficient Stoves

The beauty of this technology is that all of the components can be located either within the community, or certainly within the country. The two types of stoves being promoted by Centro DINOT at present are a Ceramic stove and the Lorena stove. (Evans and Boutette, 1981) The clay and sand required for each are available locally. The ceramic components can be manufactured within the country. The bamboo or sheet metal used for the chimneys are also readily available in the country.

The technical staff of Centro DINOT have been trained in the construction of the stoves. Facilities are also available at the University to fabricate and experiment with various designs. There are also facilties to test the various clay and sand mixtures used to construct the stoves. The objective of DINOT is to train local people in the construction techniques so that they can eventually produce the stoves independently and pass the technology to others.

The operation and maintenance of the stoves is also vitally important for their success. Training and practice are required.(Krugmann, 1988; Baldwin, 1985) The expertise for this effort is available through DINOT.

Stoves are durable with the proper care. The problems in the past have resulted from faulty construction of the stoves and the inability of the owners to repair the stoves. This is definitely a problem with the introduction of the stoves. They will not be accepted unless there is sufficient technical support or training of the owners so that maintenance problems can be dealt with.(Evans and Boutette, 1981)

Stove projects have not had a good success rate in the past. Lack of proper technical support and training and attention to social aspects of the introduction of stoves has doomed many projects. There have been projects launched in Nicaragua in the past and they have met with varying degrees of success.(Manwell, 1986) However the success rate is rising as lessons are learned. The probability of success has to be rated below that of the fuelwood plantation.

The cooking tasks in the community have traditionally been the women's tasks. Therefore, they stand to be the major beneficiaries of a stove project. Not only will it lower the time spent searching for and handling wood but the health benefits will be major. The major cause of death of Nicaraguan women today is lung disease.(Architects and Planners in Support of Nicaragua, 1986) Many of these problems have been attributed to the exposure to smoke in the kitchen.(Cookstove News, Winter 1987; Ramakrishna, 1985; Reid, 1985; Pandey, 1984; World Health Organization, 1984; Smith, 1983; Aggarwal, 1983; Economic and Social Commission for Asia and the Pacific, 1981; Environmental Protection Agency, 1980; Morris, 1980)

The benefits of this technology will accrue to those households which acquire the stoves. Therefore it may be some time before the entire community will benefit from the project.

One of the major environmental benefits of improved cookstoves will be the reduced pressure on the forests of the region. The improved stoves have the potential to reduce wood consumption by up to 67 percent. As mentioned above, another benefit, which some experts believe is just as critical, is the potential reduction in smoke exposure of cooks. Studies of human exposure have shown that third world cooks can receive exposures to hazardous pollutants, such as carbon monoxide, formaldehyde and the carcinogenic compound benzopyrene, higher than exposures received by heavy cigarette smokers.(Smith, 1983) However caution must be exercised. Studies have also shown that efficient stoves can act as gasifiers or pyrolyzers. At times without proper operation of the chimney, it is conceivable that more toxic substances can be released by the combustion within an enclosed stove.(Baldwin, 1985; Environmental Protection Agency, 1980) Studies also reveal that care must be taken to involve the users so that all repercussions of stoves are considered. For instance, studies have indicated that smokey kitchens have in some instances eliminated the plague of mosquitos and thus reduced disease rates.(Cookstove News, Winter 1987) At times the smoke serves the purpose of smoking foods also. When women see these benefits of smoke, there may be hesitation to eliminate smoke in kitchens.

Centro DINOT has estimated that each stove will cost in the order of 2000 Cordobas ($60CAN) to construct. As the calculations of chapter four showed, each household on average consumes 4.4 tonnes of fuelwood annually, at a cost of 1400 Cordobas per tonne. With an efficiency of 30 percent, a potential saving of 2.93 tonnes or 4100 Cordobas annually can be realized. In addition, fuelwood self-sufficiency can be achieved for the average household with approximately one-quarter manzana (0.36 hectares) of fuelwood crops.

6.3.1.3 Solar Grain Dryer

The construction of the grain dryer designed by Centro DINOT requires only cement, wood, re-bar, plastic and paint. All of the materials except the paint and the re-bar are manufactured within the country. The re-bar and paint are materials which are readily available.

The dryer has been designed by the staff of DINOT. Therefore, the staff of DINOT have the expertise to oversee the construction of the dryer. The construction is very straightforward. The members of the community are capable of contributing the necessary labour (masonry, carpentry, etc.).

The operation and maintenance of the dryer is very straightforward also. The only care which has to be taken is to ensure that the plastic sheeting is not torn. The transparency of the plastic will decrease over time due to exposure to the sun. Average useful life of the plastic is estimated to be four to five years.(Personal Contact, Rafael Asevedra, Centro DINOT) The critical component of the dryer, in terms of its durability, is the plastic sheeting. It is easily replaced but is costly. Otherwise the durability is dependent upon the care which the users take with the dryer.

This type of drying technology is proven.(Astrom, 1988; Flavin, 1983; Gustafsson, 1982) Technically there is no major problem. The biggest factor in the success of the dryer is the ability of the community members to organize themselves to take full advantage of the technology. For instance not all of the crop can be dried at once. This means that some type of scheduling of planting, or at least harvesting, of the crop has to be agreed upon. Also, the dryer will be stationary. Some organization will be necessary to allow all of the potential users access to the dryer. Not all of the members of the community have oxen and carts to transport their crop to the dryer.

All of the community will benefit from this technology through a greater yield of the bean crop. In a subsistence community at times a greater yield can mean the difference between going hungry or having food to eat. The men of the community will have an additional benefit because the time and effort spent ensuring a dry crop will be decreased. Properly managed, this technology can be of immediate benefit to the entire community.

The dryer will not have any major effect on the environment one way or the other except in the respect that the successful use of the dryer will mean a reduced pressure on the land as yields are increased.

