AGROFORESTRY OPPORTUNITIES AND CONSTRAINTS IN THE ÁGUA DE GATO WATERSHED, SANTIAGO, CAPE VERDE ISLANDS

by

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Thesis Submitted to the Faculty of

Virginia Polytechnic Institute and State University

College of Forestry and Wildlife Resources

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

IN

AGROFORESTRY

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August 23, 1996

Blacksburg, Virginia

Keywords: Cape Verde Islands, Extension, Agroforestry, Social forestry, Land uses,

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ABSTRACT

The objectives of this study were to determine the opportunities, constraints and willingness of the inhabitants and non-resident landowners to adopt a new land use system in the Água de Gato Watershed, to determine the degree of agroforestry technical support available to farmers in the watershed, and to determine suitable agroforestry systems which can be adapted to the watershed according to its biological and physical conditions.

A random group of farmers of the Água de Gato Watershed and a group of technicians working on the island of Santiago were interviewed in order to get individual and general information about the farms the and practice of agroforestry in the watershed. Only 56% of the technicians knew or had some knowledge about agroforestry, and the farmers think that they do not have enough technical support for better development of agriculture in the watershed. Although most of the farmers had a small piece of land, averaging 1.1 ha, most of them, 92%, were willing to adopt an agroforestry system as a new land use system for their farms.

According to the bio-physical-sociologic conditions of the watershed, four systems, homegardens, multistory tree gardens, soil conservation on edges with some multipurpose trees, and fuelwood production (wood lots) with some possibility for fodder production, were selected as choices for future land use systems to be implemented in the watershed.

ACKNOWLEDGMENTS

I would like to thank my major adviser, Dr. James E. Johnson for his continuous support since the first day of school in the fall of 1994, when I arrived in his office without notice, and Drs. James R. McKenna and W. Michael Aust for their help and support as committee members. I, also, would like to extend my thanks to the family Silva-Barbeau, for being very supportive during the two years I stayed in Blacksburg; to Jill Johnson, for helping me with the typing; and to the faculty, staff and graduate students of the College of Forestry and Wildlife Resources. I would especially like to thank Chris Davidson and Steve Shaffer for their support in the area of computing. All these people, really, contributed to make me feel more at home.

This project was made possible by funding from the USAID/Praia-C. Verde Islands. Special thanks goes to SANREM-CRSP/INIDA/DGASP whose assistance and support made the field work in the watershed more efficient and my stay and that of my adviser more comfortable. I also would like to thank all the farmers from the Água de Gato Watershed and the technicians who I interviewed, for being friendly and collaborative.

Special acknowledgment goes to my wife, Maria Fonseca Delgado, who loved and encouraged me during those stressful days I stayed alone in Blacksburg, and to my parents, brothers, and sisters who did also.

Finally, I would like to thank my sons, Guillian, Rovaldo, and Humberto, and nephews/nieces, who were always in my mind reminding me about their future and the meaning of life.

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INTRODUCTION

Cape Verde is a small country formed by ten islands and eight islets, in the Atlantic Ocean, 455 km off the west coast of Africa and 1,400 km southwest of the Canary Islands (latitude 14° 48' to 17° 12.5' north, longitude 22° 44' to 25° 22' west, Figure 1). The total land area is 4,033 km^2, but Cape Verde has an exclusive economic zone, which includes the surrounding ocean, of 734,265 km^2. The country's 423,120 inhabitants are 55% rural.

The Cape Verde Islands are divided into two groups based on wind patterns: *Barlavento*, or the northern windward group, which includes the islands of Santo Antão, São Vicente, Santa Luzia (uninhabited), São Nicolau, Sal and Boavista; and *Sotavento* or the southern leeward group consisting of the islands of Brava, Fogo, Santiago and Maio. The Sahelian climate is influenced by three wind currents: the northeast wind, which has a desiccating effect on the low plains and the lower exposed slopes, and a beneficial effect at higher elevations, usually 600 m above sea level, on the north and northeast slopes on the mountainous islands of Santo Antão, São Nicolau, Santiago, Fogo and Brava. The very hot and dry east wind or *harmatan*, which blows occasionally for a short period, has more effects on the oriental islands of Sal, Boavista and Maio. The hot and humid southwest wind causes the summer rains on all the islands.

In Cape Verde, only 10% of the total land area is suitable for agriculture. The agricultural land is distributed as follows: 2,000 ha irrigated and 38,000 ha rainfed, receiving less than 400 mm of rain annually. Agriculture is primarily for subsistence, and in regular rainfall years it can account for as much as 40% of the domestic food

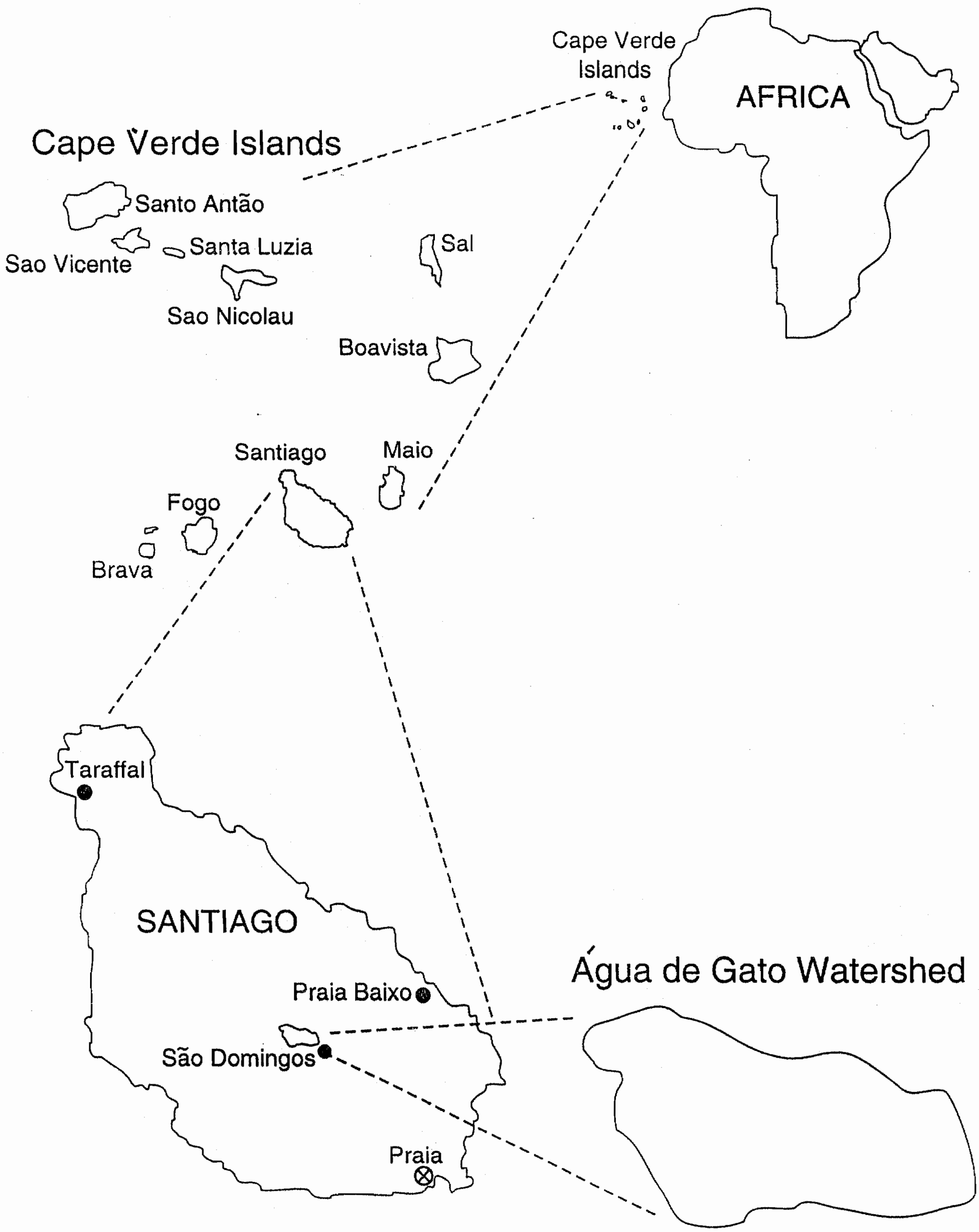

Figure 1. Map of the Republic of Cape Verde and the Água de Gato Watershed.

consumption. Although, the agricultural sector employs 50% of the population, it generates only 15% of the gross domestic product.

The islands were discovered by the Portuguese in 1460, and soon after settlement was started, they quickly became important in the slave trade. Slaves were taken from the coast of Africa to the Cape Verde Islands, where they would remain for some time before being sent to Brazil and other points in the New World. In order to produce products for exchange, to feed and house its own population and the transient slaves, the islands' natural resources were heavily exploited.

Presently, over-exploitation of the land (overgrazing, fuelwood collection, and deforestation), in connection with unsuitable land utilization, is accelerating the degradation of the soils and other natural resources throughout the country. In order to overcome this problem, in addition to a successful reforestation program and planting of trees along roads (Figure 2), new productive and sustainable land use systems must be developed and tested. Agroforestry is an example of a land use system that will meet the multiple objectives of producing food and fuel on a sustainable basis.

For this study the Água de Gato Watershed, situated on the island of Santiago, 18 km from the capital city of Praia, was chosen as the experimental site. The Água de Gato Watershed occupies an area of 350 ha with a population of 957 inhabitants (177 families) and has an annual precipitation of 300 to 500 mm. The principal activity of the inhabitants is farming, which includes crop production and animal husbandry. In the watershed, 50% of the land belongs to the Catholic Church and the other 50% is owned outright by residents or held in partnership with other landowners.

The Sustainable Agriculture and Natural Resources Management Collaborative Research Support Program (SANREM CRSP) has been working in projects around the

Figure 2. Side road plantation with neem and royal poinciana for shade and aesthetic purposes.

world trying to find new solutions for environmental problems and promote sustainable agriculture and better management of natural resources. More effort has been put in the humid and semiarid tropical regions of the third world countries, such as the Philippines, Burkina Faso, Cape Verde, Honduras, Costa Rica and Equador, where degradation is still very high. SANREM CRSP, in conjunction with other organizations, such as the U.S. Agency for International Development (U.S. AID), has been trying to mitigate degradation problems that have been resulting from over-exploitation of natural resources.

In Cape Verde, with U.S. AID support, SANREM CRSP started its activities in 1994, through initiation of the Água de Gato Watershed Project. This project, conducted in cooperation with various Cape Verdean agricultural agencies, is intended to support research to improve agriculture and natural resource management in the test area, and to develop knowledge which will apply elsewhere in the country.

RESEARCH OBJECTIVES

The objectives of this project are:

1. to assess the opportunities, constraints and the willingness of the inhabitants and non-resident land owners to adopt agroforestry in the watershed.
2. to determine the degree of agroforestry technical support available to farmers in the watershed.
3. to propose acceptable agroforestry systems which can meet the objectives of Água de Gato Watershed farmers.

LITERATURE REVIEW

General Background on Agroforestry Systems

Agroforestry is a form of land use where woody perennials (trees, shrubs, palms, bamboos, etc.), agricultural crops, and/or animals are deliberately grown together, in some form of spatial arrangement or temporal sequence. Both economic and ecological interactions occur between the different components (land, environment, agriculture, forest and management strategy) (Lundgren and Raintree, 1982). Young (1983) defined agroforestry as “any land use that maintains or increases total yields by combining food crops, livestock production, and forest crops on the same unit of land, alternately or simultaneously, using management practices that suit the social and cultural characteristics of the local people, and the ecological and economic conditions of the area”.

Although agroforestry is a new name, the system itself has been practiced since ancient times throughout the world. In tropical Central America, farmers have for a long time intimately grown various plants together, each with a different structure, in a close imitation of layers of a mixed tropical forest (Wilken, 1977). In Asia, during shifting cultivation practice, individual multipurpose trees are left standing for shade, food, medicines, construction wood, and cosmetic purposes (Conklin, 1957). In Africa, various plants are grown together in a close imitation of layers of a mixed tropical forest. Yams, maize, pumpkins, and beans are grown under a sparse tree cover (Forde, 1937). In the temperate zones, grazing animals under forest cover is an old practice.

The new phase of agroforestry began in the 1970s. Although the practice is very old it was not accepted as a system of land management applicable to both farm and forest, for all those years. Many factors contributed to the changes:

- World Bank re-assessment of development policies;
- Food and Agricultural Organization (FAO) of the United Nations reexamination of forestry policies;
- Scientific interest in agroforestry systems;
- The food shortage and quick deterioration of food supply in many developing countries;
- The rapid increase of deforestation and ecologic degradation;
- The energy crisis and as a consequence the rapid increase in price, and decrease in supply of fertilizer; and
- The establishment, by the International Development Research Center (IDRC) of Canada, of a project which has as its main goal the identification of tropical forestry research priorities (Nair, 1993).

