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Impacts of Salt Production on Pemba

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ABSTRACT

The economic, social, and environmental impacts of salt production were studied on the eastern coast of Pemba Island. Solar salt production is associated with the clear cutting of mangrove forests, which are significant as soil stabilizers, animal habitats, and as an economic resource. An environmental assessment of this industry is necessary to determine whether the socio-economic gains from salt production justify the environmental costs. Interviews with owners, employees, and day laborers from 20 salt farms were conducted to assess the general sustainability of the industry. The average annual owner income was determined to be approximately 570 000 Tsh, while employees and day laborers, usually paid in salt, earned the monetary equivalent of 245 000 Tsh and 70 000 Tsh, respectively. Field visits to salt farms were done study the surrounding mangroves and measure salinity, which was found to be 0 Be at the farms. Mangrove transects were studied in both salt farm and non-salt farm areas to determine species diversity, distribution, and average height. *Avicennia marina*, *Ceriops tagal*, and *Rhizophora mucronata* were present in all transects through salt farm and non-salt areas. Suggestions for improving salt production and quality while minimizing adverse environmental effects were recommended.

Topic Codes: 511, 537, 608

INTRODUCTION

Over the last decade, people of Pemba Island, Tanzania have begun to explore salt production as an alternative means of income. The industry has the potential to generate substantial revenue for Pemba and to provide long-term employment to coastal peoples. However, salt farming is also an activity with clear and direct impacts on mangroves, a threatened and important coastal ecosystem. For salt production to be a sustainable industry for Pemba, economic and social benefits must be able to balance and minimize environmental costs over the long-term.

The Salt Farming Community

Salt farming on Pemba is small-scale, and wealth is concentrated in the hands of a few. Farms are usually owned by small groups of two to four investors, although a few large cooperatives of ten or more owners exist. Owners are responsible for the initial farm construction costs, which are generally between 1 and 2 million Tsh, as well as for the annual operating costs, including equipment, maintenance and repairs, and employee wages. Even so, owners benefit the most from salt farms. Employees work at the farms for the entire production period and are most often paid at the end of the season in salt. Owners set aside a certain percentage of the net production for their employees usually totaling less than 35%. Most farms have 3 to 5 full-time employees and employ 2 to 10 additional workers at harvesting time. These day laborers are paid at the time of harvest either in salt or money. They earn up to one bag of salt per day and usually do not earn more than 100 000 Tsh per year.

People of a wide variety of socio-economic backgrounds participate in salt farming. Owners and employees are usually men who are supporting families. Almost all have at least 6 dependents and are the principle breadwinners in their households. Men and women ranging

from teenaged students to 65 year old grandmothers work as day laborers. These individuals work to supplement family income, but are often economically dependent on relatives. In terms of education, most salt farmers have had less than 8 years of school, and many have had none at all, but there is little correlation between education and income.

Salt farmers also engage in the subsistence farming that is typical of Pemba. Most people grow cassava and bananas, and man also cultivate rice. Pemba people usually farm for home consumption rather than for sale. Subsistence agriculture is an important activity for rural Pemba, as most of the island is used for crop cultivation.

Methods of Production

Solar salt production takes advantage of the natural salinity of seawater. Normal ocean water has a salinity of 3% to 3.5%, or approximately 35 g salt per kg seawater. [Hill 1989] Table salt, or sodium chloride (NaCl), comprises 77.8% of the ionic salts in seawater. Magnesium, calcium, potassium, and chlorine, sulfate, and bromine make up the remaining ions. [Mbarouk 2005] Salinity can be measured as an osmotic potential in atmospheres, a specific gravity, or as a concentration using the Baume scale. 1 Be is equivalent to 10 grams NaCl per kg water, or 1%. Most salt farmers monitor the salinity of water circulating through their pans with Baume hydrometers provided by UNICEF.

Salt production involves four types of pans. Water floods the reservoirs during the spring high tides and begins to mature there for 14 to 30 days before flowing to the condenser pans. The sun heats the water in the condenser pan and evaporation continues until a salinity of 7 to 10 Be is reached, at which point the brine is pumped or flows by gravity into the shallow pre-harvesting pans. Well-designed farms will allow water to pass through a series of condenser and pre-harvesting pans for about one month. This sort of slow circulation aids evaporation and

allows for precipitation of waste salts as their saturation points are reached. The crystallization series begins with calcium carbonate, followed by calcium sulfate, and finally sodium chloride. Salt quality is judged based on purity and color. High grade table salt should be at least 96% pure NaCl and should appear clear; the presence of impurities give salt a cloudy, off-white color. [Mbarouk 2005] For the purest product, water should enter the harvesting pans near the salinity at which sodium chloride begins to precipitate at 25 to 26 Be. The first harvest usually requires one week until salt precipitates and an additional week until it is ready to be harvested at 30 Be. The thin layer of salt precipitate is harvested, packed in 50 kg sacks, and sold to vendors. Farmers typically get 50 to 150 bags of salt per pan per harvest, and harvest occur 2 to 4 times per month for a harvesting period of 4 to 5 months.

Evaporative salt production on Pemba occurs during the dry seasons. The production season begins in during the southeast monsoon, as farmers begin collecting seawater in June, July or August. They harvest for the first time in August, September, or October. The timing of the process depends heavily on weather, as rain lowers salinity and clouds retard evaporation. Under the calm, sunny conditions, water should spend a total of 41 to 42 days in the condenser, pre-harvesting, and harvesting pans before the first harvest. However, many farmers on Pemba harvest the salt early and so produce salt of lower quality. Second and later harvests do not require as much time because residual salt in the pans acts as a yeast to speed up the crystallization process. Production stops during the short rains during November and December, then picks up again from January to March during the northeast monsoon. No salt is produced during the long rains which occur from late March to early June, but farmers may begin maintenance work and pan preparation in late May or June.

Permits for the construction of salt farms on Pemba are supposed to be issued through the Department of Forestry after consultation with the Department of the Environment. People interested in salt farming are supposed to first contact the local leader of the village, or Sheha, and then submit a letter to the Department of Forestry. In accordance with the Environmental Management for Sustainable Development Act of 1996, which specifies that projects involving reclamation of land requires environmental impact assessments, the Departments of Forestry and the Environment are supposed to jointly carry out a preliminary site survey. [Environmental Management 1996] However, some farmers begin construction prior to receiving permission. The Department of Forestry has not approved any new farms since 2002.

The technology used in salt harvesting varies, but production of high quality salts requires flow of water by gravity or use of water pumps. Well-constructed farms may allow water to flow passively between pans, but active pumping is usually required at some stages in the production process. On Pemba, not all salt farms use pumps because pumps and fuel are expensive. Rather, workers must carry salt between the pans in buckets. Manual water transfer lowers salt yield and quality because the action of walking through the pans disturbs the crystallization process and introduces mud and other impurities. The low-technology methods on Pemba can be contrasted with large salt operations in Mexico, where eight pumps fill 24 000 ha of salt pans and mechanized harvesting and conveyor belt system carries salt to a storage warehouse and then to the loading dock for export. [Ortega 2001]

Certain species of halophilic, or salt-tolerant, algae are associated with salt production and aid the purification process. Filamentous blue algae of the genera *Microleus*, *Oscillatoria*, and *Lyngbya* form algal mats in salt pans, and the green alga *Dunaliella salina* thrives in hypersaline environments and gives the pans a red or pink color. These algae absorb nutrients

from the brine and bind detritus. [Richmond 2002] A study on cultivated algal mats in Chinese salt farms showed that the mats increased salt yield and salt purity from 94.1% to 96.0%. The algal mats were reported to lower aqueous metal content. [Liu 2002]. Algae grow naturally in some of Pemba's salt farms.

The Salt Market

The Association for Zanzibar Salt Processing Organizations (AZASPO), a nongovernmental organization, supports and manages Pemba's salt industry. Originally funded as a project of the United Nations Development Program from 1997 to 1999, AZASPO is now independently registered under the Zanzibar Society Act. AZASPO's office is located in Machomanne, where Mr. Juma "JB" Bakari serves as coordinator for the 56 participating farms. AZASPO's goal is to regulate the salt industry and ensure its sustainability, and to that end, it has built what will soon function as a salt processing plant. Currently, most of the salt produced on Pemba is consumed locally; however, AZASPO hopes to access an international market by taking over the refining, iodation, and packaging of Pemba's salt. At the same time, AZASPO plans to provide salt farmers with a permanent market and stable price for their salt.

The salt industry is relatively new to Pemba, but has been important in other areas of the world for several millennia. People have been extracting salt from ocean water for over 4000 years. [Thys 2003; Richmond 2002] Currently, solar salt production occurs along the East African coast in Kenya, Tanzania, Mozambique, Madagascar, and Mauritius, as well as in Mexico, China and South Asia. [Richmond 2002; Semesi 1998; Ortega 2001; Liu 2002] Globally, evaporative salt pans produce between 6 and 15 million tons per year. [Richmond 2002; Thys 2003] Pemba farmers learned the methods and techniques of evaporative salt farming from experts from mainland Tanzania, who have been producing salt near Bagamoyo

and Tanga since the 1980s. In the decade following 1992, sixty two salt farms were established along Pemba's eastern coast.

Iodation of salt is important for preventing Iodine Deficiency Disorder (IDD). IDD affects neurological development, with pathology ranging in severity from mild depression or learning disorders to mental retardation. IDD is a global problem affecting 45 countries in Africa; however, in 1990 many countries agreed to the World Summit for Children's mandate to end IDD by the year 2000. The best form of iodine supplementation is through iodized salt because salt is inexpensive and widely used in cooking. The International Council for the Control of IDD, UNICEF, and the World Health Organization are currently taking action to change methods of salt production to include iodation. [Dunn 1996] UNICEF has provided Pemba farmers with hand pumps and iodine and has paid for the machinery at AZASPO's planned salt refinery to lower incidence of IDD.

In addition to its nutritional value as an iodine supplement, salt is an important source of electrolytes, which facilitate nerve conduction. Salt is used as a condiment and in cooking, especially in the preservation of fish and meat. Salt also has industrial applications, as products such as washing soda, baking soda, bleach, and chlorine contain salt. [Richmond 2002; Mbarouk 2005]

Environmental Effects

Clear cutting of mangroves for salt production poses a threat to the conservation of mangrove ecosystems. [Shunula 1996; Farnsworth 1997; Ngoile 1992] In Mozambique, salt production ranks second among human activities contributing to mangrove deforestation, [Semesi 1998] which was occurring at a rate of 1821 ha/year in 2001. [Barbosa 2001] In Tanzania, salt pans were estimated to cover 3093 ha in 1998. [Semesi 1998] In addition to

deforestation, salt pans are responsible for elevating local soil salinity and for producing a hypersaline runoff that may impair mangrove growth and regeneration. [Faki 2003; Shunula 1996] Effects on animal populations, such as fish, birds, crabs, and shellfish inhabiting the mangroves, are not well understood.