This technology is by far the most expensive. Centro DINOT estimates that a dryer of approximately fifty square metres absorber area will cost in the order of 400,000 Cordobas ($1200CAN). The plastic sheeting will cost approximately 80,000 Cordobas ($240CAN). This is a recurring cost at least every four to five years. The dryer will be used for a fourteen day period in August and again in

October to dry the bean crop. At a daily capacity of between eight and ten quintals (362 to 453 kg) of beans, assuming a twenty percent saving of the bean crop as compared to patio drying, and a bean price of 500 Cordobas per quintal, (3.32CAN/100 kg) a yearly saving of between 22,400 Cordobas ($76CAN) and 28,000 Cordobas ($84CAN) is possible. A critical factor in the decision to obtain a dryer is also the possibility that a catastrophic loss of the bean crop could occur if there are heavy rains when the harvest takes place. During this study just such a situation occurred. An estimated 80 percent of the bean crop was lost. In this situation, a dryer could have meant a saving of 180 to 224 quintals (8,145 to 10,135 kg) of beans with a value of 90,000 Cordobas ($270CAN) to 112,000 Cordobas ($336CAN). In a subsistence economy, where the loss of this amount of beans cannot simply be replaced by purchasing the same amount, this is indeed a major saving. It is much more significant than the 112,000 Cordobas monetary value.

6.4 ASSIGNING PRIORITY TO THE ALTERNATIVES

The Commission discussed each of the three alternatives. It was decided that all three technologies had merit and that the community should secure financial assistance for each. The three were assigned priority so that decisions could be made in the event that financing for all of the projects could not be found. The alternatives were ranked as follows.

1. Fuelwood Plantation. It was felt that this need was the most widely recognized throughout the community. The members of the Commission were also more comfortable with this technology than any other. It was not entirely new to them. The low cost of this option was also very attractive to the Commission.

2. Introduction of Cookstoves. The returns of this project in terms of fuelwood savings were very attractive to the Commission. However, there was scepticism as to the probability of success of these stoves, given that so called 'improved' stoves had been seen in the community before and had not lived up to expectations. Also, the price per unit of the stoves was a little high.

3. Grain Dryer. This alternative was greeted with the least enthusiasm. Initially, the Commission was very excited with the prospects of a grain dryer. This initial enthusiasm was heightened after the disastrous first bean crop. However, when the cost of the dryer became known, the enthusiasm was dampened considerably.

6.5 IMPLEMENTATION OF PROJECTS

In this section two topics will be discussed in relation to the eventual implementation of the technologies selected by the community. First, the status of the project at the end of the energy study will be reviewed. Second, financing of future projects will be discussed. Now that suitable technologies have been chosen, capital will be needed for implementation.

6.5.1 Project Status

Direct involvement of the study team terminated at the end of August 1988. At the point of termination of direct involvement, the alternative technologies had been reviewed within the Commission and three technologies selected. Discussions had already begun between the community and the Nicaraguan agencies who would supply the technical assistance to implement the selected technologies.

As explained previously, the Commission was very interested in a solar crop dryer, although once Centro DINOT gave the cooperative an estimate of the cost of the dryer, the members were less enthusiastic. The cooperative members decided that before a decision could be made, they should have the opportunity to see a dryer in operation and speak with the users. Fortunately, one other community near the study area had a dryer built in 1987. This community, Aragon, was within riding distance of the study area. The cooperative elected seven members to travel by horse to Aragon to see the dryer and to speak with the owners about its operation. This trip would have taken place the following week, the first week of September.

Centro DINOT offered to construct an indirect type dryer, similar to the one in Aragon. DINOT made it known that it was also possible to adjust the design to accommodate the cooperative if the cost was too high. Unfortunately, Centro DINOT had designed an indirect heating dryer. Studies carried out by a Swedish agency in Nicaragua have shown that a simpler, direct heat dryer was generally more efficient than the indirect type.(Astrom, 1988; Gustafsson, 1982) Nevertheless, a site for the construction of a dryer was chosen. The site was a central location on cooperative land.

The improved cookstove project was approved in principle by the Commission. At the end of August discussions had already taken place with Centro DINOT about the implementation of this project. At the point at which involvement of the study team ceased, the cooperative and Centro DINOT were negotiating the cost sharing for the project, given that it was seen as an experimental project. More detailed cost estimates, of the two types of cookstoves being proposed, were being prepared for presentation to the community.

The Commission had accepted the idea of a fuelwood plantation. It was thought that a plantation of two manzanas would be a good size to begin. A tentative site for a plantation had been selected. It was within an area of idle cooperative land near El Cacao. Further planning details for the plantation were to be addressed at a meeting between the cooperative and IRENA personnel.

6.5.2 Project Financing

As mentioned in the previous section, discussions were begun about the cost sharing arrangements of the cookstoves project. Other details of financing took place with the study team and the Commission.

Discussions with the Nicaraguan agencies, IRENA and Centro DINOT, as well as CEPA, revealed that at this time no funds were available for projects. Only the technical assistance of these agencies could be allotted to a project. As well, no funds were available from the cooperative or the community. The community could supply the necessary labor for projects. The only alternative source of funding remaining was international funding.

At the completion of the study to identify alternative energy technologies, up to and including the selection and assignment of priority to technologies, approximately one thousand dollars remained of project funds. These funds were made available to the study team through the University of Calgary. It was agreed that this sum could be used towards the implementation of specific projects.

When the study team returned to Canada, contact was made with an Alberta based, Canadian NGO, Farmers for Peace. Farmers for Peace agreed to become involved with the project in Nicaragua. A project proposal was drawn up for the community and submitted to Alberta Aid and the Canadian International Development Agency for matching funds. If all matching funds are approved a total of four thousand dollars will be made avaiable for the project.

In conclusion, three groups will be involved in the financing of this project. The Nicaraguan agencies Centro DINOT, IRENA and CEPA will provide the technical assistance to the project; the community will provide the land and labor to complete the project, and the Canadian NGO, Farmers of Peace, will provide the capital for purchase of materials.

CHAPTER 7: CONCLUSIONS

In this chapter the conclusions which have been drawn from this study will be presented. These conclusions will be presented in two categories. First of all, the success of meeting the objectives for the study, which were enunciated in Chapter two, will be evaluated. Second, conclusions specific to the conduct of this study will be presented.

7.1 OBJECTIVES

7.1.1 Identification of Basic Energy Needs.

The first objective of the study was to identify the basic energy needs of the community. This objective was fully achieved. Starting with a process to identify all of the needs of the community (Chapter 4, P. 63), a list of those needs related either directly or indirectly to energy were identified in Table 5. In the final analysis, only those needs directly related to energy were brought forward to be analyzed in the study. Those needs are itemized in Table 6.