Since then many organizations have developed projects for understanding and improving indigenous agroforestry systems. These include The International Institute of Tropical Agriculture (IITA), and The International Council for Research in Agroforestry, which helped to institutionalize the system in 1977. Many of these individual institutions have contributed to the development of agroforestry knowledge, but The International Council for Research in Agroforestry which was renamed as The International Center for Research in Agroforestry (ICRAF) in 1991, has been the leading institution in the development of agroforestry.

Agroforestry is a land-use form, more complex than monocropping, which normally involves two or more plant species and/or animals. In agroforestry one of the plant species is a woody perennial. Unlike traditional agriculture, in agroforestry the cycle is always more than one year, with always two or more outputs. Many agroforestry systems exist around world. However, the practice of agroforestry is most common in the tropics.

Based on the nature of its components, which can be managed by the farmers, agroforestry can be classified according to the tree or woody perennial, the herb (agricultural crops including pasture species), and animals (Nair, 1993) (Figure 3):

- Agrisilviculture - Combination of agricultural crops and trees;
- Silvopastoral - Combination of pasture, animals and trees; or
- Agrosilvopastoral - Combination of agricultural crops, pasture, animals, and trees.

Agroforestry can also be classified according to the function of the system (role and output of components), agroecological zones, and socioeconomic scales and management levels of the system (Nair, 1993). Many authors have classified various systems according to different criteria (Wilken, 1977; von Maydell, 1979; Seif-el-Din, 1981; Getahun et al., 1982; Lundgren, 1982; Montagnini, 1986; Le Houerou, 1987; Nair, 1989; MacDicken and Vergara, 1990; and Zhaohua et al., 1991).

The main agroforestry systems, agrisilviculture, silvopastoral, and agrosilvopastoral can be divided into more narrowed systems, according to the components, purpose and function. *Shifting cultivation and improved fallow* is a system in which land is cleared of its natural vegetation and planted with agricultural crops for few years and then abandoned, to naturally regenerate itself. After being opened, the land is often cropped for two to three years before being left in fallow for a period of 10 to 20 years. Usually, the clearing of the natural vegetation is accomplished by using the slash-

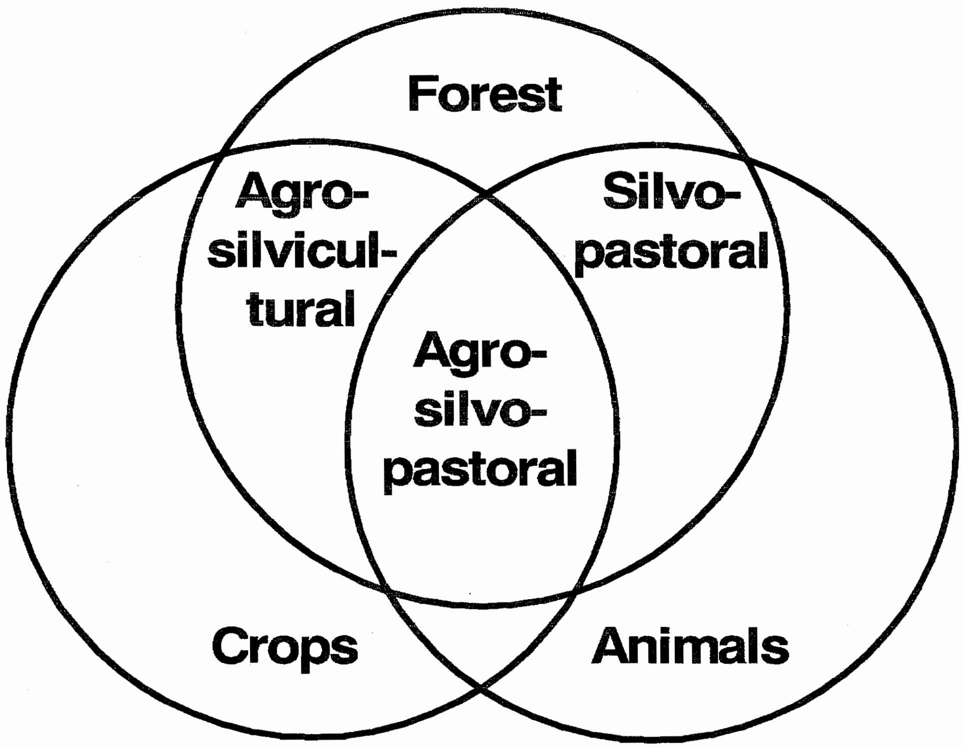

Figure 3. Classification of agroforestry systems based on the nature of its components (forest, crops and animals).

and-burn methodology. During the process of clearing the land some useful trees are left standing for future use. Those trees might be, later on, pruned periodically to diminish competition, especially for light.

After a few years of cropping, the soil begins to lose its fertility. As a result, the production becomes low and the farmer is forced to abandon and move to another spot, leaving the old one in a fallow condition in order to regain fertility. During the fallow phase, trees which naturally regenerate on the land will function as nutrient pumps. They extract nutrients from deep soil and deposit them at the surface as litter. Later on the nutrients are released from the litter and made available to plants. Various reports have shown the efficiency of trees and shrubs in taking up and recycling plant nutrients by using their deep roots to explore deeper into the soil (Jaiyebo and Moore, 1964; Nye and Greenland, 1960; Lundgren, 1978; and Jordan, 1985).

The length of the fallow is very important for the success of this system. Shortening the length of the fallow decreases the possibilities of the regenerated natural vegetation to restore the productivity of the land. A shortening of the fallow period is becoming a problem in many areas today. Population increases, and the need to produce more food, is putting too much pressure on the land, and in some places, as a result, the fallow time has been shortened. Without proper fallow time, shifting cultivation, one of the most practiced and sustainable agroforestry systems in the tropics, is starting to have a deteriorating effect on the land. The FAO (1982) estimated that 30% of the exploitable soils of the world (360 million ha) are used for shifting cultivation by over 250 million people. With so many people depending on this system, its deterioration has caused serious soil erosion and decline in soil fertility and productivity. This can have a drastic effect on the survival of those communities who depend on it. Efforts have and are being made to design and implement systems, such as improved fallow where trees/shrubs for the fallow period are carefully chosen. In the improved fallow, the trees/shrubs chosen are supposed to restore the productivity of the land in less time.

Taungya is an agroforestry system started in Burma by the British. This system appeared as a new way to grow teak (*Tectona grandis*), and at the same time mitigate soil deterioration caused by improper shifting cultivation. In this system annual agricultural crops are grown together with tree plantations. The agricultural crops are grown during the first years (around three) of the plantation establishment. After this period, competition for light, nutrients and water makes the combination of agricultural crops/trees impossible and trees are left to grow until they can be harvested. Although the main objective of this system is to produce wood, the farmers, who most of the time do not have any land, engage in this system with the intent to grow food for their own needs. This process is repeated after the tree harvesting and the starting of a new plantation.

Homegardens represent an agroforestry system usually practiced around the farmer's house, where multipurpose trees and shrubs, vines, and herbaceous plants are grown together mainly for household consumption. All the work is done by family members. Beside the main purpose of the gardens, which is family food production, they also have ornamental value, provide medicine, and create very good shade for people and animals. When animals are involved it turns into an agrosilvopastoral system. This system is very effective in producing food and at the same time mitigating the soil deterioration problem, often caused by intense practice of tillage in monoculture. The overstory vegetation, beside producing fruits and other products, also protects the land by offering cover year-round.

This system is more commonly practiced in the tropics in places where water is not a limiting growth factor. In those places, the population density is often very high, and the farmers try to produce as many diversified products as they can from small properties, most of the time less than one ha, in order to feed their family. The homegardens are characterized by high species diversity often occupying three or four vertical canopy strata. The under canopy species are shade tolerant, and in most cases the farmers try to grow taro, cassava, yams, pineapples, and other crops.

Plantation crop combinations is a system in which some tree species are used to shade commercial plantations, such as coffee, tea and cacao. Because of their commercial importance, rubber and oil palm are also grown in this system. In densely populated areas, like in the homegardens, the farmers might include some annual crops and animals with the perennial crops in order to produce some food for their household consumption. Because tillage activity is reduced and the soil is permanently covered by some kind of vegetation, this system works very well when soil conservation is a concern.

Multistory tree gardens is a system that combines multipurpose plants in various vegetation layers, where perennials most of the time are dominant. The gardens resemble mixed forest stands, and there are not individual houses integrated with the system, as is the case with homegardens. Many forms of tree gardens are found around the world. The variations are influenced by climate and soil, and socioeconomic conditions. Unlike the homegardens, this system is not mainly oriented for family food production. Various edible and nonedible products result from this system and help to improve farmer income. Products such as timber, sawlogs, poles, and various fruits and spices are among the most important ones. Sometimes animals are integrated into the system.

Alley cropping is a system in which agricultural crops are grown between established hedgerows of trees and/or shrubs. The preferred species for hedgerows are leguminous, nitrogen fixers. The edges of the rows are pruned periodically in order to provide green manure to the soil and also to diminish competition, especially for light, with the agricultural crops. The biomass added to the soil is a very important source of nitrogen, especially for those places where farmers cannot afford to buy artificial fertilizer. Torres (1983) found that hedgerows of leucaena (*Leucaena leucocephala*), located five meters apart from each other, could produce 90 kg ha^{-1} yr^{-1} of biomass when cut approximately every eight weeks. Soil under the alley cropping system is higher in organic matter and nitrogen content then soil under areas devoid of trees (Atta-Krah et al., 1985).

Tree fodder and silvopastoral systems include trees and shrubs grown as fodder in pasture land for animals. In cases when the animals are not in stalls they will browse and graze by themselves on the land. The following fodder systems have been developed:

- *Cut-and-carry system (or protein bank)* - In this system trees and shrubs are grown as fodder in a block configuration or around block boundaries. The trees and shrubs are lopped periodically and the leaves are fed to animals kept in stalls. Leucaena is one of the principal species used in this system.
- *Live-fence posts* - In this system the fodder trees planted on the boundaries are left to grow sufficient wood in order to serve as live fence posts, later on. The trees in this system are also lopped periodically for fodder, poles and posts.

Agroforestry for fuelwood production is a system in which woodlots are established on individual or communal land for the purpose of producing fuelwood. It is a newer system that developed in densely populated regions. The rapid increase in population has caused a high demand for fuelwood in communities where wood is the main source of energy for cooking, heating, and probably some industrial processing. Eckholm (1975) estimated that in the early to mid-1970s more than 1.5 billion people in under-developed countries derived at least 90% of their energy from wood and charcoal, and that another billion derived 50% of their energy from the same source.

Agroforestry for reclamation of problem soils is a system that has been used to recuperate soil which had been affected by waterlogging, acidity, aridity, or salinity. In the tropics alone, it was estimated that 4,900 million ha, around 65% of the total land area, is classified as wasted land (King and Chandler, 1978). In such cases, planting multipurpose trees tolerant to the above mentioned adverse conditions can be used as a management solution for recuperation of those lands (King and Chandler, 1978). In the case of eroded and degraded grazing lands, plantation of multipurpose trees for fodder and fuelwood has been recommended and used for reclamation purposes (Nair, 1993).

Agroforestry systems are practiced around the world. The ecologic and socioeconomic characteristics of each region have a direct effect on the kind of agroforestry to be found or implemented. Sometimes, combinations of different systems can be found in a single place, making the distinction between systems a difficult task.

Deforestation and the loss of soil fertility has been lately playing an important role in the motivation for farmers to integrate trees/shrubs on their lands. Den Biggelaar and Gold (1995) found that the disappearance of forest was the primary motivation for farmers to plant certain tree species on their farms.

Adoption of Agroforestry by Farmers

Agroforestry can be classified according to socioeconomic criteria. The systems can be grouped into commercial, intermediate and subsistence (Lundgren, 1982).

Commercial is when the main objective is to produce outputs for sale. Labor is commonly paid/contracted and the land size most often ranges from medium to large. Commercial tree plantations may include timber, fruits, or others products grown as the main crop, with some food crops possibly produced below the trees. *Intermediate* is often a mixture between cash crops (including trees) for commercial purposes and subsistence crops for the household's food needs. The size of the farms is smaller than the ones in commercial, and some labor might be hired in cases of need. The farms are usually owned by the farmers or they might have a long tenancy right over the land. *Subsistence* is when the farms are used specifically for the household's food production. The size of the farms is small and almost or all the food produced is consumed by the family. In case of surplus, some products might be sold. All the labor is provided by the owner, family members, and sometimes by exchanging labor, during different times of the year, with other farmers. The problem with this classification is the high disparity among these three levels. The levels might change from place to place. An intermediate system in one place might be considered a subsistence system in another place.

To diagnosis land management problems and to find the best suitable agroforestry system for an specific place, various methodologies have been used. The Diagnostic and Design system (D&D) has been most often used in cases when a strong social aspect treatment is needed. In the D&D approach, farmers are incorporated into research and extension activities, making adoption of the system more likely. Agroecosystem analysis is very similar to D&D, contrasting with Land Evaluation, which is strongly related to treatment of environmental aspects. The Farming Systems Research/Extension system (FSR/E), one of the first methods to be used, was developed to fill the gap when transferring new information and technologies to the farmers by the use of extension agents (Nair, 1993).