Mangrove forests are fragile, yet valuable, ecosystems. Mangroves are classified as a group of woody halophytes growing from the high water mark to the mean sea level. [Farnsworth 1997; Shunula 1996] On Pemba, there are nine species of mangroves covering an area of 12 000 ha (Table 1). [Ngoile 1992; Shunula 1996] The area of mangroves forests on Pemba is double that of Unguja and accounts for almost 9% of the mangroves in Tanzania. [Semesi 1998; Ngoile 1992]

Table 1: Scientific and Kiswahili Names of Mangroves

Scientific Name	**Local (Kiswahili) name**
Avicennia marina	Mchu, msuti, mkandaa mweupe
Rhizophora mucronata	Mkoko, mkandaa mweusi
Ceriops tagal	Mkandaa mwekundu
Bruguiera gymnorrhiza	Mkandaa, msinzi, muia
Heritiera littorals	Msikundazi, mkungu
Lumnitzera racemosa	Kilalamba, mnyanywa, kikandaa, mbaumbau
Sonneratia alba	Mlilana, mpita, mpira
Xylocarpus granatum	Mkomafi, mtonga pwani
Xylocarpus moluccensis	Mkomafi dume, mtonga

[Koenders 1992]

The intrinsic worth of mangroves is apparent from their ecological and economic importance. Villagers harvest mangrove poles for construction and export. The timber is valuable for its strength and termite resistance. Mangroves are also important sources of firewood and charcoal. The bark is harvested for its high tannin content and is used in leather treatment, and some species are used in traditional medicines to treat stomach ailments. [Farnsworth 1997; Shunula 1996] However, over-harvesting for charcoal, lime, and salt

production threatens mangroves in Tanzania and all over East Africa. [Ngoile 1992; Barbosa 2001]

The rate of mangrove deforestation is alarming because mangroves are a critical component of coastal ecosystems. They provide habitats for many species of mollusks, crabs, shrimp, and birds, and are especially significant as nurseries for juvenile fish and crustaceans. [Viles 1995] Local fisheries depend on mangroves to replenish fish populations. Fish associated with mangrove forests include important food sources such as emperor fish (*Lethrinus harak*), milkfish (*Chanos chanos*), and rabbit fish (*Signanus spp.*) [Ngoile 1992; Shunula 1996] Mangroves also function to prevent erosion by stabilizing and trapping sediments. [Viles 1995; Farnsworth 1997] The roots and trunks reduce wave energy and allow for the deposition of fine silts. The trees facilitate nutrient recycling, especially of sulfur, and remove from the water excess nutrients like nitrogen and phosphate, thus helping to prevent eutrophication. [Shunula 1996]

Anthropogenic exploitation and pollution constitute the greatest threat to mangroves. Cutting for poles, charcoal, and firewood and reclamation for road construction, aquaculture, and salt production has resulted in unsustainable deforestation. Pollution from sewage and oil continues to damage mangrove stands. [Farnsworth 1997; Semesi 1998] Elevated soil salinity and decreased water flow due to salt farms may stunt or kill mangroves or impede natural regeneration. [Viles 2005] Although all species of mangroves have adapted to salty environments, some species have higher salt tolerances than others. *Avicennia marina* can tolerate salinities up to three times greater than normal ocean water because it has evolved glands that actively excrete salt. [Shunula 1996; Semesi 1998] *Ceriops tagal* and *Rhizophora mucronata* have intermediate salinity tolerances. [Semesi 1998] The least salt-tolerant species,

found on the supralittoral fringe, estuary environments, or near freshwater sources, include *Lumnitzera racemosa, Heritiera littoralis,* and *Xylocarpus spp*. [Shunula 1996] These species are likely to be especially sensitive to hypersalinity.

Mangroves have long been recognized as important habitats, but protective measures are difficult to implement and enforce. People fail to recognize the environmental and economic value of intact mangrove stands. [Farnsworth 1997] Populations in developing countries often feel economic pressure to ignore the long-term ramifications of environmental damage in favor of short-term income and thus risk unsustainable development. [Farnsworth 1997; Department for Development Support 1993]. By contrast, sustainable development should contribute to the elimination of poverty, a more equitable distribution of resources, and overall health and education of the people. [Department for Development Support 1993]

It was the objective of this study to determine whether Pemba's salt industry is congruent with the principles of sustainable development. The social, economic, and environmental impacts of salt farming were studied, and the benefits to salt farm owners, employees, day laborers, and the wider Pemba community were assessed. Furthermore, methods and techniques of salt farming were studied and analyzed so that recommendations for improving benefits to the salt farming community, as well as production yield and quality, could be suggested.

STUDY AREA

This study took place at villages and salt farms along the eastern coast of Pemba Island. Pemba and its sister island, Unguja, together with several smaller islands make up the Zanzibar Archipelago, lying approximately 40 km off the coast of mainland Tanzania in the western Indian Ocean. Pemba covers an area of 868 km^2 and is located between 4º 45' S and 5º 30' S Latitude and between 39º 3' E and 40º E Longitude. [Faki 2003]

Pemba Island has a population of approximately 275 000 people. Most residents live in rural villages, where Shehas serve as village leaders and government liaisons. Pemba's communities are predominantly Muslim, and their primary language is Kiswahili. Many people are employed as subsistence farmers, government employees, shop owners, fishermen, or day laborers in construction or transport of goods. Women's occupations include subsistence farming and seaweed mariculture, in addition to housework and childcare.

Pemba's tropical, equatorial climate is influenced by two monsoon winds. The southeast monsoon, locally called Kusi, blows from June to September and brings relatively cool, sunny weather with average temperatures around 26 ºC and winds of 9 m/s. The northeast monsoon, Kaskazi, occurs from November to March and is associated with weaker winds of 5 m/s and hotter temperatures of up to 32 ºC. The long rains, or Masika, fall during the transition from Kaskazi to Kusi in March to June, and the short rains, Vuli, come in November and December during the monsoonal reversal between Kusi and Kaskazi. Annual rainfall is 1760 mm, and humidity remains high throughout the year. [Richmond 1997]

The island's east coast is sheltered by mangrove forests and is largely used for agriculture. Soils in the mangroves are muddy or sandy, while cropland soils are mostly sand and clay. Rice, cassava, and spinach, as well as bananas, mango trees, and coconut palms are

cultivated in farms near the coast. The area also contains 62 salt farms, covering an area of 126.5 ha. This study took place in villages along the eastern coast of Pemba Island.

The Association for Zanzibar Salt Processing Organizations (AZASPO) has organized its 56 participating salt farms into four zones. Zone 1, the Pujini Zone, includes 6 farms in Pujini and Chambani. Zone 2, the Minungwini Zone, is composed of 10 farms in Minungwini, Kichwani, and Kangagani. Zone 3, the Mchanga Mdogo Zone, has 14 farms in Kambini, Kichokochwe, Kiwani, and Likoni-Chwale. Zone 4, the Shengejuu Zone, is the largest with 26 farms in Shengejuu, Kiungoni, and Sizini-Kijichame. Farms located in the Minungwini, Mchanga Mdogo, and Shengejuu Zones were studied. The salt farms are located within or at the landward edge of the mangrove forests. They are usually at least 30 minutes from the villages by foot and often border mashamba, or croplands. Accessibility to the salt farms can be limited during the rainy seasons due to mud. Interviews with salt farmers took place in the villages of Shengejuu, Madenjani, Kiungoni, Pandani, Kambini, Mchanga Mdogo, Kangagani, Kiuyu, and Chake Chake. These sites were selected for their accessibility from the main road and for the number of salt farmers.

In addition, interviews took place in the cities of Chake Chake and Wete, and mangrove transects were surveyed in Wete and Mjini Kiuyu as control sites with no salt farming activities.

Figure 1a shows the locations of the villages and farms visited on Pemba; see Figure 1b for the general geography of Pemba. Figure 1c shows a sample farm layout.

METHODOLOGIES

I. Interviews with Salt Farmers, Shehas, and Other Experts

Formal interviews were conducted with individuals from 20 salt farms. A sample size of 30% to 50% of the total active salt farms was deemed necessary to ensure a representative sample. Of Pemba's 62 salt farms, 49 are actively used for salt production. A sample size of 20 farms represents 41% of the active farms and thus falls within the desired range. Farms were chosen based on availability and accessibility and hence do not constitute a random sample. The goal was to conduct interviews in all four zones, but heavy rains made Pujini, Zone 1, inaccessible. The 20 farms consist of 4 farms in Zone 2 (Minungwini Zone), 5 farms in Zone 3 (Mchanga Mdogo Zone), and 11 farms in Zone 4 (Shengejuu Zone).

Ideally, five individuals from each farm were questioned: one owner, two employees, and two day laborers. However, 3 farms do not employ day laborers. At least three people were interviewed at every farm for a total of 78 salt farmers. Interviews were conducted with 20 farm owners, 34 employees, and 24 day laborers. Refer to Appendix 1 for a list of interviewees and farms. Owners chose employees and day laborers to be questioned, but when possible, effort was made to interview women day laborers, as they are an important group of workers in the salt farm. 13 of the 24 day laborers are women.

Owners, employees, and day laborers were asked different sets of questions. Owners reported on the farm's history, methods and scale of production, operational costs and employee wages, selected environmental indicators, and mangrove usage. Interviews were based off questionnaires, but were semi-structured in that clarifying and probing questions were improvised to explore pertinent tangents. PRA methods were utilized to discuss production methods. Owners were asked to draw a picture of their farms in the dirt, and the sketches were

used to discuss the function of each pan, water flow, timing of the process, and salinity measurements. Production methods were analyzed by the following criteria:

- Number of pre-harvesting pans in series
- Be at transfer to the harvesting pan
- Be at harvest
- Number of days until the first harvest after water leaves the reservoir
- Number of days until the second and later harvests after water leaves the reservoir
- Presence or absence of algae in pre-harvesting or harvesting pans
- Number of pumps used
- Mechanism for water transfer between pans

These criteria were selected because they allow for comparison between farms and a quantitative assessment of production methods, which can affect yield and quality of the produced salt. When a range for salinity or number of days was given, the upper bound was used.

Interviews with farm owners typically lasted 60 to 75 minutes. Employees and day laborers were asked about their work schedule and conditions, wages, health, and mangrove usage. Their interviews were 10 to 15 minutes each and followed a questionnaire format. See Appendix 2 for the questionnaires used and their Kiswahili translations.

Interviews were arranged by appointment in most cases. The Sheha of the village was sought out and interviewed, and then asked to contact salt farmers in his Shehia. Interviews of salt farmers took place in the villages over a three week period from 13 April to 3 May. Interview locations were most often public spaces, such as under mangrove trees or public shelters, or on the front porches of peoples' homes. Said Mbarouk served as translator for all interviews, although most of the time questions were asked directly in Kiswahili. Said Mbarouk helped with interpretation of responses and with question clarification for the interviewees.

In addition, semi-structured interviews with Shehas and officers in governmental and nongovernmental organizations were conducted. The Shehas of Shengejuu, Kiungoni, Kambini, Mchanga Mdogo, Kangagani, and Kiuyu were interviewed. Juma Bakari "JB" Alawi discussed

the functions and goals of AZASPO and the social and environmental consequences of salt farming. Said Juma at the Department of Forestry answered questions regarding the history of salt farming on Pemba, governmental regulation of the industry, and the environmental effects of salt farming. Sharif Mohammed Faki at the Department of Fisheries reported on the environmental effects of salt farming and provided a copy of his undergraduate thesis on the impacts of salt farming on mangroves.

II. Field Visits to Salt Farms and Mangrove Transects

10 transects were traversed through mangroves in salt farm and non-salt farm areas. In salt farm areas, transects led from the seaward edge of the salt farm toward the coast or tidal source stream for the farm. In non-salt farm areas, transects led from the landward edge of the mangrove forest toward the ocean. Transect paths were chosen to allow the greatest accessibility. When available, streams or previously cut paths were used.