7.1.2. Identification of Available Renewable Energy Resources.

The second objective was the identification of the renewable energy resources available to the community. This objective was achieved with a combination of calculations based upon meteorological data, and direct measurements. Significant solar energy potential was identified from meteorological data. Wind potential was identified but its strength was uncertain due to the conflicting sources of data on wind speeds. Hydro power in the study area was negligible. Biomass resources were significant also. Through a combination of measurement in the community and available sources a calculation of the biomass potential of both wood biomass and animal and crop waste was possible. The estimates of renewable energy potential can be found in Table 14.

7.1.3 Matching of Energy Needs and Energy Resources.

The third objective was to match the energy needs of the community with the resources available. This objective was completed by first of all surveying the present energy use in the community. The results of these calculations can be found in Chapter 5. Both the energy quality and quantity were identified. This was followed by an identification of the quantity and quality of energy required to satisfy the needs expressed by the community. With both the required energy and the resources available, an evaluation of the technologies which could fulfill the needs was conducted.

7.1.4 Identification of Potential Technologies.

The fourth objective was to identify technologies which were both possible in the community, and appropriate. First primary criteria of appropriateness, identified by the study team, was that technologies be economically feasible and physically meet the community's needs. Eight such technologies were identified. Second, these technologies were all evaluated based on the Commission's wish to identify technologies which were accessible in the short term. Thus the study team selected three technologies for which there was technical expertise within the country for implementation. Finally, those three technologies were evaluated by the Commission using the eight criteria identified in Chapter 6. The three technologies were considered viable at this time and were ranked in order of priority by the Commission. These were a solar grain dryer, improved cookstoves and a fuelwood plantation.

7.1.5 Incorporation of Public Participation.

The fifth objective of the study was to incorporate an effective public participation component. This was accomplished much as it had been planned. The study team was composed of the study coordinator and a Canadian assistant. The liaison with the community was carried out predominantly with a Commission composed of members of the community. The original plan was to have three community representatives - one from each of the agricultural, household and industrial sectors. In fact there was no real industrial sector in the community. A compromise was reached with the community and a Commission was formed to represent it. The Commission was composed of one representative of each of the five Comarcas that formed the community, the past and present presidents of the community cooperative, and the study team.

The other members of the community were also incorporated into the process in a formal way. The needs of the community were identified by a consultation process which involved both individual interviews with community members and general assemblies in various Comarcas. A more detailed evaluation of the process is presented later in this chapter.

7.1.6 Incorporation of An Education Process.

The sixth objective of the study was to incorporate an education process into the study which would include participation on the study team of a Nicaraguan, either from the community, or training in the area of energy resources. Unfortunately, it was impossible to hire a Nicaraguan to work with the study team. Due to the war, there was a shortage of workers in the rural areas. In the study area almost all families had one young person away from the farm serving military duty. In the short time frame of the study it was impossible to find a person to work with the study team.

However, by virtue of the fact that the study team lived in the community and that there was an emphasis on community participation in the study, some degree of education took place. The Commission members as well as the community in general were introduced to the concepts of renewable energy and sustainable development. The study team observed that through the individual interviews and the general assemblies people became more knowledgeable about what energy was. Whereas originally, people associated energy with electric lights, by the end of the study most people were aware of the other types of energy available to them (e.g. wind and solar) and sources of energy they already use (e.g. biomass and solar).

One way this knowledge manifested itself was in members of the community explaining to others about the study or about the various energy resources available. For example, in the Marlon Alvarado general assembly one man explained to the others how solar energy is enhanced using a piece of glass to concentrate the energy. The fact that the community members gathered to discuss their needs gave the opportunity for the study team to introduce the concepts of renewable energy and sustainable development. During these assemblies many people participated in the discussion of the study's purpose. These discussions included not only attempts to understand the concept of renewable energy but also the notion of self-sufficiency and its benefits to the community.

One particular example of a learning experience involved the president of the co-op. At the start of the study he was very tentative and unclear about the study. For example, he relied upon the past president of the co-op to explain to the members the method to be used to measure fuelwood consumption. However, as the study progressed the president became more confident and knowledgeable. At the point in the study where the Commission had chosen the technologies, he took the lead in explaining the technologies and their benefits to the other members of the cooperative. At the end of the study, meetings were arranged with the technical agencies Centro DINOT and IRENA to discuss implementation of the energy technologies. The president took the lead in the negotiations. The study team at this time purposely withdrew from the process. The president and other members of the cooperative demonstrated a good understanding of the technologies in their discussions with Centro DINOT and IRENA.

Other members of the community who gave volunteer help throughout the study also learned about the procedures involved in energy studies, particularly, the all important fuelwood resource. One member of the Commission, Nora, was involved in the fuelwood measurement. She made the process much easier by accompanying the study team during measurements and explaining to the members of the household what was involved.

7.2 CONCLUSIONS RELATED DIRECTLY TO THE STUDY

7.2.1 Evaluation of the Community Consultation Methods.

The most important aspect of this study was the community participation. Seven points will be addressed in this evaluation. A typology formulated by Goulet is useful in evaluating the first five.(Goulet, 1989) The first point Goulet describes is whether participation is a goal or a means to a goal. The second point is whether participation occurs at the community, regional or national level, and how uniformly it occurs within those constituencies. Third Goulet asks who is the originating agent of the participation. The answer to this question has a bearing on what he calls the 'authenticity' of participation. Fourth, the process can be examined as to what point in the process participation is introduced. Is it an afterthought, or an integral part of the process from the beginning? Fifth, is an examination of where the decision making power lay. The sixth point in the evaluation is a more specific comparison of the two types of community consultation employed in the study. Finally, I include some observations about the importance of establishing a rapport with a community.

First of all, was the participation process of this study mainly a goal in itself or a means to an end. Freire has pointed out that usually there are elements of both.(Freire, 1985) In this study, participation was mainly a means to an end. It was perceived as the most effective means to select alternative energy technologies in the community. However, there were also elements of participation as a goal. The objectives of the study included a process of education derived from the participation itself. On both counts, as a goal or as a means to an end, the participation process should be viewed as a qualified success. The goal of selecting alternative technologies was achieved and some measure of education was achieved. (See Conclusion 7.1.6.)