Before the development of these methods, information was passed from researchers, who would develop it, to extension agents, who would teach or demonstrate it to the farmers, who finally could/would adopt and make use of it. It was a one-way transfer of knowledge and technology from top the down, researchers to farmers (Chambers et al., 1989). In the 1970's and 1980's the strategy started to change, especially to deal with small-scale farmers or enterprises. Brokensha et al. (1980), with the help of many case studies, argued that in order to achieve success it was, first, necessary to understand farmers when planning and implementing new projects. Farmers started to be included in research, and a two-way transfer of knowledge and technology was born. On-Farm Research (OFR) appeared as a need to include farmers in the new process of technology generation (Nair, 1993). Scherr (1991) found that there was a poor understanding of the way farmers use trees in the indigenous agroforestry systems. One of the problems was that little work was being done in what species, how, why, and where farmers grow trees. Without this information, projects might be rejected by the farmers, for their needs were not being taken into consideration.

Agroforestry, most of the time, is designed to benefit small-scale farmers who constitute the majority of the rural population. In most of the systems, the products and benefits are more of human need than commercial. Those conditions make social acceptability a better measurement of success in this land use system as opposed to traditional agriculture and forestry. Pawlick (1989) considered agroforestry to be a social science.

Burch (1991) concluded that for a better understanding of agroforestry, some social aspects had to be considered and studied. The selected aspects were: appraisal, tenure, institutional role, community and adoption. Many factors have contributed to the development of agroforestry. In the sociocultural area the most important factors are land tenure, labor and marketability of products.

- Land tenure - Farmers under land tenure that do not ensure long term control or ownership of the land often do not adopt land use systems, such as agroforestry, which tend to be long-term oriented and require more monetary/time investments. Most of the benefits of agroforestry only can be seen in the long run and because most of the farmers who practice it are poor and they are not willing to invest whatever they have in land which does not belong to them. In those cases, what they try to do is to exploit the land as much as they can in the shortest period of time. Secure land rights have proven very efficient in determining who gets the benefits of agroforestry (Bruce and Fortman, 1988). Traditionally, small farmers have been very reserved when it comes to land rehabilitation by planting trees, because of the fear of loss of control of the land and, in the case of pastoralism, the lost of access for grazing (Gregersen and McGaughey, 1985). In some places, the fear is to lose the right to collect products, such as fuelwood, fruits and medicines from the rehabilitated land. Many studies have shown the clear preference of agroforestry by farmers who have a secured land tenure (Ehrlich et al., 1987; Tschinkel, 1987; and Southgate, 1992). Beside land tenure, another problem in adopting agroforestry or planting trees in some places is the tree tenure. Sometimes the right to the trees might be different from the right to the land and agricultural crops. Even within the tree, tenure might sometimes change.

For example, in some places, the right to the tree products (fruits, medicine, fuelwood from pruned branches) might differ from the right to the whole tree harvesting (Fortmann, 1987).

- Labor - Agroforestry often demands changes in labor habits wherever it is introduced. The farm families (usually poor) have developed ways to maximize the use of family labor, in different tasks, throughout the year. Addition of more events during a different time, due to introduction of a new system, could affect members already fully occupied, resulting, later on, in rejection of the proposed system. In cases where additional labor has to be hired due to changes in the system, cost of production will be increased (Hoekstra, 1987) and, in some cases, it may act as a disincentive for adoption of the practice of agroforestry. Although agroforestry might help to spread out family labor utilization more evenly throughout the year (Nair, 1979), during implementation it might end up competing with other activities. For example, planting and weeding of trees often coincides with the labor peak from sowing to harvesting of the principal subsistence crops.
- Marketability of products - The direct and immediate results which a farmer can take from a land-use system might be the reason to adopt it. The social acceptability, most of the time, will depend upon what the farmers can visualize and get in the short run. In the developing countries, those small enterprises play an important role in the people's lives. Although, many of the farms are run by using family labor, still many of them offer jobs to a lot of people, and improved agroforestry systems might, in the future, help to improve the socioeconomic life of adopting communities. Agroforestry, in the

long run, will offer a better guaranty to the people whose jobs and lives depend on the success of the small enterprises. Recent studies have shown that small-scale, forest-based enterprises in some countries can count as one of the three top employers of rural people (FAO, 1987).

A problem with development of those systems and agroforestry is the access to market, raw material, and help from institutions after being implemented. In some societies, some of the products offered by those systems are considered free goods, and without a market people will not gain interest in growing and protecting them. Sometimes it is important to understand that a market might not mean a shortage of a product. For example, shortage of fuelwood in certain places has made governmental organizations plan and implement projects oriented for fuelwood production, thinking that a market exists, and in some cases, people end up shifting to other products such as animal and plant residues (Nair, 1993).

For an agroforestry system to be adopted, it has to offer economic advantages to the farmers. Long-term advantages, such as soil conservation, are less obvious. In many societies, one of the main concerns might be to produce enough food for human survival.

The views and influence of technicians who work with farmers may play an important role when it comes to adoption of agroforestry. In a study done by Dove (1992), most often the technicians' beliefs were different from the farmers' preferences, and government policies concerning agroforestry, forest laws, and regulations also contributed to the unsuccess of agroforestry implementation. In most cases, the decision regarding tree species to be included in agroforestry projects were made by the technicians alone, who might have a totally different background and social perception. A good understanding of the way the indigenous systems work is crucial for development of new systems (Rakotomanana, 1988), which are most often successful when based on existing practice and knowledge (Rocheleau, 1987).

For agroforestry to be successful, there is often a need to change policies. In a workshop organized in August 1991, by the International Food Policy Research Institute (IFPRI), the following components were identified as crucial for successful change in policies (Gregersen et al., 1992):

- Understanding of the existing situation, problems and opportunities which they might be associated with,
- Identifying the desired changes, and
- Defining policy instruments and mechanisms which can be used to accomplish the objectives.

The best measurement of social acceptance of an innovation sometimes brought up by implementation of a new system, such as agroforestry, is the degree of adoption by the farmers. Some projects have failed because they targeted the wrong people. If a system is not designed to target the poor farmers it might completely miss them (Chowdhry, 1985), and result in failure since it will not be adopted by the majority.

In the long-run, the social acceptability, most of the time inferred by high output, might not mean a real success in sustainability of the system, especially when the social components are emphasized over the biophysical principles. An equilibrium is crucial for the real success of agroforestry in the developing countries. Productivity, sustainability, and adoption are the cornerstones for its basic evaluation.

METHODS

Description of Study Area

The 350 ha Água de Gato Watershed is situated in the central part of the island of Santiago, 18 km northwest of the capital city of Praia, and upstream of the village of São Domingos, the seat of the municipality of the same name (Figure 1). Santiago, the biggest (991 km^2) and the most populated island of Cape Verde, is the home of more than half of the country's total population. All of the Cape Verde islands and islets are of volcanic origin. Although hilly, Santiago has more gentle relief than the other agricultural islands, such as Fogo and Santo Antão. On Santiago, 20,412 ha (21%) of the land area is suitable for the practice of agriculture, contrasting with 10% for the whole country. Irrigated land occupies only 975 ha (MPAAR-GEP, 1994), while the rest is rainfed.

The geomorphology of the Água de Gato Watershed consists of hillsides with accentuated slopes, ranging from 3 to 45%, sometimes with abrupt transitions (Marques, 1987) (Figure 4). The elevations vary between 350 and 750 m above sea level. The soils are not highly developed, and are of basaltic origin with feldspathic mineralogy (Silva et al., 1981). The soils are very susceptible to erosion, have low root penetrability resistance, and have high to medium water holding capacity. The soils are rich in nitrogen and mineral nutrients, such as phosphorous, calcium, and magnesium but poor in nitrogen and organic matter content (Bertrand, 1994). The better soils have loamy clay texture and are located on the bottom lands, where irrigated agriculture is usually practiced. On the hillsides, soils with a high percentage of gravel and pebbles are mainly used for rainfed agriculture. The bottom land and lower slope soils were formed in fine and coarse fluvial, alluvial, and colluvial deposits (Diniz and Matos, 1986). Most of the soils are shallow, with only two

Figure 4. A landscape view of the Água de Gato Watershed showing the varied geomorphology.

horizons, A and C. Faria (1970) verified that most of the soils of the Água de Gato Watershed are isohumic Vertisols.

The watershed is located in a transition zone between the sub-humid and semi-arid climatic zones, with annual precipitation varying between 250 and 600 mm, and a mean temperature of 25°C. Although the precipitation is low, the zone, due to its exposure, benefits from a microclimate suitable for agriculture. The climate is characterized by two seasons: the dry season from October to June, and the rainy season from July to September (Table 1). The rain, normally torrential, sometimes causes severe erosion and flooding in the watershed.

The vegetation is characterized as herbaceous steppe, with few shrubs and trees sparsely distributed, or concentrated in the irrigated areas. Most of the trees are fruit trees, with mango (*Manguifera indica*) the most common. In addition to the fruit trees, which most of the time are grown on the irrigated lands, some other trees, such as mahogany (*Khaya senegalensis*), silk cotton tree (*Ceiba pentandra*), mesquite (*Prosopis juliflora*), eucalyptus (*Eucalyptus camaldulensis*) and umbrella mulga (*Acacia holosericea*) are also part of the landscape (PLLA, 1994). Other species of interest include *Furcraea foetida*, which is used in soil conservation, and *Chenopodium murale*, *Calotropis procera*, aloe vera (*Aloe vera*), lantana (*Lantana camara*) and *Indigofera tinctoria* used in producing medicines. *Cloris virgata*, spiny amaranth (*Amaranthus spinosus*), *Aerva javanica* and *Dichrostachys cinera* are also found in the watershed (PLLA, 1994) and are used for forage. Due to the rapid soil and vegetation degradation caused by natural events and the action of man and animals, some species have already disappeared from the ecosystem. Although a scarce resource, fuelwood is still the main source of energy for cooking in the

Table 1. Precipitation registered by the two nearest meteorological stations to the Água de Gato Watershed, São Domingos (A) and Curralinho-Rui Vaz (B).

	July		August		September		Annual Total	
Year	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
	....	....	....	.... mm	....	....	....	....
1943	25.3	62.7	137.1	290.9	391.3	649.0	748.9	1,245.8
1947	0.0	0.0	58.7	105.0	55.9	129.0	117.1	285.5
1949	35.5	44.0	208.3	271.0	340.4	396.0	812.9	953.0
1950	10.2	4.0	177.6	234.0	490.3	598.0	883.7	1,120.0
1959	34.5	78.7	61.3	134.8	96.0	190.4	249.9	523.3
1960	18.5	48.2	108.6	207.0	153.5	332.4	320.1	743.7
1964	0.0	178	0.0	67.5	0.0	267.5	0.0	521.5
1967	46.0	2.4	543.9	98.0	153.5	635.4	750.4	1,033.6
1972	0.0	0.0	0.0	5.4	0.0	6.2	0.0	39.6
1979	20.0	41.9	64.8	98.0	7.1	22.0	237.5	376.4
1994	62.4	0.0	39.2	112.7	0.0	84.6	101.6	197.3

Source: INIDA - Department of Agroclimatology and Hydrology.

watershed. The inhabitants, especially women and children, spend many hours daily collecting whatever can be burned and used as fuel. This situation directly affects the children's education, since they have less time to do school work, and the mothers are left with little time to dedicate to them.

The natural fauna is very limited. Domestic animals, such as pigs, cows, goats, poultry, and donkey monkeys, and few birds comprise the animal population of the watershed.

Agriculture is divided into two types, irrigated and rainfed. Irrigated agriculture is mostly practiced on the bottom of the watershed, where better soils exist and water is more often available. Rainfed agriculture is practiced on the hillsides or bottom of the watershed where, although with good soils, water is a limiting factor. In the irrigated lands, besides common agricultural land use, two agroforestry systems are also found: homegardens and multistory tree gardens. In the rainfed areas, where most of the subsistence crops are grown, some multipurpose trees are found sparsely distributed throughout the farms. On the steep hillsides, a kind of shifting cultivation which might involve perennials but no trees, is a common practice among farmers. In this system the land is cultivated for few years until soil fertility fails due to soil erosion and loss of nutrients. After the soil has lost its fertility, it is left in fallow for few years before being cultivated again. Sometimes the erosion is so severe that the land is forsaken for agricultural usage.