For all transects, circular quadrats of 5 m radius were examined every 20 paces. One pace is equivalent to 1.63 m. Quadrat boundaries were estimated by sight. Within each quadrat, mangrove species were identified and the number of saplings, trees, and average tree height was recorded for each species. Height was estimated, and abundance was estimated when judged too numerous to count. Additional notes on substrate type, tide conditions, and evidence of human activity were recorded. See Appendix 3 for a sample data collection sheet.

Salinity was measured in and around salt farms and non-salt farm areas using a Baume hydrometer. 1.5 to 10 L of water was collected in a vessel deep enough to hold the hydrometer, such as a water bottle, bucket, or rain boot. The hydrometer was slowly inserted and read. Baume hydrometers use buoyancy to measure salinity: the weighted instrument floats vertically

and its height above the surface of the water depends on the specific gravity, or salinity, of the water. Samples were collected from harvesting pans, pre-harvesting pans, reservoir pans, tidal source streams and bays near salt farms and in non-salt farm areas. In addition, two control tests were designed to check the accuracy of the instrument. Approximately 0.5 kg salt was dissolved in 1.5 L water to yield an expected salinity of 33 Be.

Informal interviews of fishermen at the salt farms yielded information about fish near the mangroves and salt farms. In addition, farm layouts were noted and photographed.

III. Iodine Tests

An iodine test kit was used to determine whether or not salt samples contained iodine. The test kit contained a sample cup and 20 mL starch solution. 2-3 grains of salt of approximately 2-5 mm in diameter each were placed in the sample cup, and 3-5 drops of starch solution were added. A color change to purple indicated the presence of iodine, while no color change indicated its absence. Samples were taken from owners' salt stocks in villages and at the salt farms, owners' and employees' kitchens, roadside stands, and shops.

RESULTS

I. Results from Interviews of Salt Farmers, Shehas, and other Experts

1. The Salt Farm Population and Individual Earnings

78 individuals from 20 salt farms were interviewed, including 20 owners, 34 employees and 24 day laborers. Interviewees were between the ages of 19 and 65. 19 interviewees were women.

The average number of owners per farm is 3.85. Farms are owned by individuals, families or small groups, or cooperatives. 75% of the farms were owned by families or small groups of 2 to 4 people. 15% were owned by large cooperatives of greater than 9 people, and 10% were owned individually.

The average number of people per farm was 11.84. An average of 4.80 employees and 4.60 day laborers work at the salt farms on a typical harvesting day. Employees work for the entire production season, while day laborers have no long term contract. They may work only at harvesting time, or they may help with maintenance and pan preparation. They are paid per day or per harvest worked. Figure 2, on the following page, shows the percentage of each category of worker benefiting from the salt farm on a typical harvest day. Figure 3, also on the following page, shows the percentage of the total earnings going to owners, employees, day laborers. Salt farm owners are the smallest group, but they earn the most money from the salt farms. Employees and day laborers account for 71% of the salt farming community, but they receive less than half of the total earnings.

Figure 2

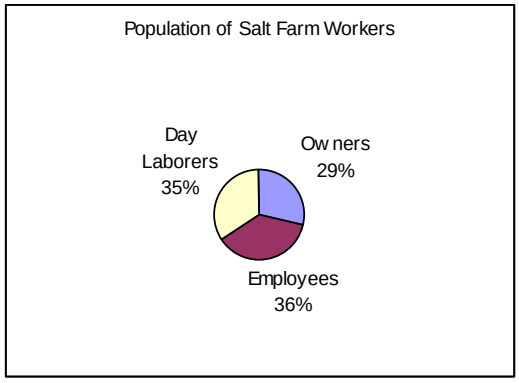
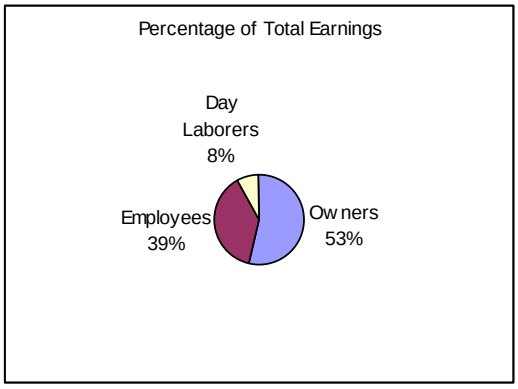
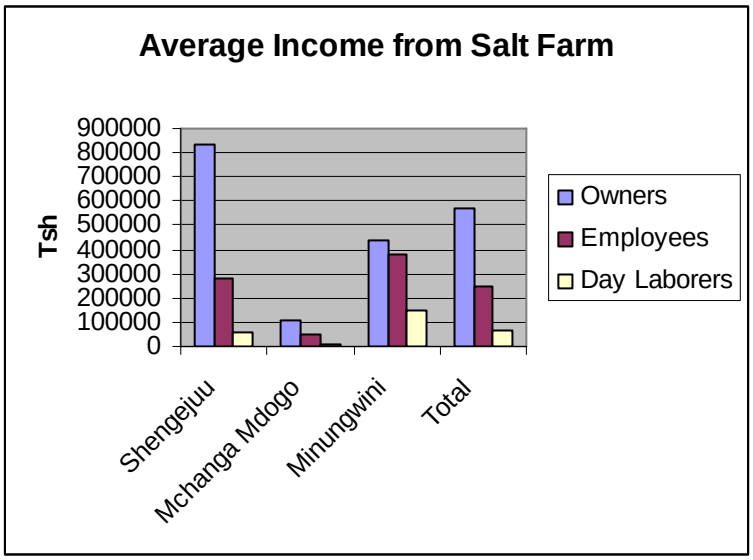


Figure 3



A comparison of average individual earnings by zone is shown in Figure 4. In all three zones, owners have the highest income, followed by employees and then day laborers. Owners in the Shengejuu Zone benefit the most from the salt farms, earning an average of 830 891 Tsh per year, but employees and day laborers have the highest income in the Minungwini Zone. The weighted average annual income for all individuals is 278 775 Tsh. Individual earnings are listed in Appendix 4.

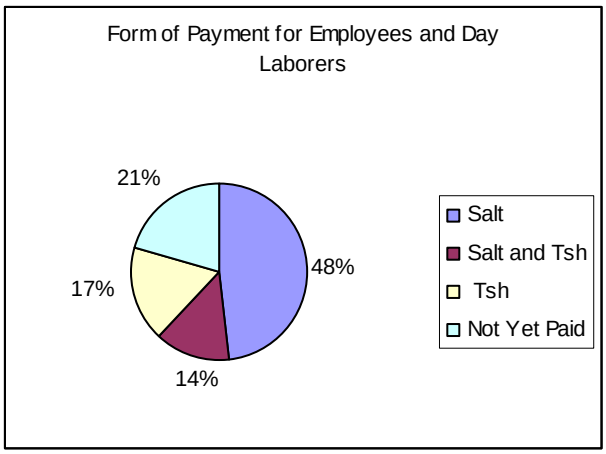
Figure 4



Employees and day laborers were paid in money, salt, both, or sometimes not at all. The unpaid workers either had not yet been paid for last season, but are expecting compensation, or

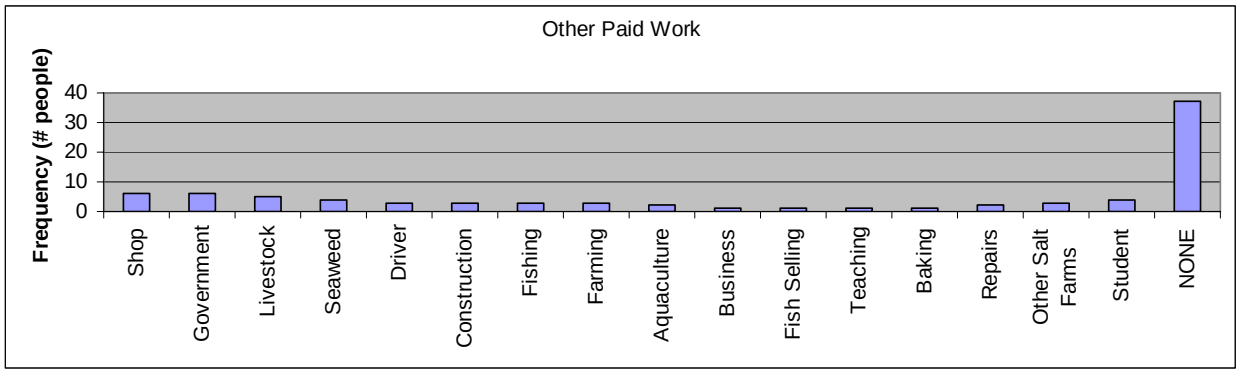
are relatives of the owners and working out of family obligation. For employees who have not yet received payment, their usual earnings were used in calculations. Most employees (59%) received salt as part or all of their wages. Employees typically received a fixed percentage of the net production, while day laborers are usually paid at the time of harvest in either bags or buckets of salt. 1 bag is approximately 4 buckets. Most employees and day laborers reported selling their salt for 2500 to 3500 Tsh per bag. A price of 3000 Tsh was used in all calculations. Figure 5 shows the proportion of workers paid in kind and in money.

Figure 5



Half of the owners and employees and 41% of day laborers rely on the salt farms as their only source of income. All interviewees reported subsistence farming as an additional occupation, and 4 day laborers are also students. Of the 41 individuals who engage in other paid work, the most common alternative sources of income were government work, shop keeping, and sale of livestock. Among women, seaweed farming and sale of livestock and baked goods were important sources of income. 16 different occupations were reported, including being a student. Figure 6, on the following page, shows alternative income sources and the number of participants.

Figure 6



Owners are the most dependent on income from their salt farms, as the farms account for 73% of their total income. However, in Mchanga Mdogo Zone, where earnings are lowest, only 20% of owners' incomes and 30% of employees' and day laborers' incomes come from the salt farms. Table 2 shows the percentages of the total income coming from the salt farm.

Table 2

Zone	Owner	Employee	Day Laborer
Shengejuu	92.6%	54.6%	65.8%
Mchanga Mdogo	20.4%	29.2%	31.7%
Minungwini	57.5%	58.9%	62.6%
Total	72.6%	53.7%	64.2%

2. Farm Production, Operating Costs, and Net Earnings

Appendix 4 shows the average production, costs, net earnings, and production per hectare for each zone. Reported production is the number of bags reported for last season's harvest. Inferred production takes into account bags given to day laborers at the time of harvest and bags sold after the first harvest to cover operating costs; it is assumed that these bags were not included in the reported production. Farmers in the Minungwini Zone were asked whether they sold or gave away salt early in the season and whether they included these bags in their estimated production. They answered yes to the former and no to the latter question, confirming the

validity of the assumptions. See Appendix 5 for an example calculation of inferred production and net owner earnings.

Equipment costs include money spent on equipment, food, and fuel. Equipments used include buckets, spades, rakes, mats, salt bags, and cooking utensils. Most of the salt farms used petrol and oil for their water pumps, and a few also used diesel. Maintenance costs include money spent on annual repairs, transportation of repair supplies, and the annual government fee for land rental. Labor costs include money and the value of salt paid to employees and day laborers. Net earnings were obtained by taking the difference of the inferred production and net costs, and the production per hectare ratio depends on the inferred production and farm area reported in the Department of the Environment's 2005 survey (see Appendix 7).