The second element is the scope of participation. This study was confined to the community level. However, within the community different groups were able to participate to greater or lesser degrees. In particular, because of the manner in which the study team was introduced to the community, through the cooperative, this small group of 40 co-op members was able to participate to a greater extent than other members of the community. Members of the cooperative did represent each of the five Comarcas in the study area. However, only a minority of the members of the community were members of the cooperative. The will existed, within both the leadership of the cooperative, and the study team, to incorporate the entire community into the consultation process. However, because the only organized group within the community was the cooperative, it proved difficult to include the rest of the community to a greater degree than has been described in chapter 4. At times the study found itself reporting to both the Commission and the cooperative. This lack of clarity in community liaison (Is the liaison the Commission or the cooperative?) and the lack of community organization outside of the cooperative, resulted in less than optimum participation by the wider community.

The third point is the evaluation of the originating agents of participation. Goulet defines three possible originating agents of participation. These are government or some other elite authority, an external facilitator, or the community itself. In this case the study team's role was that of an external facilitator. The objective of the study team was to mobilize the community around the issue of energy development. There are abundant examples of development occurring due to the mobilization of a community from within. Examples include the Chipko Movement in India (Bandyopadhyay, 1988) and Villa El Salvador in Lima, Peru. (Durning, 1989) However, there are also many examples of successful development occurring due to the facilitation of an external actor. Examples of this include the Sarvodaya Movement of Sri Lanka (Goulet, 1989; Durning, 1989; Zachariah, 1985) and Base Christian Community Movements of Brazil. (Durning, 1989) As Goulet states, the goal of the external actor is to mobilize the community around some issue and at some point extricate himself or herself from the process which is wholly taken over by the community. It is impossible to make a final judgement on the success of the participation process based on this criterion. Often, communities are very adept at deceiving an investigator as to their interest in a project brought from outside. (Konrad, 1980) However, it is possible to cite two examples which suggest cautious optimism that the community had taken on the process as its own. First, during the meetings with representatives of Centro DINOT, the members of the study team deliberately took an observer's role. The co-op leaders themselves took an active role in clarifying what technical assistance DINOT could offer and on what terms. Second, the members of the co-op took a pro-active stance in deciding to visit a neighboring community to find out about the solar crop dryer they were using.

The fourth point is at what point in a study or project is participation sought. Goulet concludes that participation is more authentic the earlier in the process the community is involved. The earliest stage of a project is the initial diagnosis of the problem or condition. In this study the community was not involved at the initial stage. The study team presented the general problem of energy needs to the community and asked for its participation in addressing it. The process did involve looking at all of the basic needs of the community, but only as a means to extract the energy related needs.

A fifth criterion identified by Goulet, with which to evaluate the effectiveness of participation, is to observe where the decision making power lay. Was it with the study team or with the community? Here again reviews are mixed. The time constraints imposed by the study team dictated that participation of the Commission in all of the decisions was not possible. For example, there was insufficient time to fully explain all of the eight potential technologies to the Commission so that it could participate in the selection of those which were appropriate. Also, the time constraint dictated that the study team formulated the methodology used and simply sought consent of the community to proceed. In these instances the study team was making the decisions. However, the Commission did have an opportunity to voice its concerns at each stage of the process. The community played the major role in designing the community consultation process. The Commission had the final say over what the initial list of needs to be addressed would be. The Commission also made the decisions concerning assignment of priority to the alternatives presented.

The sixth point is an evaluation of the community consultation methods employed. Individual interviews and general assemblies were used to identify the basic needs of the community. If it is assumed that the goal of the consultation was to enter into a dialogue with the community to arrive at a list of its needs, the general assemblies appeared to be a superior method of community consultation. The individual interviews proved to be very time consuming. At times it was difficult to command the attention of the members of the household because there were other chores to be done around the house. Also, frequently either the husband or wife of the family was not available at the time of the visits. In contrast, the general assemblies were a less intimidating atmosphere for the members of the community. It was their choice to attend or not and most households were represented. People were much more willing to express opinions at the assemblies and to discuss the issues among themselves. They also readily asked for clarification and further explanation of points which were not clear. In retrospect, individual interviews appear to have been worthwhile in providing an orientation to the community. This consultation could have been more effective if the investigators were known to the community and a more informal process could have evolved from the visits.

Finally, some observations should be made on the success of the study team in establishing a good rapport with the community. Many development professionals consider this very important to the success of a project. In an address to the New Visions IV Conference held at the University of Calgary in March 1989, Dr. Mel Kerr, of the University of Calgary Division of International Development, spoke of the importance of looking at development as a partnership, or even a friendship. In the literature the importance of a good rapport with the community is also emphasized.(Dankelman and Davidson, 1988) My experience supports these observations. Living in the community and being able to establish the respect and confidence of the members of the community was very important to the success of the project. This manifested itself, for example, in the president of the co-op considering me as an ally in dealing with the technical agencies from Managua and individual members of the community asking to be involved in the fuelwood measurement.

7.2.2 Incorporation of Energy Studies into a Broader Rural Development System

One of the flaws in the approach taken to the study was that although the community's basic needs were identified, only those needs related to energy were addressed. The community consultation involved identification of all basic needs. The needs identified included a school and teachers for La Cruz Verde and an improved road for La Cruz Verde and San Fransisco. The next step was to eliminate those needs not related to energy including the school, teacher and the improved road. For some members of the community the needs which were eliminated were undoubtedly some of the most important. By eliminating those, the enthusiasm of the community for the process has to be dampened.

A broader perspective would be more appropriate. Dankelman and Davidson point out many instances where integrated development approaches have proven very effective.(Dankelman and Davidson, 1988) This approach allows for the consideration of several objectives at the same time. If a situation existed such that a community development facilitator worked with a community, all of the basic needs could be addressed and the required technical expertise could be sought when nesessary. In this scenario, a dialogue within the community would be a prerequisite to the implementation of concrete projects, whether they be in water, energy or education. For example, perhaps education would be the most pressing need of the community. If a consensus were reached that education was the top priority, the enthusiasm of the majority of the community could be focused on this need. Once this need had been addressed, the community could focus on other needs. Eventually the focus would go to water, health care or energy. In my opinion, integrated rural energy development would be more effective in this type of broader rural development scheme.