The socioeconomic factors which affect the lives of Água de Gato Watershed residents are directly connected to the land use/tenure systems, food security, and social infrastructures (PRPI-AGW, 1994). The population of 957 inhabitants (177 families) is distributed in 13 localities. Of the watershed's total population, 453 are males and 494 are females (Table 2). The principal economic activities of the population are agriculture and animal husbandry. Although these are mostly subsistence activities, they offer the farmers opportunities to buy other products once they sell the surplus they do not consume. Of the watershed's total area, 50% belongs to the Catholic Church, meaning that most of the people living in the watershed are deprived of their own land. Since agriculture can not employ all the inhabitants, the government hires farmers on working gangs in order to create jobs and reduce unemployment. These working gangs, called *FAIMO*, usually consist of family heads, and engage in building infrastructures, like schools, roads, irrigation channels, and soil conservation structures in the watershed. The unemployment tax is very high, especially among young people who sometimes must move to the city of Praia in search of jobs. This situation has resulted in a rural exodus. The community in the watershed is very well organized, dynamic, and participative. They have created the Association for the Água de Gato Watershed Community Development (ADC-AG), a non-governmental organization whose goal is to help with some of the socioeconomic problems affecting the watershed. The Association has constructed an aviary, which employs mostly women. Traditionally, the principal activities of women have been fuelwood gathering, water transportation, child care, and domestic work. Also, a professional school is being constructed with the help of the African Development Foundation and the Canadian Fund. The school will help to prepare and train the young people, providing them with skills to compete in the working market. So far, only one infrastructure, a secondary school, exists in the watershed. Beside the professional school, a kindergarten, which will permit a better education and development of the children, and a Catholic church financed by former watershed residents who have immigrated to Portugal and France are under construction. Food supply is secured by small retailers in

Table 2. Population of Água de Gato Watershed by sex, locality, and number of families.

Zone/ Locality	Total	Male	Female	Families
Água de Gato Watershed	957	453	494	177
Achadinha	150	62	88	28
Bom Jardim	5	3	2	1
Caiada	264	130	134	48
Chãozinho	33	17	16	7
Curral	66	33	33	11
Laranjeira	9	4	5	2
Lém Freire	75	43	32	16
Lém Mendoça	152	67	85	28
Lém Pereira	40	23	17	6
Monte	69	37	32	11
Rema Rema	66	31	35	12
Travessa Baixo	17	6	11	5
Covão d'Água	11	7	4	2

Source: RGPH, 1990.

the watershed.

Although agriculture is an activity in which traditionally men are mostly involved, after a good rain everybody (men, women and children) works together in order to sow the rainfed crops, mainly corn and beans, while the soil still wet.

Land tenure is influenced by the land ownership, and for centuries three systems of land exploitation have been shaped and used in almost all the corners of the country. The Água de Gato Watershed does not escape the rules. The three principal systems are direct exploitation by owner, rented, and sharecropped or partnership.

Direct exploitation by owner is when farmers work their own lands. In this system people are more willing to invest and try new technologies in order to improve their financial status by increasing land productivity.

Rented is when the farmer pays a fixed fee in money or in products to the land owner, monthly or yearly depending on the contract. In this system, most of the time a contract is signed by the two counterparts.

Sharecropping or partnership, considered the poorest of the systems for having a degrading effect on the land and on the socioeconomic life of the farmers, is mostly used among poor farmers, especially on unprotected hillsides. In this system the land is worked by a farmer who provides all supplies and labor, and at the harvest divides the products according to a contract, which most of the time is verbal. The contracts range from 1/3 to 1/2 of the harvest for the owner, but most of the time it is 50% for each side. When the farmer does not have enough money to invest during the sowing period, the owner may lend some to him, to be discounted at the harvest or whenever a good year comes. Since no security exists in relation to the farmer investments, most of the time he tries to exploit the land as much as he can. Without major investments, especially in soil conservation structures, the farm ends up degrading and probably put out of agricultural usage.

The land tenure is different from the tree tenure. The separate tenure for trees sometimes creates differences between the owner and the farmer, discouraging the latter from planting and caring for trees on the property he works.

During 1994 SANREM CRSP selected the Água de Gato Watershed as a research site, and implemented a Participatory Landscape/Lifescape Appraisal (PLLA) process in the area. Farmers and researchers jointly identified many social and scientific problems in the watershed. Following the PLLA report a research framework plane, called Plano de Referência de Propostas de Investigação (PRPI) was prepared. The PRPI outlined priorities for research, and served as a guide for developing research work plans to be implemented on farms, in the watershed. Among the seven major areas identified during the PLLA, agro-silvopastoral production systems and agrarian systems were the ones which related to agroforestry.

Survey Research

In order to survey the farmer population in the Água de Gato Watershed, a questionnaire was developed and 51 farmers were randomly selected and personally interviewed during June and July, 1995 (Appendix I). The questionnaire solicited information on farming practices; agroforestry practices, knowledge, and interest; educational needs; and personal backgrounds of the farmers. Administration of the questionnaire took about one hour. The questionnaire was administrated in Creole, the native language of the islands. Responses were interpreted to English. The technician questionnaire was also conducted in the summer of 1995. Personal interview were conducted of 25 technicians who work in or near the watershed. Each interview took about 45 minutes, and focused on perception of farmers and their practices, agroforestry knowledge, educational needs, and personal background information (Appendix II).

Data Analysis Procedures

Statistical analyses were performed using the farmer characteristic data. Farmers were grouped according to their willingness to plant trees for three uses, fuelwood, fruit production, and shade. Differences between the willingness groups were investigated using one-way analysis of variance for the continuous variables and the Chi-square for contingency test for discrete variables. Continuous variables included age, family size, farm area owned, farm area rented, and area in partnership. Discrete variables included gender, marital status, willingness to plant trees, and currently growing trees.

A multivariate approach was taken to describe the willingness groups. The discriminant analysis procedure was used to separate the groups based on the continuous and discrete variables described above. The strength of the discriminant functions was determined by the overall correct classification of each of the 51 observations independently. A validation data set was not used due to the limited number of observations. All statistical analyses were performed using the Minitab statistical program.

RESULTS AND DISCUSSION

Characteristics of Farmers

For this study, 51 farmers, 45 men and six women, from the Água de Gato Watershed were interviewed. The oldest farmer was 86 years old and the youngest 22, and the mean age for the group was 51 years. Forty five of the farmers were married, and the mean number of people per family was eight. The smallest family had two members and the biggest 14 (Table 3). Normally, two to four generations could be found living at the same house complex, since, traditionally, the sons are supposed to care for their parents when they become old.

All the farmers worked in the watershed, but eight of them also did some extra work outside the community. Beside Água de Gato, the other places where the farmers worked were the nearby city, village and communities of Praia, São Domingos, Ribeirão Chiqueiro, Lagoa, Mendes Faleiro, João Garrido, Ribeirão Cal, Godinho and Orgãos. Twenty-seven of the farmers worked on the Frentes de Alta Intensidade de Mão de Obra (FAIMO) year round, with exception of good rainy years, when all the working gangs are closed in order to make the labor available to the agricultural sector. The remaining farmers worked either on their own land or for other farmers in the watershed. The farmers working on the FAIMO also did some work on their own lands and/or the land of other farmers during their free time, especially during the rainy season when labor needs reach a peak. Of those farmers, only 28 worked all year round on their own farms, probably using irrigated land. The others worked on their farms on rainfed lands only during the rainy season, mostly from July to December.

All the farmers were involved in raising animals. The most common animals raised

Table 3. Descriptive statistics for farmers in the Água de Gato Watershed.

	Mean	**Range**	**Standard Deviation**
Age (yr.)	51	22-86	16
Family Size (persons)	8	2-14	3

in the Água de Gato Watershed were chickens, goats, pigs, and cows, averaging in number, respectively, 16, 3, 3 and 1 per farmer. Beside raising chickens as a part of the farming subsistence system, some farmers were raising large numbers of chickens for commercial purpose. The largest chicken producer in the survey tended a flock of 300. The responsibility for the animal feeding was divided among all the family members. The feeding of cows is more the responsibility of men, while pigs, goats and chickens were tended mostly by women and children, although whoever got free time was expected to feed the animals. In the case of cows, in order to avoid injuries, the small children were not allowed to feed them.

Fuelwood, a scarce resource in the watershed, was the main source of energy used for food preparation. The main plant species being currently used by the Água de Gato's farmers as fuelwood are mesquite, *Dichrostachys cineria*, lantuna, maguey (*Furcraea foetida)*, eucalyptus, and giant reed grass (*Arundo donax*). All the farmers surveyed used fuelwood in combination with bottled gas, except five, who only used fuelwood. Some farmers also used pruned fruit tree branches, plant residues, cow residues, and kerosene. More than half of the farmers, 51%, collected fuelwood outside their farms and had to walk up to 12 km to get to the source. Although the gathering was more a responsibility of the women and children, who spent an average of eight hours weekly, men did help in this activity. Beside collecting, 43% of the farmers also bought fuelwood from other people or from the Forest Service (Figure 5), at an average price of 8 US cents per kg, varying with the species and quality. Each family used an average of 13 kg of fuelwood daily for food preparation. In the watershed, one farmer was already using bio-gas, a source of energy which can be expanded taking into consideration the number of animals being grown by each farmer. The prime material should not be a problem.

Figure 5. Fuelwood (eucalyptus) harvested on the National Forest and an improved cabin to serve as the forest guard headquarters.

Although agroforestry was a new word for most of the farmers, the system as a land use was well spread in the irrigated lands. Ninety-eight percent of the farmers surveyed showed interest in soil conservation practices as a mean to protect their lands from future degradation. Eighty-eight percent of the farmers showed an interest in growing more trees on their farms, with the main purposes being fruit and fuelwood production, and shade. As with animal feeding, the weeding and watering of trees were a whole family responsibility. Most of the farmers think that tree seedlings should be provided by the state, since they do not have enough money to purchase them. Half of the farmers surveyed feel that the farmers should be the ones to do the planting and be responsible for the costs of planting and maintenance. All the farmers surveyed were interested in more education about agroforestry. When given a choice of several different educational activities, 69% preferred an outdoor, field activity; 10% preferred an indoor workshop or seminar; 8% preferred a videotape; and 14% preferred a written publication.

Characteristics of Farms

Most of the farms in the watershed were rainfed, and the main crops, usually of subsistence nature, were corn and beans (Table 4). A small area on the bottom of the watershed, where water is available, is irrigated. On the irrigated areas, mainly sugar cane, bananas, vegetables, and fruit trees, especially mango, often grown for cash, constituted the main crops (Table 5). Beside mango, other trees were grown on the farms, integrated with the agricultural crops, to meet the farmers' specific needs (Table 6).

The mean farm area owned by each farmer surveyed in the Água de Gato Watershed, was 1.1 ha, ranging from zero to 8 ha per farmer. The average land area rented from other farmers ranged from zero to 2.1 ha, with a mean of 0.7 ha. Some of the

Table 4. Major subsistence crops grown in the Água de Gato Watershed.

Crop	No. of Farmers	%
Corn or maize	47	92.2
Snap bean	46	90.2
Pigeon pea	40	78.4
Cow pea	33	64.7
Hyacinth bean	32	62.8
Jack bean	27	52.9
Cassava or manioc	22	43.1
Sweet potato	22	43.1
Sieva bean	15	29.4
Broccoli	8	15.7
Common potato	8	15.7
Squash	8	15.7
Cabbage	7	13.7
Carrot	7	13.7
Tomato	5	9.8
Banana	4	7.8
Lettuce	4	7.8
Onion	4	7.8
Garlic	2	3.9
Cucumber	1	2.0
Turnip	1	2.0

Table 5. Major cash crops grown in the Água de Gato Watershed.

Crop	No. of Farmers	%
Cabbage	25	49.0
Peanut or groundnut	25	49.0
Carrot	24	47.1
Sugar cane	21	41.2
Cassava or manioc	18	35.3
Broccoli	17	33.3
Common potato	16	31.4
Lettuce	16	31.4
Sweet potato	16	31.4
Onion	11	21.6
Tomato	9	17.6
Snap bean	7	13.7
Turnip	6	11.8
Corn or maize	5	9.8
Cow pea	5	9.8
Garlic	5	9.8
Jack bean	5	9.8
Pigeon pea	5	9.8
Sweet pepper	5	9.8
Banana	4	7.8
Squash	4	7.8
Hyacinth bean	3	5.9
Cucumber	2	3.9
Parsley	2	3.9
Hot pepper	1	2.0
Melon	1	2.0
Sieva bean	1	2.0

Table 6. Major tree species grown in the Água de Gato Watershed and associated tree products.

Species	Fodder	Timber	Fuelwood	Fruits	Medicine	Shade	Art/Craft	Poles
	....			No. of responses			....	
Mesquite	11	1	49	0	0	36	0	1
Leucaena	1	0	0	0	0	0	0	0
Eucalyptus	0	6	4	0	1	4	1	1
Mango	0	1	0	34	0	1	0	0
Orange	0	0	0	13	0	0	1	0
Avocado	0	0	0	16	3	0	0	0
Papaya	0	0	0	8	0	0	0	0
Indian plum	0	0	3	2	0	0	0	1
Lemon	0	0	0	16	8	0	0	0
Tangerine	0	0	0	6	0	0	0	0
Quince tree	0	0	0	6	1	0	0	0
Coconut	0	0	0	7	0	0	0	0
Mahogany	0	4	0	0	0	0	1	0
Wild fig	0	2	1	0	0	1	0	0
Egyptian thorn	0	1	0	0	0	0	0	0
Guava	0	0	0	8	0	0	1	0
Indian almond	0	1	0	0	0	1	0	0
Cashew	0	0	0	3	0	0	0	0
Royal poinciana	0	0	2	0	0	1	0	0
Java plum	0	0	0	3	0	0	0	0
Neem	0	0	0	0	0	1	0	0
Tamarind	0	0	1	0	0	1	0	0

farmers with larger areas rented land to other farmers. In general, the area rented to other farmers varied between zero and 2 ha, with a mean of 0.1 ha. Farmers also worked some areas in partnership ranging from zero to 3 ha, with a mean of 0.4 ha. In reality, each farmer in the watershed was working an area between 0.3 and 5 ha, averaging 1.9 ha (Table 7). Although some farmers from the surveyed group did not own any land, all of them worked a piece of land owned, rented, or worked in partnership, where they grow some food, especially for subsistence. The mean working area was higher than the area owned. This is due to much of the watershed being owned by the Catholic Church, which rents land to the farmers.