Average production was approximately 1346 bags per year, and average net earnings were 1.8 million Tsh. The Minungwini Zone had the highest net earnings of approximately 2.5 million Tsh and the highest inferred production of 1920 bags per year, but the Shengejuu Zone had the highest reported production of 1300 bags per year. Mchanga Mdogo Zone had the lowest production and lowest earnings, as well as the lowest production per hectare. Shengejuu Zone had the highest production per hectare. Figures 7, on the following page, compares production per hectare for each zone.

Figure 8, also on the following page, compares the proportion of the inferred gross production used in operational costs for each zone. Minungwini Zone had the highest absolute operational costs, and Mchanga Mdogo Zone had the lowest; however, Mchanga Mdogo Zone's operating costs account for the greatest percentage of the total production at 74.5%. On average, operational costs account for 54.6% of the total earnings, with labor being the most significant

component of total cost. Table 3 lists the percentage of gross production spent on operational costs.

Figure 7

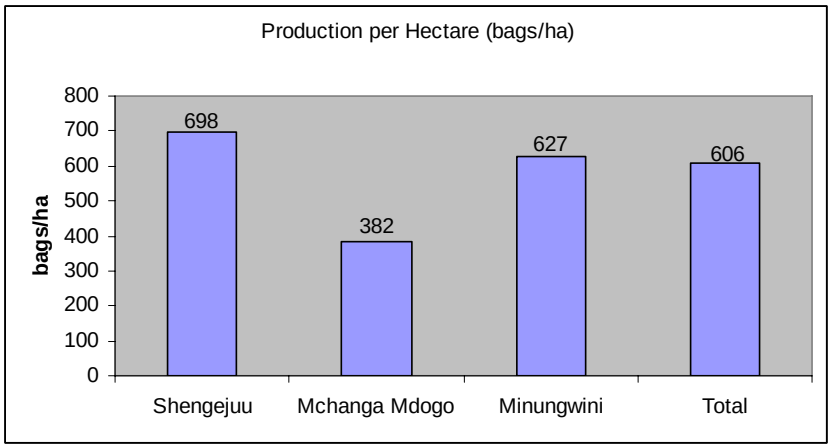


Figure 8

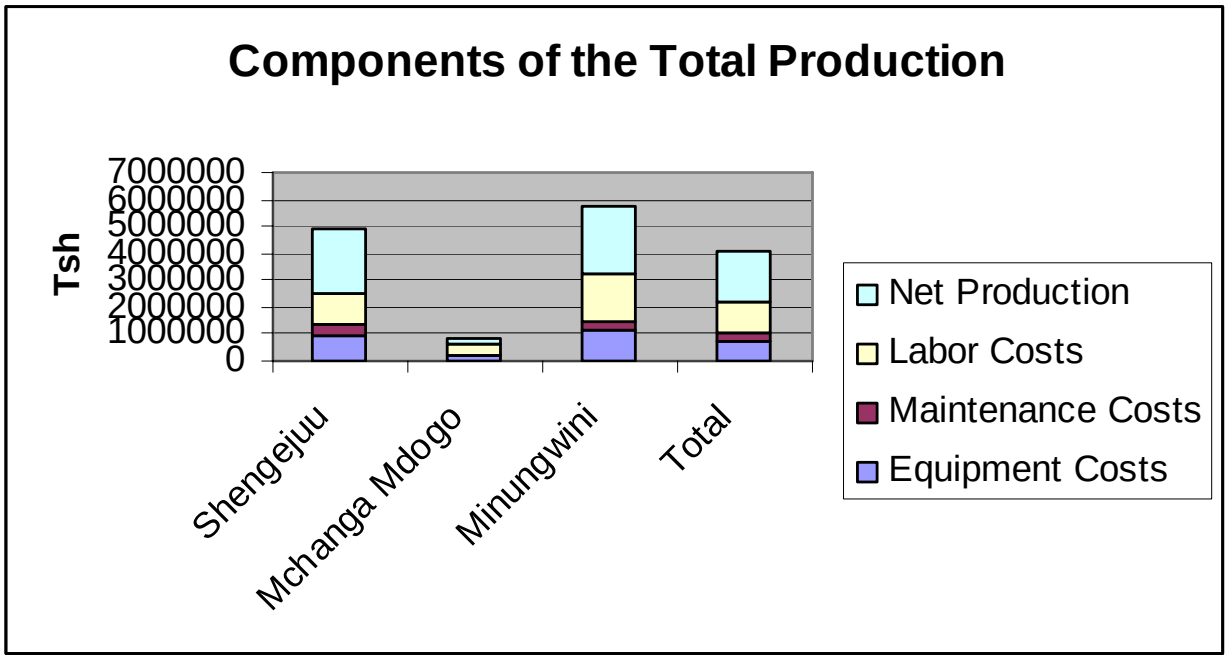


Table 3

Percentage of Total Production Spent on Operating Costs

Cost	Shengejuu	Mchanga Mdogo	Minungwini	Total
Equipment	18,5%	22,3%	19,4%	19,0%
Maintenance	8,6%	4,3%	6,4%	7,8%
Labor	25,0%	47,9%	31,1%	27,9%
Total Cost	52,1%	74,5%	56,9%	54,6%

3. Production Methods

14 farms reported an increase in production since starting the salt farm, and 2 farms reported a decrease.

Farmers use 4 kinds of pans in salt production. Water flows into reservoirs from the ocean, then into condenser pans and pre-harvesting pans, if used, and finally into the harvesting pans. The number of pans and the number of days that water remained in each pan varied greatly by farm. Most farms have one pre-harvesting pan step in their process (11 farms). 6 farms use a series of two or more pre-harvesting pans. 2 of these farms also allowed water to circulate through a series of condenser pans.

The average salinity at which water was transferred to the harvesting pan was 18 Be. The range was 10 to 24 Be.

Half of the farms do not measure salinity at the time of harvest, but most of those who do measure harvest salt at 30 Be. Owners reported that salt began to precipitate at 24 to 26 Be.

The average number of days until the first harvest was 34.7. The range was 17 to 54 days. Second and later harvest cycles took an average of 26.8 days and a range 13 to 40 days. Owners reported that second and later harvests required less time because residual salt in the harvesting pans acted like yeast and encouraged quick precipitation.

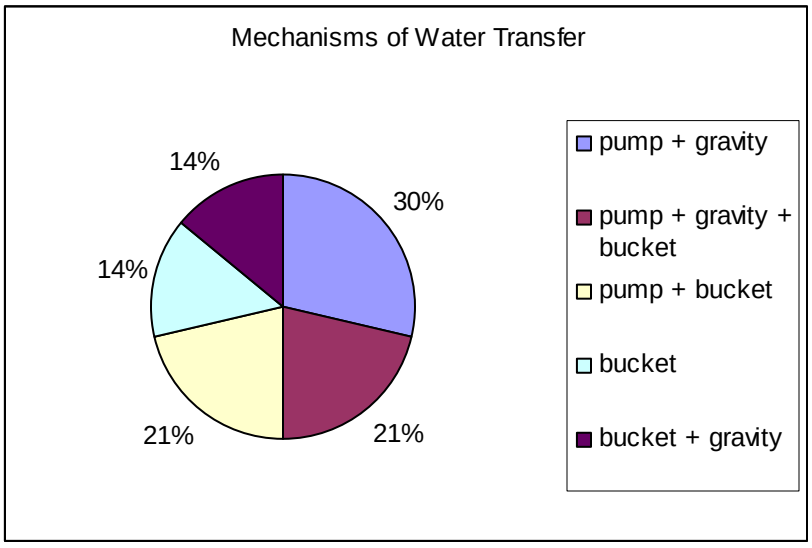
8 farms reported the presence of algae in pre-harvesting or harvesting pans, and 12 farms reported no algae in their pans. Of the 10 farms asked for their opinions on algae, 40% thought algae were not bad for production, while 60% thought algae impair salt production or quality.

10 farms own at least 1 pump and 15 farms have access to a pump. Those farms that do not own water pumps, but have access to pumps, rent or borrow them from neighboring farms.

All of the farms in the Shengejuu and Minungwini Zones have access to a pump, but no farms in the Mchanga Mdogo Zone have pump access.

14 farms reported on the mechanism of water transfer. Of these, 9 farms employ gravity flow at some stage in the process. 10 farms transfer water manually using buckets at some stage, while 4 farms rely only on transfer by water pump or flow by gravity. 4 farms never use a pump. Manual transfer does not include the use of buckets to harvest the salt, but only the transfer of water between pans. Figure 9 shows the percentage of farms employing each kind of transfer mechanism.

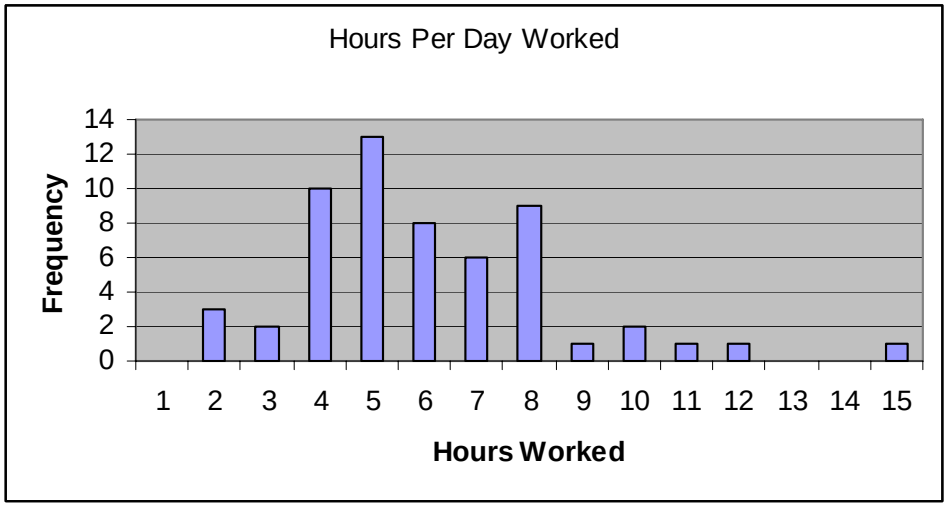
Figure 9



4. Work Conditions

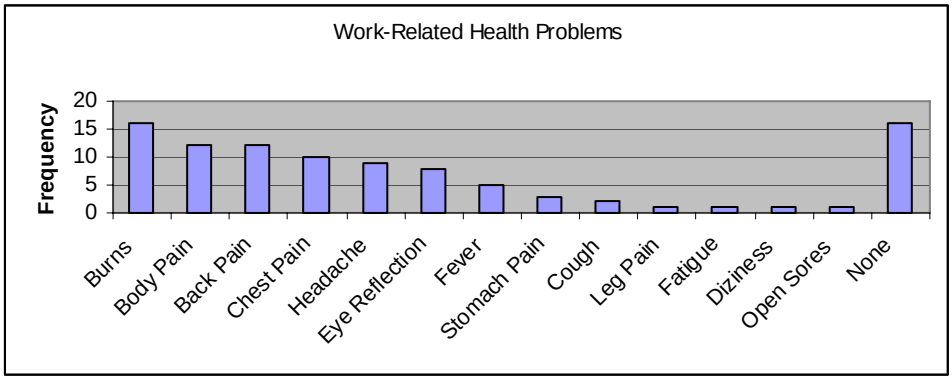
Employees and day laborers both work an average of 6 hours per day. 45% of owners work full time in the salt farms. The number of hour per day worked depends on the stage in the production process. At harvesting times, people reported working into the night. Figure 10, on the following page, shows the frequency of hours per day worked at the salt farm.