7.2.3 Integration of Agencies with Technical Resources and Those With Community Development Resources

One method which could achieve an integrated development approach is for NGO's with diverse mandates to form alliances. In Nicaragua there are many NGO's. Many of these NGO's are either technically oriented or education oriented. Examples of technically oriented agencies are Centro DINOT and IRENA with technical expertise in reforestation and renewable energy development. Likewise, CEPA and CEPAD (the development agency of the protestant churches) are two organizations which are education oriented. They concentrate on community organization and human resource development. From the experience gained in this study, working with both CEPA as a host organization and with IRENA and Centro DINOT, it was evident that both organizations would benefit from a greater degree of cooperation. More importantly, the rural people with whom they work would benefit from such cooperation.

Although the direct involvement of the study team with CEPA was minor beyond the introduction to the community, even this link gave the study team credibility within the community. CEPA is a respected grassroots organization which can relate to the rural people. However, development also involves progress in technical areas such as energy and water management. IRENA and Centro DINOT have the expertise in technologies appropriate to rural areas. They are not as proficient in community organizing, human resource development and group facilitation. This deficiency manifested itself in attitudes of the rural people towards them. The study team observed that often the rural people showed a lack of confidence in these technicians from Managua.

Konrad has addressed this rural - urban gap in relation to rural communities in Mexico. (Konrad, 1980) This problem has also been identified by CUSO development workers in Tanzania. While the opportunities exist in Tanzania for genuine community participation, the people have become disenchanted since often no concrete improvements have been forthcoming from the participation. (Personal Communication, Brenda Naylor, CUSO volunteer) It would be beneficial for both technical and community development NGO's to forge closer, more formal links. The individual strengths of both organizations could be combined to enhance the success of rural development projects.

7.2.4 Introduction of Key Concepts to the Community

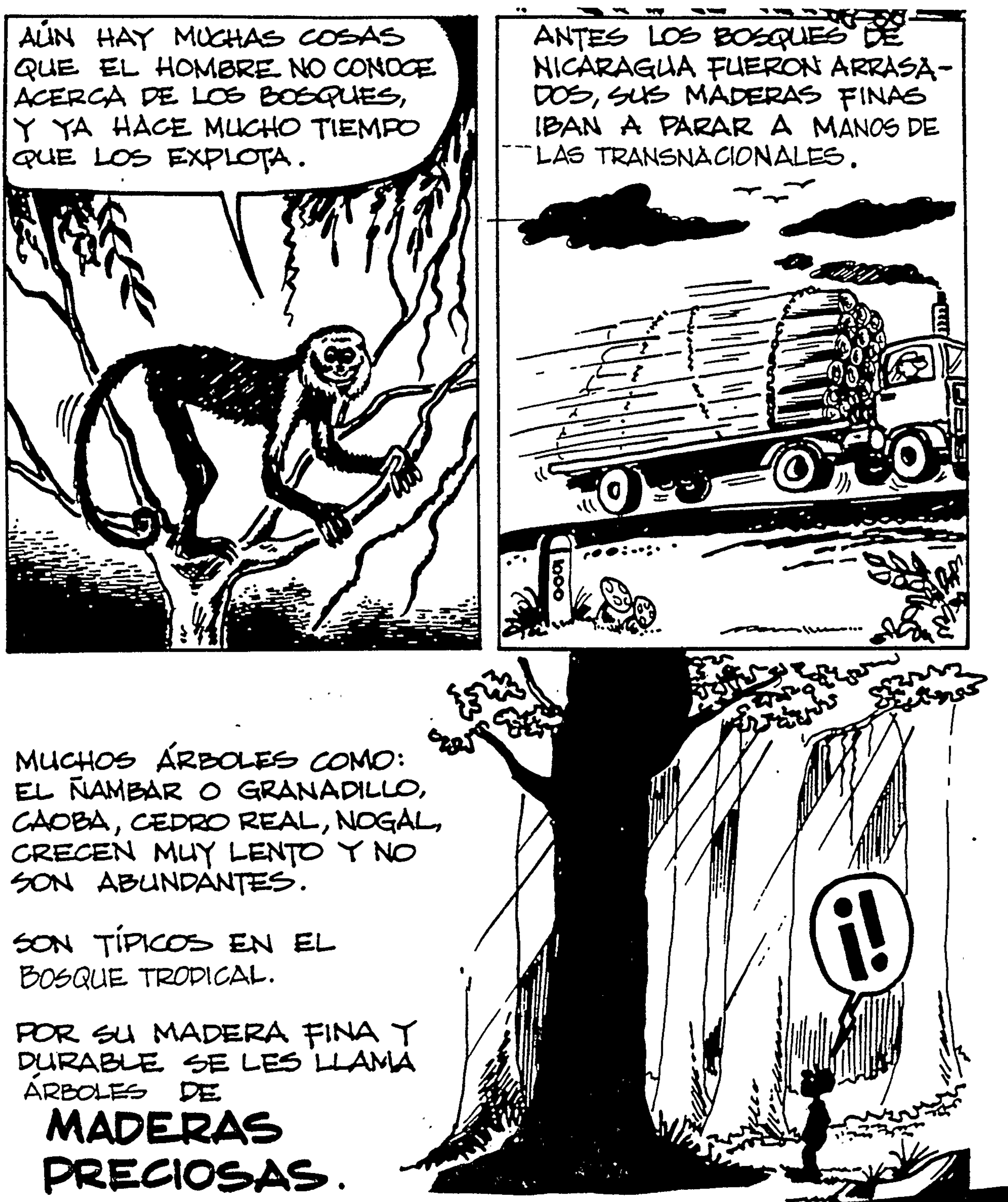
One weakness of this study was the way in which the concepts of renewable energy development and the technologies employed were introduced to the members of the community. In the course of the study, the study team had the opportunity to meet other people involved in rural development projects from water supply to reforestation. These interactions provided the study team with an insight into other teaching methods which had proven successful in other areas. Some of these could be incorporated into energy development. Two tools in particular which could have improved the study were the use of physical models and popular education materials.