Artificial fertilization was used only in irrigated lands by 45% of the farmers. The low utilization was due to the high price and the difficulty to get hold of it. Manure, which is cheaper and available in the watershed, was used in both irrigated and rainfed fields. Manure was used by 58% of the farmers in irrigated lands, and by 37% in rainfed. A total of 12 farmers did not use either artificial fertilizer or manure on their lands. The low utilization of fertilizer was not only caused by the high price, but also by the low water availability in most of those sites.

Relating Characteristics of Farmers and Farms to Agroforestry

The result of the surveyed farmers showed a very high desire for implementation of agroforestry in the watershed. Of the 51 farmers surveyed, 92% would like to see agroforestry implemented in their lands and the rest (8%) were uncertain. None of the farmers said no to agroforestry implementation. The only problem might be the Catholic Church which holds, as a landowner, 50% of the watershed's land. If the institution, which was not surveyed, is not interested in agroforestry implementation on its land, that would

Table 7. Descriptive statistics of farm size in the Água de Gato Watershed.

Farm	Mean	Range	Standard Deviation
	.... ha	....	
Area Owned	1.1	0.0-8.0	1.9
Area Rented from Others	0.7	0.0-2.1	0.7
Area Rented to Others	0.1	0.0-2.0	0.4
Area Worked in Partnership	0.4	0.0-3.0	0.7
Total Working Area	1.9	0.3-5.0	1.2

mean that at least half of the land in the watershed would be left out of any intervention, but the opposite can also occur. Furthermore, future disputes between the Church and the farmers may arise due to the practice of separated tree tenure by the landlord. This situation may discourage farmers from planting trees or adopt the agroforestry system on the land they rented from or work in partnership. Trees are a long term investment and most of the times they don't know for how long they will rent the land. In these cases their preference might be for a system which can warrant them an annual return.

Although the majority of the farmers surveyed showed willingness to adopt an agroforestry system, they also recognize the existence of constraints which slow development of agriculture in the watershed. These constraints, if not solved, could also hinder adoption of agroforestry in the watershed. By order of importance the constraints were identified as: need for a line of credit (100%), land and space availability (94%), availability of seedlings (88%), need for incentives (84%), land and water availability for nursery implementation (61%), land and tree tenure (55%), laws (20%), and the need for technical support (18%). Other lesser constraints included the need for more help, availability of pesticides, seedlings damaged by people and animals, lack of money, and lack of rain. None of them had more than 6%.

Twenty-seven of the farmers surveyed (53%) expressed a willingness to plant more trees for fuelwood production. Although this group tended to be younger, 49 vs. 53 yrs, than the group unwilling to plant more fuelwood trees, the difference was not significant (Table 8). Farm size and family size did not appear to have a significant effect on willingness to plant fuelwood trees (Table 8), although the willing farmers tended to control somewhat more land, since they owned outright and had partnerships on an average of 1.58 ha, compared to 1.48 ha for the unwilling farmers. There was tendency for

Table 8. One-way analysis of variance results for continuous variables related to willingness of farmers to plant more trees for fuelwood production, where 0=no and 1=yes.

	0			1				
Variable	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**F**	**p**
Age (Yr.)	24	53.40	16.40	27	48.80	15.70	1.03	0.32
Family Size (persons)	24	7.80	3.10	27	7.70	2.60	0.03	0.87
Farm Area Owned (ha)	24	1 .12	1.49	27	1.14	2.17	0.00	0.97
Farm Area Rented from (ha)	24	0.78	0.66	27	0.71	0.75	0.12	0.73
Area Farmed in Partnership (ha)	24	0.36	0.50	27	0.44	0.82	0.17	0.68

farmers who rented more land to be less willing to plant fuelwood trees. Males were nearly evenly spit between their willingness or unwillingness to plant more fuelwood trees, 23 vs. 22, respectively (Table 9). Although the female sample was quite low, twice as many females were willing to plant more fuelwood trees, 4 vs. 2. This is probably related to the fact that more women are responsible for fuelwood collection in the watershed. Although willingness to plant more shade trees was not related to willingness to plant more fuelwood trees, all of the farmers who wished to plant more shade trees also desired more fuelwood trees (Table 9). This was highly significant ($\chi^2 = 8.43$, $p = 0.00$).

When a suite of continuous and discrete farmer variables was used in a linear discriminant analysis to group farmers on their willingness to plant more fuelwood trees, a fairly strong relationship emerged (Tables 10 and 11). An overall total correct classification of 75.5% resulted, with 88% of the unwilling farmers correctly classified and 63% of the willing farmers correctly classified. This process indicates that, for the 51 farmers surveyed, it is possible to classify them into two groups based on their demographic characteristics and willingness to plant trees. The two groups indicate their willingness to plant fuelwood trees.

Thirty-seven of the farmers surveyed (73%) expressed a willingness to plant more trees for fruit production. Age seems not to have an effect on the willingness to plant more trees for fruit production ($p = 0.92$), since the mean age was the same for both groups, 51 years (Table 12). Also farm size and family size did not appear to have a significant effect on willingness to plant fruit trees (Table 12). The willing farmers controlled almost the same area as the unwilling, which they owned outright and had partnerships on an average of 1.54 ha, compared to 1.50 ha for the unwilling farmers. There was a tendency for farmers who rented more land and work less land in partnership to be more willing to

Table 9. Chi-square test results for classification variables related to willingness of farmers to plant more trees for fuelwood production, where 0=no and 1=yes.

		Count			
Variable	**Classification**	**0**	**1**	χ^2	**p**
Gender	Male	22	23	0.51	0.47
	Female	2	4		
Marital Status	Unmarried	3	3	0.02	0.88
	Married	21	24		
Willingness to Plant Fruit Trees	No	8	6	0.79	0.37
	Yes	16	21		
Willingness to Plant Shade Trees	No	24	19	8.43	0.00
	Yes	0	8		
Currently Growing Fruit Trees	No	7	6	0.32	0.57
	Yes	17	21		

Table 10. Discriminant analysis correct classifications for three dependent variable groups describing willingness of farmers to plant more trees for fruit production (y1), fuelwood (y2), and shade (y3), where 0=no and 1=yes.

	y1		**y2**		**y3**	
	0	**1**	**0**	**1**	**0**	**1**
Predicted 0	11	10	21	10	32	2
Predicted 1	3	27	3	17	11	6
Total N	14	37	24	27	43	8
N Correct	11	27	21	17	332	6
% Correct Class.	0.79	0.73	0.88	0.63	0.74	0.75

Table 11. Linear discriminant analysis function for three dependent variable groups describing willingness of farmers to plant more trees for fruit production (y1), fuelwood (y2), and shade (y3), where 0=no and 1=yes.

	y1		y2		y3	
Independent Variables	**0**	**1**	**0**	**1**	**0**	**1**
Constant	-15.651	-16.430	-16.380	-18.241	-16.831	-18.116
X1=Age (yr.)	0.195	0.158	0.195	0.186	0.195	0.167
X2=Gender	14.383	12.276	14.383	16.112	14.383	13.995
X3=Marital Status	11.880	14.276	11.880	12.124	11.880	14.576
X4=Family Size	0.880	0.991	0.880	0.871	0.880	0.803
X5=Farm Area Owned (ha)	-0.474	0.009	-0.474	-0.639	-0.474	-0.241
X6=Area Farmed in Partnership (ha)	-1.681	-2.427	-1.681	-1.531	-1.681	-1.437
X7=Farm Area Rented From (ha)	-1.536	-0.968	-1.536	-1.745	-1.536	-0.851
X8=Willingness to Plant Fruit Trees	--	--	3.653	5.109	3.653	1.595
X9=Willingness to Plant Fuelwood Trees	0.853	2.309	--	--	0.853	4.013
X10=Willingness to Plant Shade Trees	1.233	-0.825	1.233	4.393	--	--
X11=Currently Growing Fruit Trees	5.273	4.293	5.273	6.252	5.273	3.945

X2 - 0 = male, 1 = female, X3 - 0 = unmarried, 1 = married; X8 to X11 - 0 = no, 1 = yes. Y1 = willingness to plant more trees for fruit production, y2 = willingness to plant more trees for fuelwood, y3 = willingness to plant more trees for shade.

Table 12. One-way analysis of variance results for continuous variables, related to willingness of farmers to plant more trees for fruit production, where 0=no and 1=yes.

	0			1				
Variable	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**F**	**p**
Age (Yr.)	14	51.40	19.30	37	50.80	14.90	0.01	0.92
Family Size	14	7.10	2.70	37	8.00	2.90	1.15	0.29
Farm Area Owned (ha)	14	0.99	1.84	37	1.18	1.89	0.11	0.74
Farm Area Rented From (ha)	14	0.65	0.46	37	0.78	0.77	0.32	0.58
Area Farmed in Partnership (ha)	14	0.51	0.51	37	0.36	0.74	0.48	0.49

plant fruit trees. The reason might be in the land security. Rented land is usually more secure than partnership. Males were more willing to plant fruit trees than females. While the males willing to plant fruit trees had a ratio of 3.5:1, the females had a ratio of 0.2:1. This was significant ($\chi^2 = 5.25$, $p = 0.02$) (Table 13). This is probably related to the fact that fruit is a cash crop and often men control the return (cash) in the rural areas. Although not significant, farmers willing to plant fruit trees were also willing to plant fuelwood trees. The reason might be because when fuelwood is more available for the household, less damage is done to the fruit trees. This is because when fuelwood is not available fruit trees might be unnecessary pruned in order to get fuel for cooking. The farmers currently growing fruit trees also had a similar response (Table 13).

When a suite of continuous and discrete farmer variables was used in a linear discriminant analysis to group farmers on their willingness to plant more fruit trees, a fairly strong relationship emerged Tables (10 and 11). An overall total correct classification of 76% resulted, with 79% of the unwilling farmers correctly classified and 73% of the willing farmers correctly classified. This process indicates that, for the 51 farmers surveyed, it is quite possible to classify them into two groups based on their demographic characteristics and willingness to plant trees. The two groups indicate their willingness to plant fruit trees.

Only eight of the farmers surveyed (16%) expressed a willingness to plant more trees for shade. Although this group tended to be younger, 50 vs. 51 yrs, than the group unwilling to plant more shade trees, the difference was not significant (Table 14). Farm size and family size did not appear to have a significant effect on willingness to plant shade trees (Table 14), although the willing farmers tended to control somewhat more land, since they owned outright and had partnerships on an average of 1.86 ha, compared to

Table 13. Chi-square test results for classification variables related to willingness of farmers to plant more trees for fruit production, where 0=no and 1=yes.

		Count			
Variable	**Classification**	**0**	**1**	χ^2	**p**
Gender	Male	10	35	5.25	0.02
	Female	4	2		
Marital Status	Unmarried	4	2	5.25	0.02
	Married	10	35		
Willingness to Plant Fuelwood Trees	No	8	16	0.79	0.37
	Yes	6	21		
Willingness to Plant Shade Trees	No	11	32	0.48	0.49
	Yes	3	5		
Currently Growing Fruit Trees	No	3	11	0.17	0.68
	Yes	10	27		

Table 14. One-way analysis of variance results for continuous variables, related to willingness of farmers to plant more trees for shade, where 0 = no and 1 = yes.

	0			1				
Variable	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**F**	**p**
Age (Yr.)	43	51.23	16.62	8	49.50	13.43	0.08	0.78
Family Size	43	7.84	2.89	8	7.38	2.67	0.18	0.68
Farm Area Owned (ha)	43	1.09	1.69	8	1.31	2.74	0.09	0.76
Farm Area Rented From (ha)	43	0.74	0.69	8	0.75	0.81	0.00	0.97
Area Farmed in Partnership (ha)	43	0.37	0.61	8	0.55	1.03	0.46	0.50

1.46 ha for the unwilling farmers. Although the difference in age was not much, there was tendency for farmers who rented more land to be less willing to plant shade trees. Gender seems not to have influence in the willingness to plant more trees for shade. Although the female sample was quite low, five as many females were unwilling to plant more shade trees, 5 vs. 1. Only 7 males expressed a willingness to plant shade trees, while 38 did not (Table 15). This is probably related to the fact that most houses on the watershed already have one, or more, shade trees in their yards (Figure 6). All unmarried farmers were unwilling to plant trees for shade. This is probably related to the place where farmers in the watershed plant shade trees. Often they plant shade trees in the yard, and generally unmarried people do not own a house. Although not significant, the same number of farmers willing to plant shade trees were willing to plant fruit trees or already were growing fruit trees. The same thing happened with the farmers unwilling to grow fruit trees or already were growing fruit trees (Table 15).