Figure 10



72% of employees and day laborers reported work-related health problems. The 3 most common health problems were burns, body pain, and back pain. Figure 11 shows the frequency of health complaints.

Figure 11



Only 1 farm provides protective gear to its employees. Kicha Kaa Si Shangi in Kiuyu was given 12 pairs of gloves, rain boots, and overalls for free by the Tanzanian president's wife. Kicha Kaa Si Shangi is owned by a cooperative of 18 farmers, and all of the owner/employees interviewed reported that they used the gear. The day laborers did not have access to the gear. Individuals from other farms mentioned that they needed rain boots and gloves to prevent buns from the hot water, as well as hats and eye protection for the sun and the reflection off the water.

5. Social Conflicts

Shehas and salt farm owners reported on the social conflicts associated with salt farming. Most salt farmers reported no social conflicts, but among those that did report conflicts, the most common was destruction of salt farm walls by non-salt farmers. Owners and Shehas also reported stolen salt or tools and trespassing by people and livestock as problems. Deviated water currents due to salt farm construction were noted to damage nearby croplands, and in Shengejuu, sand mining by Kojani people was reported to cause water to flood the salt farms. Farmers complained that the community demands free salt, but does not want to wait for the salt to be properly dried and iodated before taking it. Illegal harvesting of mangroves near the salt farms was also noted as a social conflict. There was one conflict concerning farm ownership.

Shehas and government officers noted that people illegally clear plots larger than the permitted area and that they sometimes clear mangroves and begin farm construction prior to the site survey and receiving proper permission. Of the 20 farms interviewed, 20% reported beginning construction before receiving permission from the government.

Government officers and shehas commented on general environmental changes linked to salt farms. The most often reported change was a decrease in fish and crabs due to deviated water currents, mangrove deforestation, and elevated salinity. One Sheha noted an increase of fish in the reservoirs. Other reported impacts included increased human disturbance in the surrounding area, mangrove deforestation beyond the perimeter of the farm, elevated salinity near the farm, and changes in bird behavior due to human impact. Two people noted that salt farmers cleared excess land and recommended that farmers be required to replant or facilitate natural regeneration of mangroves in unused or abandoned areas.

When asked for their overall opinions of the salt farms, Shehas and government officials unanimously said that they had an overall positive effect. They all noted that their communities benefited from the salt farms because they received free salt at harvest time and because the farms are a source of income. One Sheha noted that day laborers, however, do not benefit from salt farms. All but one reported that salt farms are bad for the environment, citing the decrease in fish populations, deforestation of mangroves, and decreased rain. The one who reported that salt farms did not have a negative environmental effect explained that the Department of Forestry and the Department of the Environment had carried out a preliminary site survey and had approved the farms prior to construction.

Said Juma and Juma Bakari both stated that the government does not want to expand salt farming on Pemba by approving new sites. The Department of Forestry has rejected all applications for new farms since 2002.

6. Environmental Impacts

15% of farms report current problems with erosion. Of these, 2 farms in Mchanga Mdogo Zone said erosion had always been a problem, but that the rate of erosion increased since starting the salt farm. The other farm reporting current erosion said that the construction of the salt farm said that the construction of the salt farm in Shengejuu blocked and changed tidal flow so that the sea now accesses croplands. 2 farms in Minungwini Zone claimed that the salt farm has remedied past erosion problems by blocking a tidal stream that used to reach land.

70% of owners reported a change in bird populations since starting the salt farm. 15% noticed a decrease in the number of birds, citing habitat destruction as a possible cause. 55% reported an increase in the number of birds and attributed the change to the presence of fish in the reservoirs and open land for wading and feeding.

78% of 78 individuals asked say that they currently use mangroves around the salt farm. Of 67 individuals asked, 49% say they also use other mangroves far from the salt farm. Of 60 individuals asked, 30% say they used the mangroves around the salt farm before working there. A table of these results is listed in Appendix 4.

4 usages of mangroves were reported. Mangroves near the salt farm were most heavily used for pan construction. Mangrove poles are cut into pegs that anchor the mats lining the harvesting and pre-harvesting pans. Mangroves near the salt farm are also used to build huts for storing salt on site and as a source of firewood for use at home or at the salt farm for cooking lunch. People reported using mangroves far away from the salt farms for the same 4 uses. Before the salt farm, the mangroves were reported to be used only for firewood and as a building material. All species present were used. Figure 12 shows the frequency of reported usages of mangroves near the salt farms, far away from the farms, and before the salt farms. Figure 13, on the following page, shows how mangroves near the salt farms are currently used.

Figure 12

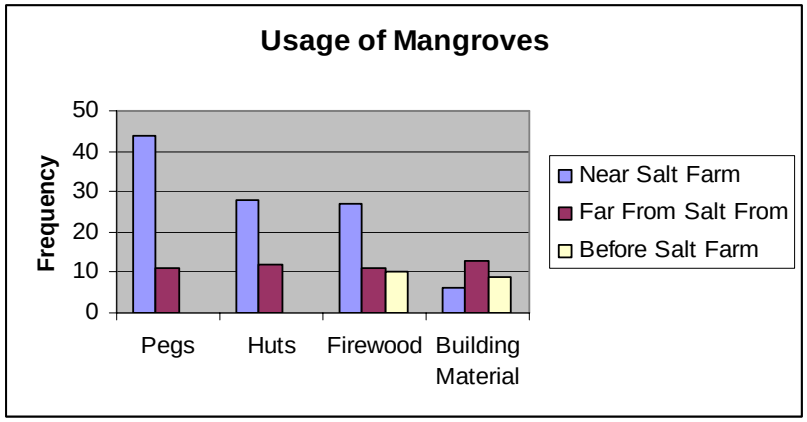
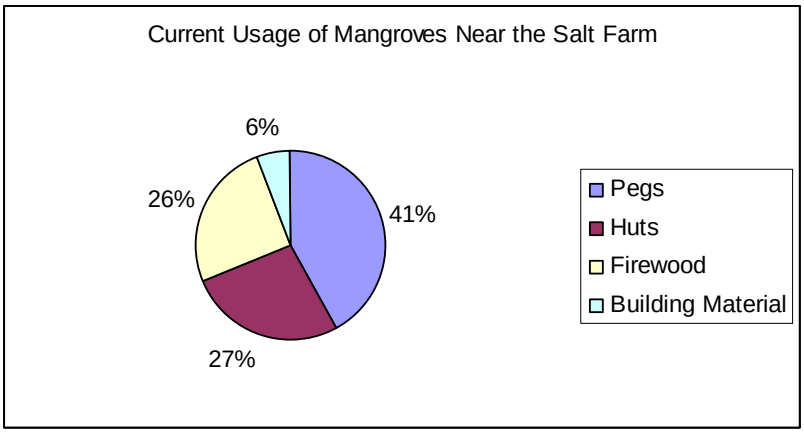


Figure 13



Avicennia marina was the most often-reported mangrove species near the salt farms. *Ceriops tagal* and *Rhizophora mucronata* were also reported to grow near the salt farms. There has not been a change in species composition since construction of the salt farms. Of the 13 owners asked, 69% reported that the mangroves near the salt farms are healthy, while 31% said that some or all of the mangroves were not healthy. They cited the terrestrial location of the salt farm and elevated salt concentrations near the farm to explain the unhealthy mangroves. All farmers asked view mangroves as important. They most often mentioned mangroves' significance as a resource for humans and their environmental importance as barriers against big waves and erosion. They also mentioned that mangroves bring rain to the area and that they are important for conservation.

II. Results from Field Visits to Salt Farms and Mangrove Transects

3 mangrove species were observed along 7 transects in areas surrounding salt farms. The same three species were observed along every transect. *Avicennia marina* dominated close to land and near the salt farms. *Ceriops tagal* and *Rhizophora mucronata* grew farther from the salt farms and toward the sea. An unidentified species known locally as mdaamba was observed

only in Kiuyu and at the control sites. *C. tagal* was more abundant, but *R. mucronata* was taller in all transects. *R. mucronata* trees were between 2.5 and 4.5 m in height, while *C. tagal* trees were 1.5 to 2.5 m tall. The height of each species was observed to increase with increasing distance from the salt farm.

3 transects were studied as controls in non-salt farm areas. 2 of these transects occurred in Wete and 1 in Mjini Kiuyu. The control areas had greater species diversity than the salt farm areas, as 6 mangrove species were identified in the non-salt farm areas. *Bruguiera gymnorrhiza* and *Lumnitzera racemosa* were only observed in Wete. The substrate at salt farm and non-salt farm areas was mud with some sandy areas.

Salinity measurements are listed in Appendix 6. A salinity of 0 Be was recorded for all 9 measurements in and around salt farms. Ocean water sampled near Shengejuu was 2.5 Be, and ocean water near Wete was 2 Be. The control tests yielded a reading of 20 Be when a theoretical salinity of 25 to 30 Be was expected. The reading falls within a reasonable margin of error given the imprecision inherent in estimating a mass of 0.5 kg salt.

IV. Results from Iodine Tests

The results of the 20 tests for iodine in salt samples are also listed in Appendix 6. 6 salt samples were taken from people's kitchens, 2 from village stocks, 3 from on-site storage huts, 2 from roadside stands and 6 from shops. 100% of the salt in the village stocks was iodated, but 0% of the salt from storage huts at the salt farms contained iodine. 50% of salt tested from roadside stands and shops was iodated. 33% of the tested kitchen salt was iodated. Overall, 42% of the 19 samples of Pemba salt contained iodine. The control sample, processed salt from Tanga, also tested positive for iodine.

DISCUSSION

The goal of this study was to answer the question, "Is salt farming beneficial to Pemba?" To do so, the economic, social, and environmental effects of salt farming were examined.

Economic Effects and Production Methods

Salt farming is an important source of employment and income for communities along Pemba's eastern coast. Salt production is also recognized as a nationally significant industry and potential long-term source of employment for coastal populations in Tanzania [Ruitenbeek 2005]. It was expected that, within the industry, farm owners would benefit the most and day laborers the least. It was also expected that earnings would be concentrated in the smallest sector of the population of salt farmers. Both of these trends were observed to be true.

A clear disparity between owner, employee, and day laborer earnings was observed. Owner earnings, averaging 570 000 Tsh, are high because owners keep the entire net production gain after taking out operating costs, accounting for half to three-quarters of gross production. However, owners must earn back the steep initial investment costs before realizing a true profit. Start-up costs are approximately 1.2 million Tsh, and it usually takes farmers a few seasons to raise production to profitable levels. [Mbarouk 2005] Employees, making an average of almost 245 000 Tsh, put in the greatest number of work hours, but are compensated significantly less than owners. Also, employees are often paid in kind rather than in money. Given that no permanent market for salt is currently available, employees' earnings are contingent upon their ability to sell salt to convert it into money. Once the AZASPO refinery is ready, employees will be expected to sell their salt for a lower price to reflect the global market. This will further depress employee earnings. Day laborers' low income of only 70 000 Tsh is attributed to their low time investment at the salt farms. Day laborers work only at harvesting time, which usually

totals 2 to 6 days per month, and they are paid per day or per harvest worked. Day laborers and owners often work part-time, while employees work full-time during the production season.