Models have been used very successfully in the introduction of appropriate water supply technologies.(Brown, 1985; Personal Contact, Jan Haemhouts, INAA, Managua) Models, either full scale or miniature, have been used to demonstrate the operation of various pumps. For example the rope pump has been demonstrated very successfully. Presently, this technology is spreading throughout rural communities at the impetus of farmers themselves. Not only is the technology being propagated but innovations are occurring as each community adopts the technology.(Personal Communication, Jan Haemhouts, INAA, Managua)

Popular educational materials have also proven very effective throughout Nicaragua. These materials are produced to address problems encountered in rural areas such as soil erosion. They are produced within the country. They use themes familiar to the rural farmers, in language which they understand, and usually with a great deal of humor. An example of one of these popular education materials is contained in Figure 10. This type of education material would be very useful as part of an integrated rural energy development in explaining key concepts such as renewable energy and sustainable development.

One other tool for popular education which is used very extensively in Nicaragua is popular theatre. Through popular theatre many issues within the community are dealt with. These include social analysis and dissemination of technology. In the community of Santa Cruz, the dissemination of the rope pump technology was achieved in part through methods of popular education demonstrating the benefits of the pump. (Personal Communication, Marta Lorena, CEPA) In 1984 I experienced popular theatre in action in the northern Nicaraguan community of Achuapa. The church is a major actor in the personal lives of Nicaraguans as well as politically at all levels. The local theatre group in Achuapa used theatre to analyze the role of the church in its community. Popular theatre has also been used in the study community to address the problem of machismo. (Personal Communication, Antonio Vega Lopez, Cooperative President)

FIGURE 10: EXAMPLE OF POPULAR EDUCATION MATERIALS



IRENA, 1988

CHAPTER 8: RECOMMENDATIONS

This chapter sets out a proposal for a revised methodology for integrated rural energy systems. Such a methodolgy was used for this study. However, with the experience gained in the execution of the study, it has been revised in the following proposal.

The proposal elaborated in this chapter is an attempt to use the experience gained in the study carried in Nicaragua, to contribute to the work of the Brace Research Institute and the Integrated Rural Energy Systems Association. The Director of the Institute, Tom Lawand, and various researchers at the Institute; The United Nations University and many practitioners in developing countries have proposed strategies for rural energy development.(Kandpal, 1987; Ives, 1986; Lawand, Coffin, Alward, n.d.)

It should be noted that this proposal encompasses only the first stage of a complete integrated rural energy strategy. That first stage concludes with the selection of appropriate technologies for a particular community under study. Lawand, Coffin and Alward outline a general methodology which deals with the entire energy development from selection to installation and monitoring of technologies. (Coffin, Alward, Lawand, n.d.)

The following outline is recommended as a participatory process by which communities can evaluate energy usage and

2. Management of the Study

Control of the decision making should remain in the hands of the community. In this way the relevance of decisions can be assured. Also, the energy and support of the community members, which will be required to complete the project, can be assured. The actors in this process can be divided into three categories.

First, the study should include the outside study team which will provide the technical expertise. Second, there should be a liaison between the study team and the community. The liaison group would be responsible for working with the study team throughout the study. It would bring concerns of the community at large to the study team. It would also represent the community in the study and be the group which is charged with decision making for the community. Interests within the community to be considered in this liaison group include:

1. the agricultural, household and industrial sectors of the economy,
2. men and women,
3. young people,
4. large landowners, small landowners and agricultural workers,
5. other interested community organizations.

Third, participation of the general population should also be incorporated into the study. There are a variety of methods to incorporate the community's participation. These methods include:

1. individual interviews,
2. general assemblies,
3. popular education techniques (e.g. theatre).

Education should be an integral component of the participatory process. This fact is stressed in much of the literature on participation (Goulet, 1989; Dankelmann and Davidson, 1988; Freire, 1985; Harrison, 1983; Mackie, 1981) Both the <u>World Conservation Strategy</u> and <u>Our Common Future</u> emphasize the importance of education if a sustainable future is to be achieved. Chapter 2 contains a review of the literature on this subject. An integrated approach to energy development should recognize the importance of education. In particular, attention should be given to an approach which will facilitate the comprehension within the community, of energy related concepts. This approach should be culture specific and maybe even community specific. Three of the key concepts which should to be addressed are:

1. energy,
2. sustainable development,
3. integrated energy planning.

Lack of sufficient consideration of the importance of establishing a base of common understanding with the community (e.g. what does energy mean?) presented problems at the start of the study discribed in this MDP. Various tools can be used to introduce these concepts. These tools include:

1. physical models,
2. popular education materials,
3. popular theatre.

Examples of successful application of each of these techniques are found in Nicaragua, and are reported in chapter 7.

3. Establish Objectives of the Study

The objectives of the study should be established in consultation with the community representatives. The objectives should be consistent with the goals of sustainable development and energy self-reliance.

4. Profile of the National Environment within which the Project will Operate.

This profile will include:

1. the national energy profile (i.e. type of energy used, quantity of energy used, planned energy development, government energy policy),
2. the relevant bio-physical characteristics of the study area,
3. the relevant ecological problems of the study area,
4. the institutions, non-governmental agencies (both national and international), and government

agencies involved in energy planning within the country,

5. industrial infrastructure within the country which could support the manufacture and maintenance of energy technologies.

5. Profile of the Community Where the Study Takes Place.

This profile should include:

1. industrial capability available within the community relevant to the manufacture and maintenance of energy technologies,
2. demographic characteristics of the community,
3. economic profile of the community,
4. relevant transportation and communications infrastructure available to the community,
5. education levels of the community including an identification of skills within the community relevant to the development of energy technologies,
6. identification of key actors or organizations within the community.

6. Identification of Basic Energy Needs

If an integrated development project is under way in the community it may be possible to start with a list of basic needs which has already been defined and select those needs which are energy dependent. If not, it will be necessary to begin with a community process to identify the needs. There are at least two methods to achieve this.

First, individual interviews with community members can be conducted along with a follow-up review carried out with the community representatives. In this way a broad base of opinion concerning the needs of the community can be gathered.

Second, community meetings can be conducted with a follow-up review by the community representatives. Members of the community again have the opportunity to voice their concerns. The advantage of this approach is that it allows for interaction of the community members. There is the opportunity to discuss the issues among themselves and better define the needs.

Once the basic needs have been defined, they can be divided into categories of needs which are related directly to energy, indirectly to energy, or not energy related at all. Presumably the final list of energy related needs will be composed of either the directly related needs only, or the directly and indirectly related needs.