When a suite of continuous and discrete farmer variables was used in a linear discriminant analysis to group farmers based on their willingness to plant more shade trees, a fairly strong relationship emerged (Tables 10 and 11). An overall total correct classification of 74.5% resulted, with 74% of the unwilling farmers correctly classified and 75% of the willing farmers correctly classified. This process indicates that, for the 51 farmers surveyed, it is possible to classify them into groups based on their demographic characteristics and willingness to plant trees.

Characteristics of Technicians

In this study 25 technicians, 17 males and eight females, working on the island of Santiago, were interviewed. The mean age was 38, ranging from 27 to 54 years old. The

Table 15. Chi-square test results for classification variables related to willingness of farmers to plant more trees for shade, where 0 = no and 1 = yes.

Variable	Classification	Count 0	Count 1	χ^2	p
Gender	Male	38	7	0.01	0.94
	Female	5	1		
Marital Status	Unmarried	6	0	1.27	0.26
	Married	37	8		
Willingness to Plant Fuelwood Trees	No	24	0	8.43	0.00
	Yes	19	8		
Willingness to Plant Fruit Trees	No	11	3	0.48	0.49
	Yes	32	5		
Currently Growing Fruit Trees	No	10	3	0.72	0.40
	Yes	33	5		

Figure 6. Trees, mostly mesquite, grown in yards to serve as shade for people and animals.

working experience was high, with a mean of 10 years. The technician with the least experience had worked for two years and the most experienced for 28 years (Table 16). They worked for different federal agencies and institutes. Fourteen worked for the Directorate General of Agriculture, Silviculture and Animal Husbandry (DGASP), five for the National Institute of Rural Engineering and Forestry (INERF), four for the National Institute for Agricultural Research and Development (INIDA), one for the Directorate General of Rural Animation (DGAR), and one for the National Institute for Promotion of Agriculture (INFA).

All the technicians, except three with two years of education, were trained outside the country, due to the lack of a university in Cape Verde. In order of frequency, the interviewed technicians received their education on the following countries: Portugal, USA, Cuba, Brazil, Bulgaria, France, Niger, Morocco, Ex East Germany, Romania, and Ex USSR. The areas of expertise and degree level of these technicians also varied from agronomist (28%), agronomic technicians (20%), foresters (16%), hydrologists (8%), and the rest, forest technicians, extension agents, entomologists, agrometeorologists, civil engineers, veterinarians, and plant protection technicians all with 4% each. Only 48% of the technicians were working in his/her area of specialization.

Fifty six percent of the technicians knew or had some knowledge about agroforestry, and only three had been involved in some kind of agroforestry management. Most of them had learned about agroforestry through college/university courses, shortcourses/workshops, field experience on the job, textbooks/journal articles, or government publications. Eleven of the technicians recognized the practice of agroforestry on the island of Santiago, nine in irrigated areas and three in rainfed areas. Although no local name could be established for these systems, which means that there is not a specific

Table 16. Descriptive statistics for technicians working on the island of Santiago.

	Mean	Range	Standard Deviation
Age (yr.)	38	27-54	7
Work Experience (yr.)	10	2-28	7

name for the different systems being used in Cape Verde, the technicians indicated a series of species being grown by farmers in order to fulfill some of their needs (Table 17). Most often the agriculture is classified as irrigated or rainfed, without a specific system name. The technicians with some knowledge about agroforestry were able to recognize the occurrence of cultural changes on the practice of agriculture (Figure 7) in Santiago, over the last few years.

For the technicians the four most important sources used for fuelwood by the farmers in Santiago were mesquite, Egyptian thorn, winter thorn, and plant residues. Other fuelwood sources were mentioned as being used (Table 18). The technician information about the main fuelwood used by farmers matched somewhat the one provided by the Água de Gato Watershed's farmers. For example, most of the technicians correctly identified mesquite as the dominant fuelwood species. Some of the differences might be because the farmers had provided information about a specific place, the Água de Gato Watershed, and the technicians the whole island. Various fuelwood constraints were identified by the technicians. From their point of view the ones which mostly affect the farmers are ownership of land/trees, identified by 96% of the technicians, land/space (88%), laws (76%), climate (16%), information/education (12%), low plant diversity (8%), price of fuelwood (8%), distance to the source (4%), seedling availability (4%), and no line of credit (4%). Again, the absence of a line of credit, which was first for the interviewed farmers, came to be the last in the opinion of the technicians.

All the agroforestry systems described in the literature review were presented and explained to the technicians with the objective of helping in the selection of suitable systems for the Água de Gato Watershed. The first five systems ranked by the technicians were the plantation-crop combination, soil conservation in hedges, intercropping (alley),

Table 17. Technician perceptions of major tree species and tree products produced by farmers on the island of Santiago.

Species	Fodder	Timber	Fuelwood	Fruits	Medicine	Shade	Art/Craft	Poles
Acacia victoriae	1	0	0	0	0	0	0	0
Apple	0	0	1	2	0	0	0	0
Avocado	0	0	1	9	8	0	0	0
Baobab	0	0	1	0	0	0	0	0
Bread tree	0	0	1	0	0	0	0	0
Cashewnut	0	0	1	6	1	0	0	0
Beefwood	1	1	0	0	0	0	0	0
Coconut	0	4	3	7	0	1	4	0
Coffee	0	0	2	2	0	0	0	0
Quince tree	0	0	1	4	0	0	0	0
Royal poinciana	0	0	0	0	0	4	0	0
Egyptian thorn	1	1	9	0	0	3	1	0
Eucalyptus	0	6	5	0	13	2	2	13
Fig	0	0	1	1	0	0	0	0
Silk oak	0	0	0	0	0	2	0	1
Guava	0	0	1	7	1	0	1	0
Indian almond	0	1	1	0	1	2	2	0
Indian plum	2	0	0	5	0	1	0	0
Java plum	0	0	1	3	0	0	0	0
Jerusalem thorn	13	0	3	0	0	0	0	1
Lemon	0	0	1	9	5	0	0	0
Leucaena	3	0	0	0	0	0	0	0
Mahogany	0	1	2	0	0	2	0	0
Mango	2	2	3	24	0	10	1	1
Mesquite	20	1	17	0	0	20	1	7
Neem	0	1	0	0	5	7	0	2
Orange	0	2	2	12	3	0	1	0
Papaya	0	0	0	12	0	0	0	1
Pepper tree	0	0	0	0	0	1	0	0
Silk cotton tree	0	0	0	0	0	1	0	0
Sweetsop	0	0	1	4	0	0	0	0
Tamarind	1	1	3	8	8	4	1	1
Tangerine	0	0	1	3	0	0	0	0
Umbrella mulga	1	0	0	0	0	0	0	0
Wild fig	1	1	1	0	0	0	3	0
Winter thorn	2	1	8	0	0	3	2	0

Note: pruned fruit trees' branches are often used as fuelwood.

Figure 7. Use of *Furcraea foetida* strips to minimize erosion on steep hillsides. Unprotected land on the right shows top soil erosion.

Table 18. Technician perception of fuelwood sources used by farmers on the island of Santiago.

Source	Nº	%
Mesquite	22	88.00
Egyptian thorn	11	44.00
Fruit trees' branches	8	32.00
Plant residues	8	32.00
"Animal residues"	6	24.00
Dichrostachys cineria	5	20.00
Eucalyptus	5	20.00
Lantana	5	20.00
Jerusalem thorn	4	16.00
Maguey	4	16.00
Indian plum	3	12.00
Jatropha curcas	3	12.00
Pigeon pea	3	12.00
Tamarind	3	12.00
Coconut	1	4.00
Giant reed grass	1	4.00
Leucaena	1	4.00
Mahogany	1	4.00

Note: an interviewed could mention more than one source.

multipurpose trees on farmlands, and multipurpose trees for fuelwood and fodder.

The technicians surveyed, except one, showed interest in learning about agroforestry. When given a choice of several educational activities, the most preferred three were indoor workshop with field activity, indoor workshop with video, and indoor workshop with handbook (Table 19).

Agroforestry Sytems Proposed for the Água de Gato Watershed

Four agroforestry systems are proposed for future projects to be implemented in the Água de Gato Watershed. These systems all meet the following criteria:

- physically and biologically feasible,
- socially acceptable to people, and
- meet long range objectives for improvement in the watershed, such as soil conservation, biodiversity, soil quality (organic matter, fertility, biota), improved food supply, and/or socioeconomic conditions.

Physically the watershed can be divided into three areas or zones, which are the irrigated, the rainfed, and the lands out of any agricultural usage. The four systems to be proposed will be implemented on those three zones. Two systems for the irrigated areas, one for the rainfed areas, and one for the lands out of any agricultural usage.

In the irrigated areas where the farmers have been practicing some kind of agroforestry, instead of introducing new systems, improvements will be made on the traditional, a kind of homegardens and multistory tree gardens (Figure 8 and 9). These two systems are very similar, with the difference of having the family house included or not into the system. They will be of an intermediate character, where cash crops will help to improve the socioeconomic condition of these farmers, and the subsistence crops will

Table 19. Educational activities preferred by technicians on the island of Santiago.

	Educational Scale				
	Preferred				Dislike
Educational Activities	**1**	**2**	**3**	**4**	**5**
Written Handbook	10	6	7	1	1
Video	5	10	7	3	0
Indoor Workshop	8	7	8	1	1
Indoor Workshop with Handbook	13	8	3	1	0
Indoor Workshop with Video	14	7	1	0	1
Indoor Workshop with Field Activity	23	1	0	0	1
Field Activity Only	4	6	11	4	0

Note: the interviewed could choose more than one activity and classified them independently from each other.

Figure 8. Practice of indigenous agroforestry in the Água de Gato Watershed. Corn, oranges, beans, papaya, mangos, coconuts, cassava and other vegetables are grown together on irrigated land.

Figure 9. A close view of an indigenous agroforestry system with an association of cassava and beans under mango trees.

guarantee some of the household food production. Labor will be provided year round by family members, but some outside labor might be hired when the need becomes high. Since most of the trees already growing on the irrigated areas are for fruit production, major improvements include improving the genotypes and health of existing species and trees, improving fertility, and the introduction of new species which can be marketable. For the agricultural crops, besides establishment of a better irrigation system, such as drip irrigation, species improvement and fertilization should be the main concern. For the animals, and in order to improve the community health, stables far enough from the houses should be constructed, and in case a theft problem exists the farmers should have their animals close to the house. In these cases the farmers should be informed about potential disease problems which could surge from those places if not cleaned often. Here extension technicians could play a big role, and gain trust from the farmers who he/she works with.

In the rainfed areas, soil conservation on edges, a low-cost vegetative approach, with some sparse multipurpose trees is proposed. It is necessary to increase the productivity and longevity of the lands under rainfed systems, where most of the erosion occurs, and this system will help to protect the down stream properties , including the irrigated areas, by decreasing the chance of flooding. For the strips, domesticated vetiver grass (*Vetiver zizanioides*) will be the main element in conservation of soil and water. Vetiver grass is a perennial that grows in dense clumps with leaf blades which can reach 2.5 m, sterile seeds, and propagates mainly by root divisions or slips. The fact that it does not reproduce by seeds, stolons or rhizomes (not a weed candidate) make it very acceptable among farmers. Vetiver grass clumps form good edges and its deep rooting habit gives it excellent soil conservation qualities and a low competition against agricultural crops (NRC, 1993). The vetiver grass strips will be 30 cm wide, and the plants laid just one near the other in order not to have openings along the strips. The strips will function as barriers, trapping soil behind them, this way leveling the corridors. Beside trapping soil, the vetiver grass strips will help diminish the surface water runoff velocity and so help to increase its infiltration. In order to reduce competition for water, light and nutrients between the vetiver grass and the agricultural crops, the vetiver grass will be maintained at a height of 15 to 20 cm above the soil upstream. Although studies have shown that vetiver grass, when used as strips for soil conservation, the competition with agricultural crops is minimum (NRC, 1993), the few roots which might grow into the corridors will be trimmed at the beginning of the rainy season, to make sure that almost no competition occurs. The no competition characteristics of this grass might be not only because of its physiologic characteristics, such as deep rooting, but also due to a high water infiltration and retention, and nutrient accumulation behind the strips. The parts of the leaves trimmed from the grasses can be used as mulch, fodder, roof covering, and prime material for art/crafts. For this project farmers will be advised to accumulate part of the trimmed leaves on the upper side of the strips to stimulate infiltration and help to reinforce the sponge effect that is created around the vetiver grass strips. On the corridors, with a width depending on the slope of the terrain, the common crops maize and beans will be grown. Among the beans, pigeon pea will be an important component since it is a small shrub nitrogen fixer and is deep rooted. Its characteristics will help to enrich the soil by making nutrients, especially nitrogen, more available at the top of the soil, creating a better environment for the shallow rooters, such as maize. It has been reported that with vetiver grass hedge rows along the slope contour, steepness does not appear as a constraint and that agriculture can be safely practiced on hill side terrains with slopes higher than 50%, and could even reach 100% without causing erosion problems. Due to the small size of the farms, trees with multipurpose use will be interspersed and pruned during the rainy season. Beside the ones already adopted by the farmers, other species such as pepper tree (*Schinus molle*) could be introduced and tested in the watershed.