Estimates for owner earnings are probably less accurate than those calculated for day laborers and employees, as owner earnings depended heavily on assumptions. The inaccuracy is due to a lack of records of production and operating costs. Earnings were first calculated by treating the reported production as gross production, but these calculations implied that 40% of farms were losing money. While a high failure rate is possible, it is more likely that farmers were not providing accurate estimates of gross production. Thus, inferred gross production was calculated based on operating costs and day laborer earnings, since day laborers are usually paid according to the yield at the time of harvest. Recalculated owner earnings may be overly optimistic because they assume that operating costs were paid for with unaccounted for salt sold early in the season rather than with out-of-pocket cash. However, they are believed to be closer to the market reality than calculations based on reported production alone. The trend showing owner income to be greater than both employee and day laborer income seems plausible and is likely true.

Overall, income is linked to production. Employees are typically paid a fixed percentage of the net production. Usually, 30 to 35% of the net production is set aside for 3 to 5 employees. Employees, and even day laborers, at farms with high production are paid well. For an employee receiving 10% of the total production to make the minimum annual government salary of 600 000 Tsh per year, the farm must bring in a net production of at least 2000 bags per year. Only 25% of the farms have achieved this production. Currently, farms have an average net production of approximately 1015 bags per year. In order to raise income, farms must

concentrate on increasing production. Based on the analysis of production methods, Pemba's farms have not maximized their production capacity or the quality of the salt produced.

Production yield is correlated with the use of technology such as water pumps. Shengejuu and Minungwini Zones had the highest production and all farms there had access to water pumps to transfer water between pans. In Mchanga Mdogo Zone, where no farms had access to water pumps, production was significantly lower. Manual water transfer using buckets is less desirable as it lowers yield. It is thought that manual transfer hinders the crystallization process because of the turbulence from walking through the pans. Manual transfer is also less time-efficient and much more strenuous work than transfer by machine. However, pumps are expensive and require regular maintenance and repair. Fuel adds significantly to operating costs. The operating costs in Mchanga Mdogo Zone are low partly because those farmers do not pay money for fuel. The returns on pumps are good, but the initial capital for investment in machinery and repair must be available.

Farms can save money on fuel if their farms are designed to allow for flow by gravity at some stages of production. All farms catch water in reservoirs without machines, and most let water flow into condenser pans using gravity. It may be appropriate to pump water from the condenser into the pre-harvesting pans, but flow from the pre-harvesting pans to the harvest pans should be by gravity when possible. Water is highly saline after evaporating in the pre-harvesting pan, and the concentrated water corrodes pumps.

Water entered the harvesting pans at an average of 18 Be, but the ideal range for high quality yield is 25-26 Be, as calcium sulfate, an impurity in the production of sodium chloride, precipitates at this salinity. The presence of calcium sulfate gives salt a cloudy, off-white appearance, and global standards dictate that high quality salt must be 96% sodium chloride.

[Mbarouk 2005] It is necessary for calcium sulfate to precipitate in the pre-harvesting pans so that water moving to the harvesting pans has a low concentration of impurities. Farmers explained that they introduce water to the harvesting pans at lower salinities because the machines are unable to pump, and the workers unable to carry, the heavy, highly concentrated water. Thus, gravity flow at this stage would be ideal, as it would allow farmers to let water into the harvesting pans at the proper salinity and would help produce a higher grade salt.

The best production methods allow for slow circulation of water. Circulation through a series of condenser or pre-harvesting pans facilitates the precipitation of impurities prior to harvesting. Circulation seems to have a neutral effect on production, but is believed to significantly increase salt quality. Currently, only 30% of farms use a circulation model. The other farms let water evaporate in only one pre-harvesting pan before going to the harvesting pans, or they do not use pre-harvesting pans at all. When pre-harvesting pans were not used, farmers manually removed water from the harvesting pan to a dry pan, cleaned the harvesting pan, and returned the water there the same day. That procedure does not allow for the precipitation of waste salts prior to harvest.

The number of days allowed before the first harvest also affects quality. Ideally, a minimum of 41 to 42 days is required for the production of mature salt, but the process may take longer with inclement weather. Rain and wind slow down the evaporation and precipitation processes. Pemba farmers are harvesting their salt too early, after an average of 35 days. An extra week is necessary to produce high-quality salt.

Attitudes toward algae indicate that farmers are unaware of the important role that algae play in salt production. 60% of farmers viewed algae as bad for production, explaining that algae made salt unclean and of lower quality. Many reported cleaning their harvesting pans prior

to harvest to remove algal mats. However, algae have been shown to enhance salt quality. In a study conducted in China, purity was observed to increase when algal mats were present in pre-harvesting and harvesting pans. [Liu 2002] There is a fundamental misunderstanding among Pemba farmers of the function of algae in salt pans.

Attention to salt quality is especially important in light of AZASPO's plans to open a salt processing center by the end of May 2006. If Pemba is to access the global market for salt, it must be able to sell a competitive, high quality product. AZASPO hopes to facilitate this by grinding, iodating, and packaging salt into a fine-grained product that will compete with salt coming from Tanga. However, production of high-quality salt must start in the salt farm. Farmers need to adapt their production methods to maximize salt purity.

Mr. Juma Bakari counts improvement of salt quality and yield among the most immediate needs of Pemba's salt industry. He estimates that AZASPO members produce less than 3000 tons of salt per year. Extrapolation of the calculated average production of 1346 bags per year to the 56 farms belonging to AZASPO yields an estimated gross production of 3769 tons per year. Based on the area cleared for salt farming, Mr. Bakari estimates that the production capacity is 15 000 tons per year, which is 4 to 5 times the current production. If salt production is to be a sustainable industry, farmers must increase production because AZASPO is expecting to purchase salt for a lower price than farmers currently get. Farmers sell salt for approximately 3000 Tsh per bag, but AZASPO aims to purchase salt at 2000 Tsh per bag and to sell it for a marginal profit at a price of 2200 to 2500 Tsh. This price would be competitive with prices of salt on mainland Tanzania.

If farmers manage to increase production, they stand to benefit from AZASPO's salt refinery. AZASPO can guarantee farmers a permanent, stable market for their salt. Employees

paid in salt could also be guaranteed monetary rewards for their labor. Owners and employees report that salt usually sits in stock for 3 to 6 months, but some owners are currently unable to sell salt for up to 1 year after harvesting. Although the unit price for salt will decrease, AZASPO will enable farmers to sell all of their salt regardless of the season. Unfortunately, salt farmers will continue to earn only a fraction of what shopkeepers earn from selling salt. The market price for consumers is 200 Tsh/ kg salt, or the equivalent of 10 000 Tsh per bag. Farmers get a lower price because they sell their salt in bulk.

Also, the prospect of using the pans for aquaculture during the off-season seems promising. Farmers often reported fishing in their reservoirs for home consumption, but one farm uses their pans for commercial aquaculture during the rainy seasons. They earn up to 1.5 million Tsh per year from selling their fish. They reported feeding the fish cornmeal, rice meal, and coconut scraps. This is similar to the feed used in experiments in the aquaculture ponds of the Institute of Marine Sciences. In a 2001 study, IMS explored the use of low-cost fish food composed of 18% corn meal, 18% broiler mash, 18% coconut, 14% seaweed, and 32% fish meal for its stock of milkfish and rabbit fish. [Mineau 2001] If the salt farms can increase production and quality and pursue aquaculture during the off-season, salt farming stands to be a highly lucrative industry.

Social Effects

Extrapolating from the 20 farms interviewed, Pemba's salt farms provide a source of income to approximately 480 owners and employees. The number of day laborers benefiting from the farms is difficult to determine because different individuals may work at each harvest. One owner estimated employing up to 10 day laborers for a single harvest, but between 40 and

50 individuals over the course of the season. The salt farming community on Pemba is sizable regardless.

The major negative social impact identified concerns the frequency of work-related health problems and the lack of protective gear. Many of the health problems could be avoided if employees and day laborers are provided with rain boots, gloves, sunglasses, and hats. Rain boots and gloves reduce burns from the hot water in the pans, while sunglasses will address complaints of painful light reflection in workers' eyes as well as retinal damage from ultraviolet radiation. Hats will help prevent sun-related headaches. This basic equipment is inexpensive and can dramatically improve work conditions.

The average work day of 6 hours per day seems fair and not exploitative. Employees and day laborers typically take an hour break for lunch, which is provided for them at the salt farms. The work schedule leaves them with enough time to pursue subsistence farming, the most commonly mentioned alternative occupation.

Salt farms help their communities by providing free salt at harvesting time, but this salt is usually not yet iodated. Once iodation is taken over by AZASPO, the free salt will still not be iodated. However, it is expected that people will get enough iodine from salt purchased in shops during the off-season. Farmers reported that Pemba people prefer local salt to imported salt because the local salt is cheaper and believed to be iodated. They also mentioned that Pemba salt is derived from a clean, unpolluted environment. Salt sold in shops will likely be iodated with greater reliability when AZASPO controls the iodation process. It is important that communities have access to iodized salt to reduce incidence of iodine deficiency disorder.

There is no regulation of salt iodation at present. Proper iodation requires that iodine be added to salt with moisture content between 2% and 4.5%; however, farmers currently spray salt

with iodine when the moisture content is as high as 15%. Farmers are responsible for using the hand pumps provided by UNICEF to spray their salt. All farms reported using the iodine pumps, but they noted that salt is sprayed at the time of sale rather than at harvest to prevent the iodine from leaching out of the salt in Pemba's moist and humid climate. Farmers noted the lack of proper polythene-lined bags as the cause for iodine leaching. Current modes of salt iodation are not effective, as less than half of the sampled salt tested positive for iodine.

The social conflicts mentioned did not seem cause for significant concern. The most commonly reported social consequence of construction of salt farms was the deviation of water currents to impact nearby areas of cultivation. There were a few reports of rice patties being flooded with salt water due to shifting tidal flow associated with construction of salt farms. However, these reports were offset by reports of farms blocking tidal streams that were previously detrimental to croplands.

Environmental Effects

The environmental footprint of salt farms was noted to extend beyond the farm boundaries. It was expected that salt farms would be overwhelmingly detrimental to the environment, but the data seem to suggest that salt farms may be less harmful than anticipated. In some way, salt farms may even have a positive effect.

55% of salt farm owners reported an increase in the number of birds around the farm. They attributed this to the presence of fish in the reservoirs, where the birds were seen roosting and feeding. Thus, birds seem to benefit from the salt farms. On a national level, Tanzanian salt farms are noted to be significant as habitats for 300 000 migratory waders. [Ruitenbeek 2005] However, additional studies are necessary to determine the overall ecosystem effects of attracting large bird populations. Although a presence of birds is generally viewed as an

indicator of environmental health, it is possible that salt farms are changing bird behavior or species diversity in the area. These changes may or may not have beneficial environmental consequences. It should also be noted that 15% of farmers reported a decrease in bird populations, noting habitat destruction as a cause.

Salt farms seem to have mixed consequences for erosion. It was expected that farms would exacerbate erosion by deforesting the mangroves. Some farmers in Mchanga Mdogo Zone had reported exacerbated erosion due to the salt farms, but two farms in Minungwini Zone actually improved conditions. If erosion becomes a more pressing problem, perhaps manmade seawalls would be constructed to protect croplands, but since no new salt farms are planned for Pemba, conditions are not expected to worsen. Salt farms do not seem to constitute a significant threat with respect to erosion.