7. Present Energy Use in the Community

The present energy use in the community is important to provide a base from which to plot the future energy strategy. This inventory will include human energy, animal energy, renewable sources such as biomass and non-renewables such as diesel fuel. Sources of such information will vary from government records for diesel consumption, to direct measurement of fuelwood consumption.

8. Available Renewable Energy in the Community

The sources of renewable energy within the community may include wind, solar, biomass and water. The potential of these resources can be compiled from three sources.

1. Historical data on the site in question may be available from government, aid agencies, or development agencies.
2. Data from similar sites can be extrapolated to estimate the resource at the site in question.
3. Field measurements can be taken. Depending on the constraints of the particular project, these may be one time measurements, which can be projected over the long term, or they may be long term measurements.

9. Basic Energy Requirements to Meet Energy Needs

From the list of energy related needs previously defined, a calculation of energy requirements to fulfill those needs can be made. As well, the quality of each energy requirement should be identified. (e.g. mechanical, electrical, low grade heat).

10. Potential Alternative Technologies

Once the energy needs and the available resources are identified, the existing conversion technologies which can supply the quantity and quality of energy required can be identified. At this point in the process the criteria applied to potential technologies should be (1) some general sense of economic feasibility and, (2) that they be technically feasible.

11. Evaluation and Selection of Appropriate Technologies

The list of potential technologies should be evaluated based upon a set of criteria of appropriateness drawn up by the study team and the community representatives. Many of these criteria will be specific to the particular community. The following is a list of some of the criteria which should be considered for the evaluation.

1. Economic costs and benefits.
2. Availability of materials needed to manufacture the technology.
3. Availability of technical expertise to assist the implementation of the technology.
4. Availability of expertise to operate and maintain the technology.
5. Durability of the technology.
6. Probability of success of the technology.
7. Affects on the environment of the technology.
8. Who will operate and who will benefit from the technology?
9. Will the technology enhance or decrease the self-reliance of the community?
10. Will the technology promote the development of small business in the community?
11. What level of community organization will be required to make use of the technology?
12. Does this technology fit into the energy plans of the region or country?

These technologies should be chosen based upon their appropriateness as measured by the set criteria. In addition, the technologies should be ranked in order of priority. This ranking will reflect the perceived needs of the community. At times this may result in a compromise between what the energy 'experts' may feel is important, and what the community decides is important.

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APPENDICES

APPENDIX 1: SUMMARY TABLES OF RELEVANT INDUSTRIAL INFRASTRUCTURE

TABLE A1 - INDUSTRIES OF THE DEPARTMENT OF CARAZO

PLASTINICA - This business is state run and produces many types of plastics. It produces mostly bags for products such as milk. However, in the past it has also produced a plastic which has been used for solar grain dryers. Production is very sporadic at present because of a chronic shortage of chemicals for the process. This is the only plant of its kind in the country.

HULESA - This is state owned company which produces a variety of rubber products.

FIBRATEC - This privately owned company produces textiles.

MADECASA - This privately owned company produces lumber from a local forestry operation.

FABRICA de CONSTRUCCION CEMENTAL - This privately owned company produces concrete products including clothing washers and stoves.

SACSA - This privately owned company produces cloth products; predominantly sacks.

FABRICA de MATERIALES de CONSTRUCCION - This privately owned company produces concrete construction blocks.

INTERCASA - This privately owned company produces barbed wire.

PROCESADORA de ARENA - This privately owned company produces refined sand for construction.

FABRICA de BICICLETAS - This privately owned company assembles and refurbishes approximately 70 bicycles annually.

TABLE A2 - INDUSTRIES FROM THE ENERGY CONSERVATION STUDY

#32 - Textile, Clothing and Leather Industries

Industry	Product	Annual Production
FANATEC	cloth	7,745 m
PROSAN	cotton	184,649 kg
	gauze cloth	363,085 m
TENERIA BATAAN	cowhide	67,380 hides
TEXNISA	thread	1,898,395 kg
	fabric	6,636,807 m
TEJIDOS NICARAO	thread	158,209 kg
COTEXMA	textiles	405,928 kg

#33 - Wood

PLYWOOD DE NICA.	plywood sheet	9,990 cubic metres
	doors	500 cubic metres

#35 - Basic Chemicals, Soaps and Perfumes

ELECTROQUIMICA	caustic soda	14,075 tonnes
PENWALT	chlorine	4,460 tonnes
	NaCl2	12,000 tonnes
	H2S	9377 tonnes
POLYCASA	PVC resin	4,275 tonnes
	PVC compound	3.3 tonnes
ESSO	pesticide solvent	---
QUIMICA BORDEN	formaldehyde	3,276,270 kg

#36 - Cement and Concrete

COMPANIA NACIONAL PRODUCTORA de CEMENTA	cement ---	173,050 tonnes ---
MAYCO	cement	14,750 tonnes
	paving block	7,484,228 units
	cement block	1,009,000 units
	prefab concrete	9,405 tonnes
	other	1,965 tonnes

#38 - Structural Metal Products

METASA	angles and tubes	8,450 tonnes
	structures, tanks	5,740 tonnes
	steel rods	3,840 tonnes
INCA	barbed wire	6,270 tonnes
	regular nails	2,375 tonnes
	galvanized mesh	586 tonnes
	galvanized clamps	423 tonnes
	copper hoops	397 tonnes
	roof nails	210 tonnes
	construction steel	13,800 tonnes

APPENDIX II: QUESTIONNAIRE RESULTS

The questionnaire of Table 4 was used in household visits in the Comarcas of La Union and San Fransisco. Approximately 40 households were visited over a two week period. This was the study team's first introduction to the community outside of the cooperative. As such, the questionnaire did not provide an abundance of detailed information to the study team because: (1)the study team was not familiar with the study area; and (2)the people of the study area were not accustomed to North American internationalistas living in their community.

What the questionnaire did accomplish was to introduce the study team to the community. The responses received enabled the study team to formulate a general picture of the community, introduce the study, and document the perceived needs of the Comarcas of La Union and San Fransisco. This informal process helped prepare the study team for the general assemblies. Below is a synthesis of the responses received. The percentage responses reported should be viewed as estimates derived from informal conversations with the members of the households, not as exact figures.

Questionnaire #1

QUESTION 1. HOW DO YOU DRY YOUR CROPS?