For the lands out of any agricultural usage the agroforestry system for fuelwood production (woodlots) with some possibilities for fodder production will be the best choice. Small patches of trees on contour bench terraces will be established on the degraded lands where most of the vegetation cover has been destroyed and fertile topsoil washed away, and on the ones with a high quantity of pebbles where agriculture is not practiced. The species will be the preferred ones of the farmers, mesquite (Figure 10), acacias, and even the small shrub, *Dichrostachys cineria*, which germinates naturally on the slopes, but its heavy use as fuelwood has been causing its disappearance from the sites closer to the communities. The fuelwood will be mainly for household consumption, but in cases where surplus might exist it could also be for cash. Increased fuelwood production in the watershed, would help to forestall the premature harvesting of trees (Figure 11), shorten the time needed for its gathering, and as a result, increase the time children and women have for other activities, such as education. Increased fuelwood availability in the watershed may also result in a decrease in use of crop and animal residues as fuel, which could otherwise contribute to a higher soil organic matter, and so a better yield. For example it has been reported that 50% reduction in soil organic matter has been shown to reduce maize yields by 25% (NRC, 1993).

Since implementation of these systems will require high labor input the proposal will be for them to be carried out by the government agencies and maintained by the farmers. FAIMO will be used as the work force. After implementation, and even after adoption of the systems by the farmers occur, continuous technical support should be

Figure 10. Mesquite is one of the most popular non-fruit trees grown in the watershed for fuelwood, shade, and fodder.

Figure 11. Mesquite tree, which used to serve as shade for animals, harvested prematurely for fuelwood.

provided to the community in order to help to improve the systems, and at the same time, bring a better and closer relationship between the farmers and the governmental agencies. If labor maintenance, especially of the strips, becomes too high, a system of incentives could be established to remunerate the farmers who self-engage in the maintenance of the systems. Otherwise, the farmers may abandon the systems, before results can be seen, due to increases in labor, especially during the peak. A failure for not understanding the farmers needs could mean the failure of the whole project, which will have as its final goal adoption of the systems in other watersheds. Demonstrating that agroforestry systems, when well chosen and maintained, can provide ecological stability and sustainable benefits for the land's users is a major goal.

SUMMARY AND CONCLUSION

The community of the Água de Gato Watershed, perhaps similar to others in the country, consist of farmers with very small farms, averaging 1.1 ha, that are reluctant to adopt new land use systems, such as agroforestry. This is because agroforestry always has trees or other woody perennials as a component, and most of the time these forms of vegetation are highly competitive with agricultural crops, especially for light, nutrients, and water. The last one is even more important in places where water is a limiting factor. In Cape Verde, due to its climate, water is the number one agricultural limiting factor.

In Cape Verde, farmer behavior may be due to the long history of land degradation; the scarcity of fuelwood which is the main form of energy for household food preparation in the rural areas; and strong desire of the people to improve their financial status in order to guarantee their future and that of their children.

In general, the farmers were willing to plant trees for different purposes, especially for fuelwood and fruit production. Most farmers, however, were unwilling to plant more trees for shade. The unwillingness of the farmers to plant more trees for shade might be related to the existence of already a large number of yard trees which provide shade not only for the people but also for the animals living around the houses.

If the Água de Gato Watershed's farmers adopt agroforestry as a future system for their lands, it will bring productivity to a higher level because more water and healthy soil will be available. The system is also sustainable because less erosion will take place, permitting the practice of agriculture even on the steep hillsides which are often abandoned after a few years of cultivation due to loss of the topsoil. Agroforestry systems will also help to better distribute labor and agricultural products throughout the year, giving the farmers more security year round. The final result will be communities with a better socioeconomic life, resulting in less people migrating to the urban areas.

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APPENDICES

Appendix I. Farmer Questionnaire.

FARMER AGROFORESTRY SURVEY

I. BACKGROUND INFORMATION-FARM

1. What kind of agricultural crops do you grow?

a. Subsistence crops: (Specify) ____

____

b. Cash crops: (Specify) ____

____

____

2. What kind of trees do you grow? ____

____

____

3. What products do you grow trees for?

		species:
_______	Fodder	________________________
_______	Timber	________________________
_______	Firewood	________________________
_______	Fruits (food)	________________________
_______	Medicine purpose	________________________
_______	Shade	________________________
_______	Art/craft	________________________
_______	Poles	________________________
_______	Other (Specify)	________________________

____

4. Do you use fertilizer on:

a. Irrigated crops?

_______ Yes _______ No

b. Rain-fed crops?

_______ Yes _______ No

5. Do you use manure on:

a. Irrigated crops?

_______ Yes _______ No

b. Rain-fed crops?

_______ Yes _______ No

6. Do you grow animals?

a. _______ Yes b. _______ No (Do not answer questions 7 and 8)

What kind and number of heads of each category? ________________________

____

7. How do you grow them?

a. _______ Caged b. _______ Free

c. _______ Does someone take them to pasture?

8. Who is in charge of feeding the animals?

a. _______ Man b. _______ Woman c. _______ Children

9. Are you interested in conservation practices that would ensure the future productivity of the land? ___________________________________

II. AGROFORESTRY INTEREST

1. Do you know about agroforestry?

a. _________Yes b. __________No

2. Willingness

a. Do you have any interest in growing more trees? _______Why? ___________

____

b. Who do you think should pay for seedling production and planting? _________

Why? ____

____

c. Who will own the trees and their products? _______________________

Why? ____

____

3. Who will be responsible for the maintenance of the trees?

a. Weeding
- Man _______
- Woman _______
- Children _______

b. Irrigation
- Man _______
- Woman _______
- Children _______

4. Constraints for agroforestry implementation?

_______ Land/space

_______ Ownership of land/trees

_______ Laws

_______ Availability of seedlings

_______ Land and water availability for seedling production

_______ Need of support (Specify) ______________________________

_______ Need of incentives

_______ Need of a line of credit

_______ Other (Specify) ___________________________________

____

III. EDUCATIONAL NEEDS

1. If there was in Cape Verde or other places, training courses or other means to learn about agroforestry, would you have desire to learn about it?

a. _______ Yes b. _______ No c. _______ Uncertain

2. Using the rating matrix below, circle the appropriate numbers to rate your preferences for learning how to use agroforestry (Please circle a number for each preference only once).

	Prefer			Dislike
a. Written handbook	1	2	3	4
b. Video	1	2	3	4
c. Workshop	1	2	3	4
d. Field activity	1	2	3	4

IV. BACKGROUND INFORMATION-INDIVIDUAL

1. Please identify the type of employer you work for and when.(Please check where appropriate)

a. _______ F.A.I.M.O. When ______________________

b. _______ Farmers at the community When ______________________

c. _______ Farmers at other communities When ______________________

d. _______ Other (Specify) __________ When ______________________

2. In what community(s) do you primarily work? ___________________________

3. Please answer the following questions.

a. How old are you? ______________________________

b. What's your gender? ______________________________

c. Do you have husband/wife? ______________________________

d. How many people live in your home? ______________________________

e. How many hectares do you own? ______________________________

f. How many hectares do you have rented from someone else? ______________

g. How many hectares do you have rented to someone else? ______________

h. How many hectares are you working in the partnership regime? ____________

4. Needs for fuelwood

a. Is the availability of fuelwood a problem? ______________________________

b. Where do you usually collect your fuelwood? ______________________________

c. How far from your house do you have to go? ______________________________

d. How much time do you spend each week collecting fuelwood? ____________

e. Do you walk? ______________________________

f. How is the fuelwood transported? ______________________________

g. Who collect it? ______________________________

h. How much do use daily? (Please specify in kg) ______________________________

i. What do you use the fuelwood for? ______________________________

j. Do you buy fuelwood? _______ If yes, how much does it cost? ____________

k. Which species are currently used for fuelwood: (Please rank by preference) ___

5. Beside fuelwood, do you use other kind of energy for cooking?

a. _______ Yes b. _______ No

_______ Electricity _______ Bottled gas

_______ Charcoal _______ Bio-gas

Other _______ (Specify) ______________________________

Appendix II. Technician Questionnaire.

TECHNICIAN AGROFORESTRY SURVEY

I. BACKGROUND INFORMATION-INDIVIDUAL

1. Please identify the type of employer you work for.(Please check where appropriate)

_______ D.G.A.S.P.
_______ D.G.A.R.
_______ I.N.I.D.A.
_______ I.N.E.R.F.
_______ I.N.F.A.
_______ Other Governmental Agencies
_______ Consultants
_______ Other (Specify) ______________________________________

2. In what island and region do you primarily work? ______________________

3. Which of the following positions most closely describes yours? (Please check only one)

a. Forest technician　　b. Forester　　c. Extension agent
d. Agronomic technician　　e. Agronomist　　f. Administrator
e. Other(Specify) ______________________________________

4. Please, answer the following questions.

How old are you? ______________________________________
What's your gender? ______________________________________
Where did you get your education? ______________________________
What's your specialization? ________________________________
How long ago? ______________________________________
Are you presently working in your area of specialization? ________ Why not? ___
____
____

II. KNOWLEDGE ABOUT FARMERS ACTIVITIES

1. Fuel wood species: (Please rank by preference) ______________________
____
____

2. Fuelwood Constraints

_______ Land/space
_______ Ownership of land/trees
_______ Laws
_______ Other (Specify) ______________________________________

3. What do you think the farmers use the trees for?

Species:

_______ Fodder ______________________________
_______ Timber ______________________________
_______ Firewood ______________________________
_______ Fruits(food) ______________________________
_______ Medicine purpose ______________________________
_______ Shade ______________________________
_______ Art/craft ______________________________
_______ Poles ______________________________
_______ Other(Specify) ______________________________
____
____

III. AGROFORESTRY KNOWLEDGE

1. Do you have any knowledge about agroforestry?

a. _______ Yes
b. _______ No (Do not answer questions 2 to 7)

2. For how many years have you been involved in the management of agroforestry?

____

3. Do the farmers in the Água the Gato Watershed practice any kind of agroforestry? ____ If so, give the name of the system, where it's practiced and why. ____
____
____
____
____

4. From the view point of your employer, please rank the top 3 of the following agroforestry systems, which are or could be implemented in the Agua the Gato Watershed, with regard to economic importance and need for erosion control, where 1 is the most important and 3 is the least important.

a. _______ Shifting cultivation
b. _______ Taungya
c. _______ Multilayer tree gardens
d. _______ Silvopastoral systems
e. _______ Plantation-crop combination
f. _______ Intercropping systems (alley cropping)
g. _______ Windbreaks and shelterbelts
h. _______ Multipurpose trees for fuelwood and fodder
i. _______ Multipurpose trees on farmlands
j. _______ Soil conservation hedges

5. How many change from traditional agriculture to agroforestry over the course of the last 4 years have you experienced in your career? ____________________

6. If you have experienced at least one change, how many years ago did the last change occurred? ____

7. Please rank the top 3 (1 is most important), where you've learned about agroforestry systems (Please use each number only once).

a. _______ College/university course
b. _______ Short course/workshop
c. _______ Government institution publications
d. _______ Textbook/journal articles
e. _______ Field experience/on the job
f. _______ In-service training
g. _______ Video(s)

IV. EDUCATIONAL NEEDS

1. If there was in Cape Verde or other places, training courses or other means to learn about agroforestry, would you have desire to learn about it?

a. _______ Yes b. _______ No c. _______ Uncertain

2. Using the rating matrix below, circle the appropriate numbers to rate your preferences for learning how to use agroforestry (Please circle a number for each preference).

	Prefer		Neutral		Dislike
a. Written handbook	1	2	3	4	5
b. Video	1	2	3	4	5
c. Indoor workshop	1	2	3	4	5
d. Indoor workshop with handbook	1	2	3	4	5
e. Indoor workshop with video	1	2	3	4	5
f. Indoor workshop with field activity	1	2	3	4	5
g. Field activity only	1	2	3	4	5

Appendix III. Subsistence crops in the Água de Gato Watershed.

SUBSISTENCE CROPS

Common Name	Scientific Name	Portuguese (C. Verde) Name
Banana	*Musa* spp.	Bananeira
Broccoli	*Brassica oleracea*	Couve
Cabbage	*Brassica oleracea* var. *capitata*	Repolho
Carrot	*Daucus carota*	Cenoura
Cassava or manioc	*Manihot esculenta*	Mandioca
Common potato	*Solanum tuberosum*	Batata Inglesa
Corn or maize	*Zea mays*	Milho
Cow pea	*Vigna unguiculata*	Feijão bongolon
Cucumber	*Cucumis sativus*	Pipino
Garlic	*Allium sativum*	Alho
Hyacinth bean	*Lablab niger*	Feijão pedra or careca
Jack bean	*Canavalia ensiformis*	Feijão fava
Lettuce	*Lactuca sativa*	Alface
Onion	*Allium cepa*	Cebola
Pigeon pea	*Cajanus cajan*	Feijão congo
Sieva bean	*Phaseolus lunatus*	Feijão bonge or bonjinho
Snap bean	*Phaseolus vulgaris*	Feijão sapatinha
Squash	*Cucurbita* spp.	Aboboreira
Sweet potato	*Ipomoea batatas*	Batata doce
Tomato	*Lycopersicon* spp.	Tomato
Turnip	*Brassica rapa*	Nabo

Appendix IV. Cash crops in the Água de Gato Watershed.