Effects on fish are also mixed, but crab populations are thought to decline due to salt farms. While owners reported an increase of fish due to the presence of fish in the reservoirs, Shehas mentioned that certain species of fish living in estuary environments were poisoned by increased salinity from the salt farm. Sharif Mohammed at the Department of Fisheries also mentioned that crab populations are much lower near salt farms. These changes may be linked to the destruction of mangroves, which serve as nurseries and habitats for species of fish and crabs. Apart from aquaculture and fishing in the reservoirs of salt farms, fishing did not seem to be a common activity in the vicinity of the salt farms. There is no evidence that local fisheries are affected by the salt farms.

Salt farms were observed to have a clear negative impact on mangroves. First, mangroves are clear cut during farm construction. Some farms occupy inland areas that were previously bare, but most are located within the intertidal zone and among mangroves. Shehas

noted that farmers sometimes clear plots larger than the permitted area or expand their farms after the initial construction without permission. In one such case, a farmer who illegally expanded his farm was ordered to replant mangroves in cleared area.

Additionally, salt farms increase pressure on the surrounding mangroves by encouraging their use. 78% of farmers reported using mangroves near the farms. This is significantly higher than the reported use of other mangrove stands, indicating that the salt farm areas are more heavily used. Current usage is also greater than usage before the salt farm, when the areas were lightly used for firewood and building material. The two major uses of the mangroves surrounding the salt farms are for pegs, used in pan construction, and for construction of mabanda, the huts for storing salt at the salt farm. Use of mangroves for pegs and huts is directly linked to the presence of the salt farms, themselves. If there were no salt farms in the area, then those mangroves would not be used for pegs or huts. The increase in use is also due to increased human access to the mangroves. The salt farm workers take advantage of the mangroves for building material and firewood for home use. However, most workers who currently use the mangroves near the farm did not use the mangroves before working there. This is especially true of women day laborers, who bear the responsibility of finding firewood. Many reported that they used to use terrestrial wood around the village, but since working at the salt farm they gather wood from the mangroves there out of convenience.

Elevated salinity near the salt farms may also have a harmful effect on mangroves there. A 2003 report recorded an average salinity near salt farms of 4.97 Be during the dry season. This is elevated compared to the average measured salinity of 3.55 Be in non-salt farm areas, although no statistical difference was found. [Faki 2003] In this study, salinity was measured during the rainy season and no increase in salinity was found. The particularly heavy rains

during the study likely influenced the results, but the data contradict the hypothesis that salt farms cause long-term changes in salinity. Rather, salinity is elevated only during the production season. These data imply that mangrove regeneration in abandoned salt farms should not be impaired due to elevated salinity levels. Natural regeneration of *Avicennia marina* was observed in one abandoned salt farm in Shengejuu, supporting this conclusion.

However, the seasonal spikes in salinity may have a negative effect on the mangroves surrounding the salt farm. The 2003 study found that mangroves in salt farm areas were shorter, but more abundant, than mangroves in non-salt farm areas, although a statistical difference was observed only in Kiuyu. Elevated salinity was suggested as a possible cause for the stunted tree height in salt farm areas. [Faki 2003] The results of this study also indicate that trees were shorter near the salt farms. This could be due to the preferential cutting along the farm perimeter of large trees, which block sunlight to the pans. It is also expected that the most landward mangroves will naturally be shorter than trees well within the intertidal zone, as this is the primary habitat for mangroves. Most species of mangroves can tolerate salinities up to double normal ocean water. *A. marina* is the most salt-tolerant species, withstanding salinities of over 9 Be, and *Rhizophora mucronata* can tolerate a salinity of up to 6.5 Be. Optimal growth, however, occurs at normal salinities, and it is plausible that trees are stunted, but not killed, by hypersalinity from the salt farms.

Salt farmers are aware of the ecological and socio-economic significance of mangroves. They believed mangroves to important as a resource, citing building material and firewood as common uses of mangroves, and for the environment. Some farmers specifically mentioned the role of mangroves in preventing erosion, and many also thought mangroves were responsible for bringing rain. The reported correlation between mangroves and rain is interesting, though its

scientific basis is unclear. It is possible that transpiration from the mangroves locally increases vapor pressure and encourages cloud condensation and precipitation.

The Department of Forestry and the Department of the Environment seek to minimize environmental impacts by carrying out a site survey prior to granting approval for new salt farms. However, 20% of farms reported starting construction without official permission. It is hoped that non-permitted farm construction will cease to be an issue since the government has stated its commitment toward maintaining, but not expanding, the areas currently used for salt farming.

RECOMMENDATIONS

- Owners need to record the production at each harvest, as well as all salt sold early in the season for operating costs. The farmer training courses organized by AZASPO should include a segment on basic accounting so owners can learn how monitor their income or losses and the earnings of their employees and day laborers. This will enable farmers to determine for themselves the economic viability of their farms.
- Owners should provide protective gear for employees and day laborers. Appropriate gear includes gloves, rain boots, and eye protection. Employees and day laborers should also wear hats to protect against the sun.
- When possible, farms should be designed to allow for gravity flow in the final step, where water enters the harvesting pan. Farmers should consult with engineers when planning farm renovations or major repairs.
- Water should have a salinity of 25 to 26 Be upon entering the harvesting pan to encourage production of a high quality salt.
- The mangrove pegs used in pan construction may be able to be cleaned and reused for 2 to 3 seasons rather than being replaced annually. Reuse would help decrease pressure on the surrounding mangroves.
- Farmers in the Mchanga Mdogo Zone should pool money and buy a water pump. Their farms are adjacent, so sharing a pump is feasible and could greatly increase production.
- Farms should focus on increasing production within the existing farm area rather than expanding their farms or building new farms. The government should continue its policy of rejecting applications for new farms and should address illegal expansion of existing farms.

- The possibility for commercial aquaculture during the rainy season should be explored. Aquaculture can add significantly to the revenue generated. Farmers should contact Narriman Jiddawi at the Institute of Marine Science for advice on aquaculture techniques and feasibility.
- Farms should support AZASPO in its goal of producing high quality salt for international export. It is expected that farmers will reap economic benefits from AZASPO's proposed refinery despite the lower unit price of salt if they concentrate on raising production.
- Salt farmers should join to form cooperatives to encourage more equitable distribution of wealth.
- The environmental effects of salt farms on birds, crabs, fish, and mangroves should be studied in greater depth. Studies of the effects on bird behavior, species diversity, and abundance are necessary to determine whether salt farms are suitable bird habitats. Studies on the effects of salinity on mangrove height and abundance, as well as studies on crab populations and microfauna in the mangroves surrounding salt farms, would be helpful to better understand the environmental impacts of salt farming. Salinity studies should be planned for the dry season, when salt production occurs. A study on the species of fish and crustaceans present around the salt farms, with special attention to viable options for aquaculture, would also be useful. Finally, many farmers reported that mangroves are important for bringing rainfall. It would be interesting to test the scientific validity of this belief by looking for a correlation between rainfall and mangrove cover.

CONCLUSION

As can be expected for any industry, salt farming has advantages and drawbacks. Currently, farmers fail to optimize production yield and quality. However, if farmers make an effort to raise production and if AZASPO manages to export refined, high quality salt to an international market, the salt industry stands to bring significant socio-economic benefits to Pemba. The revenue generated from salt, and potentially aquaculture, has the potential to outweigh the localized environmental impacts. Of the environmental impacts associated with salt farming, the most serious seems to be the increased pressure on the surrounding mangroves due to their exploitation for pan construction, hut construction, and firewood. Regulation of mangrove usage around salt farms could help alleviate this problem. In addition, seasonally elevated salinity may stunt mangrove growth. It is difficult to determine whether these impacts are limited to the environs of the salt farm or whether they may have detrimental effects for Pemba's wider coastal ecosystem. It is the goal of integrated coastal zone management plans to encourage sustainable use of environmental resources and to maximize benefits to coastal populations. Overall, Pemba's salt industry seems congruent with this goal, especially if action is taken to increase salt production and quality.

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Appendix 1: Individuals Interviewed

Farm No.	Farm Name	Position	Name
1	Umoja Ni Nguvu	Owner	Juma Ali Hamad
		Employee	Amour Ali Hamad
		Employee	Idi Ali Hamad
		Day Laborer	Fatma Kombo
		Day Laborer	Zuwena Masoud
2	Shengejuu Society Salt	Owner	Omar Moh'd Omar
		Employee	Abdalla Moh'd Omar
		Employee	Sadik Omar Hemed
3	Ambasha Salt Farm	Owner	Ali Omar Salum
		Employee	Issa Hamad Ali
		Employee	Abeid Omar Salum
4	Juhudi	Owner	Assa Ali Hamad
		Employee	Ali Hamad Ali
		Employee	Othman Bakari Othman
		Day Laborer	Fakih Hamad Ali
		Day Laborer	Zainab Ali Omar
5	Mbuyuni Salt Farm	Owner	Issa Aseid Hamad
		Employee	Hussein Salim Hamad
		Employee	Suleiman Seif Omar
		Day Laborer	Amir Hamad Ali
		Day Laborer	Seif Khamis Omar
6	Takawani Salt	Owner	Abdalla Juma Ali
		Employee	Said Juma Ali
		Employee	Juma Abdalla Juma
7	Subira Salt Farm	Owner	Said Omar Kombo
		Employee	Moh'd Said Seif
		Employee	Said Ali Hamad
		Day Laborer	Nazira Omar Kombo
		Day Laborer	Siti Bakari Juma
8	Msutini Salt	Owner	Hamad Omar Salim
		Employee	Omar Saleh Omar
		Day Laborer	Rahma Amour Abdalla
9	Shengejuu	Owner	Ali Juma Ali
		Employee	Mbarouk Khamis Omar
		Day Laborer	Hamad Rashid Hamad
		Day Laborer	Dhamir Ali Faki
10	Mfuujumbe Salt Farm	Owner	Khamis Faki Hamad
		Employee	Kombo Khamis Kombo
		Employee	Said Khamis Bakari
		Day Laborer	Bakari Khamis Bakari
11	Chabwi Salt Farm	Owner	Moh'd Salim Juma
		Employee	Said Bakari Shaame

		Day Laborer	Sada Hassan Juma
		Day Laborer	Bahati Ala Faki
12	Kichokochwe Salt Farm (C)	Owner	Hamad Said Ali
		Employee	Siti Khamis Hamad
		Employee	Mariam Seif Gharib
13	Kichokochwe Salt Farm (B)	Owner	Ali Hator Ali
		Employee	Salama Juma Salim
		Employee	Hadia Bakari Omar
		Day Laborer	Time Ali Kombo
14	Kibwekiti Salt Farm	Owner	Said Suleiman Ali
		Employee	Seif Khamis Suleiman
		Employee	Time Mbarouk Hamad
		Day Laborer	Mati Hamad Tani
15	Kichokochwe Salt Farm (A)	Owner	Shavuai Ali Malim
		Employee	Salama Ali Seif
		Day Laborer	Sada Hamad Khamis
16	Mkulima Salt Farm	Owner	Hamad Moh'd Masoud
		Owner/Employee	Hamad Omar Masoud
		Day Laborer	Kombo Ali Kombo
		Day Laborer	Haji Moh'd Faki
17	Mwanzo Mgumu	Owner	Rashid Ali Salim
		Employee	Kasim Juma Faki
		Employee	Ali Rashid Ali
		Day Laborer	Rehema Salum Omar
		Day Laborer	Asha Masoud Hamad
18	Kichumbini Salt Mining Cooperation	Owner	Mbarouk Hamad Yussuf
		Employee	Said Rashid Said
		Employee	Hussein Omar Rajab
19	Kicha Kaa Si Shangi	Owner	Othman Bakari Shehe
		Owner/Employee	Ali Issa Ali
		Owner/Employee	Said Hassan Salim
		Day Laborer	Hamad Bakari Shehe
		Day Laborer	Hassan Ali Hassan
20	---	Owner	Talib Seif Khamis
		Employee	Mussa Ali Mkombozi
		Day Laborer	Ali Juma Faizi

Appendix 2: Interview Questionaires

A: Questionnaire for Salt Farm Owners

1. Identifying Information:
    a. What is your name?
    b. How old are you?
    c. Do you have a family? How many dependents?
    d. Do you own your farm with others? How many and what are their names?