All households dry the crop in the open air patio style, or sell them directly to the state agency, ENABUS, where they are dried in the diesel powered dryers.

QUESTION 2. HOW MANY MANZANAS DO YOU HAVE CULTIVATED ANNUALLY?

The average landholding is approximately three manzanas.

QUESTION 3. WHAT PERCENTAGE OF CROPS DO YOU LOSE DUE TO INSECTS, MOISTURE OR FUNGUS?

Crop loss estimates ranged from ten to twenty percent.

QUESTION 4. WHAT TYPE OF CROPS DO YOU PLANT?

Eighty percent of households plant only beans and corn. Twenty percent supplement these crops with sugarcane, rice, yucca(a root crop) or wheat.

QUESTION 5. HOW MANY PEOPLE LIVE IN THE HOUSE?

The average household has five to six people.

QUESTION 6. DO YOU CUT YOUR WOOD?

Ninety percent of the families in La Union buy their wood; ten percent cut it. Forty percent of the households in San Fransisco cut their own wood, and 60 percent buy it.

QUESTION 7. IF YOU CUT YOUR WOOD, WHERE DO YOU GET IT FROM? IF YOU DO NOT CUT YOUR OWN, WHOM DO YOU GET IT FROM? WHERE DO YOU GET IT?

Those who cut their own wood, cut it from their own land. Those who buy their wood, buy it from local wood merchants or neighbours with forested land available.

QUESTION 8. HOW MUCH DOES WOOD COST?

The cost of wood ranges from $2.40CAN to $8.40CAN per tonne. This is a very rough figure. With an annual inflation rate of over 10,000 percent in Nicaragua, it was difficult to estimate costs.

QUESTION 9. WHAT TYPE OF TREES DO YOU USE FOR FIREWOOD?

Many species were reported. All have local names and it was impossible to obtain the scientific names of many species. The most commonly used species include: Chapino; Acetuna; Madrono (Calycophyllum candidissimum); Madero Negro (Gliricidia sepium); Laurel; Quebracho (Lysiloma Seemannii); Guacimo (Guazuma ulmifolia) and Nispero.

QUESTION 10. DO YOU PLANT TREES? FOR WHAT PURPOSE? WHAT TYPE?

Twenty percent of households reported that they had planted trees in the last five years. Most often fruit trees such as aguacate or orange are planted. Often trees are planted not only for the fruit, but as a wind break.

QUESTION 11. HOW DO YOU SPEND A TYPICAL DAY?

All the homes visited function traditionally. The mother of the family does the household chores including washing, childcare, and fetching water and firewood. The men spend the day working in the fields.

QUESTION 12. WHAT TYPE OF TOOLS DO YOU HAVE AVAILABLE TO YOU?

The only agricultural tools used by the men are the machete, the hoe and the ox-plow.

QUESTION 13. HOW MANY CATTLE DO YOU HAVE?

On average each household has two cattle.

QUESTION 14. WHAT TYPE OF TRANSPORTATION DO YOU HAVE?

One-third of households have an ox and cart. Two-thirds of households have a horse. The horse is the most common form of personal transportation.

QUESTION 15. WHAT ARE THE BIGGEST PROBLEMS YOU HAVE HERE IN THE COMMUNITY?

The problem cited most often in La Union was the lack of firewood. In San Fransisco, firewood was a problem also. Other problems in San Fransisco included poor roads; lack of a school and a teacher, and lack of access to potable water.

Questionnaire #2

QUESTION 1. DO YOU HAVE A SYSTEM OF IRRIGATION?

Neither of the Comarcas has an irrigation system.

QUESTION 2. WHAT ARE YOUR RESPONSIBILITIES AS A MEMBER OF THE CO-OP?

Co-op members are responsible for contributing labour to the land which is farmed communally. They are also expected to take on positions of responsibility. (i.e: president, vice-president, treasurer, etc.)

QUESTION 3. HOW MANY PEOPLE LIVE IN YOUR COMARCA?

No accurate figures of population were reported. This data eventually was obtained from the regional government offices.

QUESTION 4. ARE THERE ANY MECHANICAL WORKSHOPS IN THE COOPERATIVE?

No mechanical workshops exist in the cooperative.

QUESTION 5. WHAT DO YOU THINK YOU CAN DO ABOUT THE PROBLEM OF FIREWOOD?

All of the co-op members felt that one solution to the firewood problem was to plant more trees. Two or three members suggested they would like to see propane gas cookstoves in the community.

APPENDIX 3: EFFICIENCY CALCULATIONS FOR OPEN FIRE COOKING

Constants

1. Density of water = 1,000 kg/m3
2. Heat to raise temperature of 1 gram of water 1 degree celsius = 1 calorie
3. Heat of Vapourization of Water = 536 cal/gram
4. Heat Energy of Wood = 4,800 cal/gram

Materials Used

Weight of Wood = 33.8 kg
Weight of Pot = 6.5 kg
Weight of Pot and Water = 24.9 kg
Weight of Water = 18.4 kg
Estimated original water temperature = 20 degrees celsius

Procedure

The iron pot was filled with water and placed over the fire. A woman in the house tended the fire in order to simulate the cooking style as closely as possible. The fire was begun at 6:30 AM and extinguished at 1:15 PM. Total time of operation was six hours and 45 minutes. The pot was weighed empty, filled with water and weighed, and weighed at the end of the experiment. The wood was also weighed before and after the experiment.

Calculations

Weight of Wood	= 33.8 kg
Remaining Wood after experiment	= 14.0 kg
Wood Consumed	= 19.8 kg

Original Weight of Water and Pot	= 24.9 kg
Final Weight of Water and Pot	= 9.0 kg
Water Consumed	= 15.9 kg

Heat to raise water temp. to 100C
= 1 cal/g-C * (100-20)C * 18,400 grams consumed
= 1,472 Kcal

Heat to vapourize water
= 536 cal/g * 15,900 grams vapourized
= 8,522.4 Kcal

Total energy transferred to water
= 1,472 Kcal + 8,522.4 Kcal = 9995 Kcal

Energy expended in wood
= 4800 cal/g * 19,800 grams = 95,040 Kcal

Efficiency of Delivery of heat to the water

$$= \frac{9995 \text{ Kcal}}{95,040 \text{ Kcal}} = 10.5\%$$