CASH CROPS

Common Name	Scientific Name	Portuguese (C. Verde) Name
Banana	*Musa* spp.	Bananeira
Broccoli	*Brassica oleracea*	Couve
Cabbage	*Brassica oleracea* var. *capitata*	Repolho
Carrot	*Daucus carota*	Cenoura
Cassava or manioc	*Manihot esculenta*	Mandioca
Common potato	*Solanum tuberosum*	Batata Inglesa
Corn or maize	*Zea mays*	Milho
Cow pea	*Vigna unguiculata*	Feijão bongolon
Cucumber	*Cucumis sativus*	Pipino
Garlic	*Allium sativum*	Alho
Hot pepper	*Capsicum frutescens*	Malagueta
Hyacinth bean	*Lablab niger*	Feijão pedra or careca
Jack bean	*Canavalia ensiformis*	Feijão fava
Lettuce	*Lactuca sativa*	Alface
Melon	*Citrullus vulgaris*	Melancia
Onion	*Allium cepa*	Cebola
Parsley	*Petroselinum crispum*	Salsa
Peanut or groundnut	*Arachis hypogaea*	Mancarra
Pigeon pea	*Cajanus cajan*	Feijão congo
Sieva bean	*Phaseolus lunatus*	Feijão bonge or bonjinho
Snap bean	*Phaseolus vulgaris*	Feijão sapatinha
Squash	*Cucurbita* spp.	Aboboreira
Sugar cane	*Saccharum oficinalis*	Cana de açúcar
Sweet pepper	*Capsicum annuum*	Pimento
Sweet potato	*Ipomoea batatas*	Batata-doce
Tomato	*Lycopersicon* spp.	Tomato
Turnip	*Brassica rapa*	Nabo

Appendix V. Fruit trees in the Água de Gato Watershed.

FRUIT TREES

Common Name	**Scientific Name**	**Portuguese (C. Verde) Name**
Apple	*Pyrus malus*	Mancieira
Avocado	*Persea americana*	Abacateiro
Baobab	*Adansonia digitata*	Imbondeiro or calabaceira
Bread fruit	*Artocarpus altilis*	Fruta pão
Cashewnut	*Anacardium occidentale*	Cajúeiro
Coconut	*Cocos nucifera*	Coqueiro
Coffee	*Coffea arabica*	Café
Fig	*Ficus carica*	Figueira mansa
Guava	*Psidium guajava*	Goiabeira
Indian plum	*Ziziphus mauritiana*	Zimbrão
Java plum	*Eugenia jambos*	Jamboeiro
Lemon	*Citrus limonia*	Limoeiro
Mango	*Mangifera indica*	Mangueira
Mock orange or syringa	*Phyllanthus acidus*	Azedinha or groselheira
Papaya	*Carica papaya*	Papaeira
Quince tree	*Cydonia oblonga*	Marmeleiro
Sweet orange	*Citrus sinensis*	Laranjeira doce
Sweetsop	*Annona squamosa*	Pinha
Tamarind	*Tamarindus indica*	Tamarindeiro
Tangerine	*Citrus nobilis*	Tangerina

Appendix VI. Fuelwood trees in the Água de Gato Watershed.

FUELWOOD TREES

Common Name	Scientific Name	Portuguese (C. Verde) Name
Beef wood	*Casuarina equisetifolia*	Casuarina
Egyptian thorn	*Acacia nilotica*	Espinho preto
Eucalyptus	*Eucalyptus* spp.	Eucaliptus
Golden wreath wattle	*Acacia cyanophylla*	Acácia cianófila
Indian almond	*Terminalia catappa*	Amendoeira
Indian plum	*Ziziphus mauritiana*	Zimbrão
Jerusalem thorn	*Parkinsonia aculeata*	Acácia Martins
Leucaena	*Leucaena leucocephala*	Acácia leucena
Mahogany	*Khaya senegalensis*	Mogno
Mesquite	*Prosopis juliflora*	Acácia Americana or prosopis
Neem	*Azadirachta indica*	Neem
Pepper tree	*Schinus molle*	Pimenteira
Silk cotton tree	*Ceiba pentandra*	Poilão
Tamarind	*Tamarindus indica*	Tamarindeiro
Umbrella mulga	*Acacia holosericea*	Acácia holocericea
Wild fig	*Ficus gnaphalocarpa*	Figueira brava
Winter thorn or gao	*Acacia albida*	Espinho branco

Appendix VII. Fodder trees in the Água de Gato Watershed.

FODDER TREES

Common Name	**Scientific Name**	**Portuguese (C. Verde) Name**
	Acacia victoriae	Acácia Vitória
Golden wreath wattle	*Acacia cyanophylla*	Acácia cianófila
Indian almond	*Terminalia catappa*	Amendoeira
Indian plum	*Ziziphus mauritiana*	Zimbrão
Jerusalem-thorn	*Parkinsonia aculeata*	Acácia Martins
Leucaena	*Leucaena leucocephala*	Acácia leucena
Mesquite	*Prosopis juliflora*	Acácia Americana
Neem	*Azadirachta indica*	Neem
Silk cotton tree	*Ceiba pentandra*	Poilão
Tamarind	*Tamarindus indica*	Tamarindeiro
Umbrella mulga	*Acacia nilotica*	Espinho preto
Winter thorn or gao	*Acacia albida*	Espinho branco

Appendix VIII. Shade trees in the Água de Gato Watershed.

SHADE TREES

Common Name	**Scientific Name**	**Portuguese (C. Verde) Name**
Beef wood	*Casuarina equisetifolia*	Casuarina
Egyptian thorn	*Acacia nilotica*	Espinho preto
Eucalyptus	*Eucalyptus* spp.	Eucaliptus
Indian almond	*Terminalia catappa*	Amendoeira
Mahogany	*Khaya senegalensis*	Mogno
Mesquite	*Prosopis juliflora*	Acácia Americana or prosopis
Neem	*Azadirachta indica*	Neem
Pepper tree	*Schinus molle*	Pimenteira
Royal poinciana	*Delonix regia*	Acácia rubra
Rubber tree	*Ficus elastica*	Borracha
Silk cotton tree	*Ceiba pentandra*	Poilão
Silk oak	*Grevillea robusta*	Grevília
Tamarind	*Tamarindus indica*	Tamarindeiro
Wild fig	*Ficus gnaphalocarpa*	Figueria brava

Appendix IX. Miscellaneous vegetation in the Água de Gato Watershed.

MISCELLANEOUS VEGETATION

Shrubs

Common Name	Scientific Name	Portuguese (C. Verde) Name
	Calotropis procera	Bombardeiro
	Dichrostachys cineria	Espinho cachupa
	Jatropha curcas	Purgueira
Indigo	*Indigofera tinctoria*	Tinta
Lantana	*Lantana camara*	Lantuna or trepadeira

Herbaceous Plants

Common Name	Scientific Name	Portuguese (C. Verde) Name
	Aerva javanica	Florinha
	Cloris virgata	Barba de bode fêmea
	Desmanthus virgatus	Caiumba
Aloe vera	*Aloe vera*	Babosa
Bermudagrass	*Cynodon dactylon*	Grama
Giant reed grass	*Arundo donax*	Cariço or caniço
Maguey	*Furcraea foetida*	Carrapato
Spiny amaranth	*Amaranthus spinosus*	Bredo
Wormseed	*Chenopodium murale*	Fedegosa

Appendix X. Domestic animals in the Água de Gato Watershed.

DOMESTIC ANIMALS

Common Name	Scientific Name	Portuguese (C. Verde) Name
Chicken	*Gallos gallos*	Galinha
Cow	*Bos taurus*	Vaca
Donkey	*Equus asinus*	Burro
Duck	*Cairina moschata*	Pato
Goat	*Capra hircus*	Cabra
Pig	*Sus scropha domesticus*	Porco
Sheep	*Ovis aries*	Carneiro

Appendix XI. Wild Animals Água de Gato Watershed.

WILD ANIMALS

Common Name	**Scientific Name**	**Portuguese (C. Verde) Name**
Barn owl	*Tyto alba detorta*	Coruja
Blackcap	*Sylvia atricapilla*	Toutinegra
Coconut sparrow	*Passer hispaniolensis*	Tchota de coco
Country sparrow	*Passer iagoensis*	Pardal de terra
Crow	*Corvus ruficollis*	Corvo
Eurasian kestrel	*Falco tinnunculus*	Francelho or filili
Glede	*Milvus migrans*	Milhafre
Guinea fowl	*Numida meleagris*	Galinha de Guiné or galinha do mato
Hawk	*Buteo bannermani*	Asa curta
House sparrow	*Passer domesticus*	Pardal das casas
Monkey	*Cercophitecus aethiops*	Macaco
Rock dove	*Columba livia*	Pombo das rochas
Sparrow	*Estrilda astrild*	Bico de lacre
Sparrow (native)	*Halcyon leucocephala*	Passarinha endémica
Sugar cane sparrow	*Acrocephalus brevipennis*	Tchota de cana
Swift	*Alpus alexandri*	Andorinha
Vulture	*Neophron percnopterus*	Canhota or abutre

Appendix XII. List of Acronyms and Abbreviations

LIST OF ACRONYMS AND ABBREVIATIONS

ADC-AG	Association for the Água de Gato Watershed Community Development
D&D	Diagnostic and Design
DGAR	Directorate General of Rural Animation
DGASP	Directorate General of Agriculture, Silviculture and Animal Husbandry
FAIMO	Frentes de Alta Intensidade de Mão de Obra (working gangs)
FAO	Food and Agricultural Organization
FSR/E	Farming Systems Research/Extension
GEP	Cabinet of Studies and Planning
ICRAF	International Center for Research in Agroforestry
IDRC	International Development Research Center
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
INERF	National Institute of Rural Engineering and Forestry
INFA	Directorate General of Rural Animation
INIDA	National Institute for Agriculture Research and Development
MA	Ministry of Agriculture
MPAAR	Ministry of Fisheries, Agriculture and Rural Animation
NCR	National Research Council
OFR	On Farm Research

PLLA	Participatory Landscape Livescape Appraisal
PRPI	Plano de Referência de Propostas de Investigação (research framework)
SANREM CRSP	Sustainable Agriculture and Natural Resources Management Collaborative Research Support Program
U.S AID	U.S. Agency for International Development
WARD	Watershed and Applied Research Development

VITA

The author was born in Povoação-Santo Antão, Republic of Cape Verde April 7, 1959. The fourth of the Zacarias and Ilda Delgado's six children. He speaks Creole (maternal language), Portuguese (official language) and English fluently, and his French and Spanish is fair. He did his elementary school at the Escola Central, Povoação-Santo Antão, 1967 to 1973, complementary school at Ciclo Preparatório, Povoação-Santo Antão, 1973 to 1975, and high school at Liceu Ludgero Lima, Mindelo-São Vicente, October, 1975 to July, 1982. In October, 1983 he went to Colorado State University, Ft. Collins, Co.-USA where he studied English and got a BS degree in Forest Management, December, 1988. In August, 1994 he became a graduate student at Virginia Tech, Va-USA, and completed his master (MS) degree in Agroforestry, August 23, 1996.

Professionally he taught Portuguese at Ciclo Preparatório (complementary level), and a nocturne drawing course (high school level), Povoação, October, 1982 to July, 1983. His first job after return from USA was as Chief of the Project Integrated for the Development of Planalto Leste, Água das Caldeiras-Santo Antão. At the same time he supervised the Project for Reforestation and Soil Conservation in the Sahel, Porto Novo-Santo Antão, and worked part time as a drawing teacher at the Santo Antão High School-Povoação, October, 1990 to July, 1992. He became the S. Antão's Regional Director for the Ministry of Fishery, Agriculture and Rural Animation (MPAAR) in 1993, and with major changes in the country, and so in the ministry, the directorship position was extincted and he became the Santo Antão's Delegate of the Directorate General of Agriculture, Silviculture and Animal Husbandry (DGASP) for the same ministry, until August, 1994, when he had to abandon in order to attend Virginia Tech.

While working, from 1989 to 1994, he frequented various seminars and conferences in the country and abroad. In 1990, he frequented a seminar in the area of timber preservation, Paris-France, and in 1991, Environmental Impact of Forest Harvesting on Steep Terrain, Ort and Ossiach-Austria.

Socially he has been active in many areas, being the most relevant:

- His service in the Cape Verde Army for 22 months, 1978 to 1979.
- Been a founder member of the Santo Antão magazine, MONTANHA.
- Member of the Ribeira Grande (municipality) local government, 1991 to 1994.
- President of the soccer team Rosariense Clube da Ribeira Grande, 1992 to 1994.

The Author is a Capeverdean citizen and employee of DGASP, Ministry of Agriculture (MA), and he plans to return to his home country to continue his work over there.

Orlando Jesus Delgado