    Jina lako nani? Una miaka mingapi? Una familia? Wangapi wanaokutegemea? Una shamba la chumvi na watu wengine? Wangapi? Majina yao nani?

2. History of Farm and Owner
    a. How long have you had your farm?
    b. What work did you do before owning your salt farm? Do you do other work now? What kinds? How much are you paid for your other work?
    c. Do you work full-time or part-time?
    d. Did you study in school? For how many years?
    e. What was the procedure for starting your salt farm?

    Ulikuwa na shamba la chumvi kwa miaka mingapi? Kabla ya shamba la chumvi, ulifanya kazi gani? Sasa hivi, unafanya kazi nyingine? Kazi gani? Unapata pesa ngapi kwa kufanya kazi nyingine? Unafanya kazi wakati wote au si? Ulisoma? Mpaka darasa la gani? Taratibu kwa kuanzisha shamba lako la chumvi ni zipi?

3. How many bags did you get for this season? How many bags do you normally get per year? How much money do you sell them for?

Ulipata polo ngapi msimu huu? Kwa kawaida, hupata polo ngapi kwa mwaka? Unauza polo moja kwa shilingi ngapi?

4. Has production changed since starting your farm? How?

Mavuno yameongezeka au yamepungua au sawasawa tangu kuanza shamba la chumvi?

5. Do you have a market for your salt? Do you have bags in stock? Do you think that you will sell your salt to JB at AZASPO? Even for a lower price?

Una soko kwa chumvi yako? Una polo zinakaa katika stock? Unafikiri utamuzia chumvi yako JB, AZASPO? Japo kwa bei ndogo?

6. Costs of Operation

    Now, please tell me about your operating costs. First, how much do you think you spend for everything all together (labor, fuel, equipment, maintenance). Then we will go through each cost individually.

    a. Labor: How many employees do you have? How do you pay them? How many months do they work? Do you use day laborers? When do employ day laborers? How do you pay them?

b. Fuel: Do you use fuel? What kinds of fuel do you use? How many liters per month, or per day, do you use? How many months do you use it for? How much does one liter cost?
c. Equipment: How much do you spend on equipment per year? What kinds of equipment do you use? How many? What is the unit cost? (checklist: buckets, spades, rakes, artesanal rakes, hoes, mats, machetes, salt bags, cooking utensils)
d. Food: Do you buy food for the salt farm? How much do you spend on food per day? For how many days do you buy food?
e. Maintenance: How much do you spend on maintenance per year?
f. Other: Are there any other costs? Do you pay a fee to the government?
g. How do you pay for these costs? Do you pay cash? Do you sell salt? For which costs? When do you sell salt to pay for costs?

Sasa, niambie juu ya uduma za uendeshaji? Kwanza, unafikiri unalipa pesa ngapi kwa zote zote (wafanyakazi, mafuta, vifaa, ripea). Halafu, moja moja. Wafanyakazi: Una wafanyakazi wangapi? Unawalipa vipi (kwa chumvi au pesa)? Wanafanya kazi kwa miezi mingapi? Unatumia vibarua pia? Wakati gani? Unawalipa vipi? Mafuta: Unatumia mafuta? Mafuta gani (disel, petroli)? Unatumia lita ngapi kwa mwezi (au kwa siku)? Unatumia kwa miezi mingapi? Shingapi kwa lita moja? Vifaa: Unalipa pesa ngapi kwa vifaa kwa mwaka? Unatumia vifaa gani? Vingapi? Shingapi kwa moja? (ndoo, pauro, reki, mbau, makuti, mapanga, polo, vifaa vya kupikia) Chakula: Unanunua chakua kwa kula shambani kwa chumvi? Pesa ngapi kwa siku? Unanunua chakula kwa siku ngapi kwa mwezi (au kwa mwaka)? Kwa miezi mingapi? Ripea: Unalipa pesa ngapi kwa ripea kwa mwaka? Upo uduma wengine? Unalipa idara ya misitu? Pesa kwa uduma inatoka wapi? Unalipa ceshi? Unauza chumvi? Wakati gani? Kwa uduma gani?

7. Process

Please draw a picture of your farm. Where do you catch water into the farm? For the first harvest, how many days does the water stay there? Do you measure salinity there? Until what Be measurement does water stay there? Where does the water go next? Etc. [Repeat for second and later harvests.] When do you start collecting water to the reservoir pan? How many times a month do you collect water there? Do you use machines to move water between pans? Do you use buckets? Where does water flow by gravity and where do you have to use machines or buckets?

Tafadhali, chora picha ya shamba lako. Unapata maji wapi? Kwa mara ya kwanza, maji yanakaa pale kwa siku ngapi? Unapima maji pale? Maji yanakaa pale mpaka pointi ngapi? Na helafu, maji yanakwenda wapi? [Fanya tena kwa mara ya pili.] Unaanza kupata maji rezav mwezi wa ngapi? Unapata maji mara ngapi kwa mwezi? Unatumia machini kupata maji birikani hii? Unatumia ndoo? Maji yanakwenda bila machini au ndoo wapi mpaka wapi? Unatumia machini au ndoo birika gani mpaka birika gani?

8. What machines do you use? Do you use a generator? Do you use iodine?

Unatumia machini gani? Ngapi? Wota pump? Jenereta? Unatumia iodine?

9. Are there algae in your pans? Which pans? What color is it? When do you find it there? Are algae good or bad for the salt?

Ipo rangi birikani (kama kijani au nyekundu)? Birikani gani? Rangi gani? Ipo rangi wakati gani? Ni nzuri au mbaya kwa chumvi?

10. Are there any social conflicts associated with salt farming? What are they?
Kuna mogogoro ya jamii kwa kulima chumvi? Nini?

11. Do you provide employees with protective gear? What kinds? Do they wear them?
Unawapa wafanyakazi vifaa vya kinga? Kama nini? Wanavaa?

12. Mangroves

What species of mangroves are around the salt farm now? What species were there before building the farm? Are the mangroves near the farm healthy?

Do you use the mangroves near the salt farm? For what purposes?

Do you use mangroves far from the salt farm (too) ? For what purposes?

Before beginning the salt farm, did you use the mangroves there? For what purposes?

Which species do you use? Do you think mangroves are important? Why?

Karibu shamba la chumvi, ipo mikandaa gani na gani na gani? Kabla ya kujengea shamba, kulikuwa na mikandaa gani? Na mingine? Sasa hivi mikandaa ina afya? Ni freshi? Unatumia mikandaa karibu shamba la chumvi? Kwa shuhuli gani? Unatumia mikandaa mbali na shamba (pia)? Shuhuli gani? Kabla ya kuanzisha shamba, ulitumia mikandaa pale? Shuhuli gani? Unatumia mikandaa gani? Ni mingine? Unafikiri mikandaa ni muhimu? Kwa nini?

13. Erosion

Is there a problem with erosion now? Was there a problem before the farm was there? Why is there a problem? Is it worse or better now than before?
Kuna matatizo ya mimomo nyoko sasa hivi? Kulikuwa na matatizo kabla ya shamba la chumvi? Yapo matatizo kwa nini? Ni nzuri zaidi au si sasa kuliku kabla ya shamba?

14. Birds: Have the number of birds increased, decreased, or remained the same since starting the farm?
Ndege wameongezeka, wamepungua, au sawasawa tangu kuanzisha shamba la chumvi?

15. Do people prefer your salt or imported salt and why?
Watu wanapenda chumvi yako au chumvi ya nchi tafauti, na kwa nini?

B: Questionnaire for Salt Farm Employees and Day Laborers

1. What is your name? How old are you? Do you have a family? How many dependents [Males only]?

Jina lako nani? Una miaka mingapi? Una familia? Wangapi Wanokutegemea?

2. Did you study in school? For how many years?
Ulisoma? Mpaka darasa la gani?

2a. [Day Laborers only] Why are you working at the salt farm?
Kwa nini unafanya kazi shamba la chumvi?

3. How long have you worked at the salt farm?
Umefanya kazi shamba la chumvi kwa miaka mingapi?

4. Do you do other work? What kinds?
Unafanya kazi nyingine? Nini?

5. How are you paid for working in the salt farm? (in salt? In money?) How many bags/ How much money did you get for this season? How much do you usually get?
Unalipwa kwa kufanyakazi shamba la chumvi vipi? (na chumvi? au pesa?) Ulipata polo ngapi/ ulipata pesa ngapi kwa msimu huu? Na kawaida, unapata polo ngapi/ pesa ngapi?

6. Are you paid for doing other work? What? How much money do you get?
Unalipwa kwa kufanya kazi nyingine? Nini? Unapata pesa ngapi?

7. What are your working hours? How many days per week do you work? (Do you rest on Friday?) How many weeks per month do you work?
Unafanya kazi saa ngapi mpaki saa ngapi? Unafanya kazi siku ngapi kwa wiki? (Unapumzika Ijumaa?) Unafanya kazi wiki ngapi kwa mwezi?

8. Which months do you work? (Or which season?)
Unafanya kazi miezi gani—mwezi wa ngapi mpaka mwezi wa ngapi? (Au, unafanya kazi msimu gani?)

9. Do experience any health problems at work? What kinds? When do you experience them?
Wakati wa kazi, una matatizo ya afya? Nini? Una matatizo wakati gani?

10. Are you given protective gear? If Yes: What kinds? Do you wear them? If No: Would you wear them if you were given them? If answered No to #9: Do you need them?
Unapewa vifaa vya kinga? If Yes: Vifaa gani? Unavaa? If No: Ukipewa, utavaa? If answered No to #9: Unahitaji?

11. Do you use mangroves near the salt farm? For what purposes?
Do you use mangroves far from the salt farm? For what purposes?
Before working at the salt farm, did you use the mangroves there? For what purposes?
Which species do you use?
Unatumia mikandaa karibu shamba la chumvi? Kwa shuhuli gani? Unatumia mikandaa mbali na shamba (pia)? Shuhuli gani? Kabla ya kufanya kazi shamba la chumvi, ulitumia mikandaa pale? Shuhuli gani? Unatumia mikandaa gani? Ni mingine?

C: Questionnaire for Shehas

1. What is your name? How old are you? How long have you been the Sheha?
Jina lako nani? Una miaka mingapi? Ulikuwa Sheha kwa miaka mingapi?

2. Did you study? For how many years?
Ulisoma? Mpaka darasa la gani?

3. What is the procedure for starting a salt farm?
Taratibu kwa kuanzisha shamba la chumvi ni zipi?

4. How many farms are there in _____?
Yapo mashamba mangapi _____?

5. How many applications for new farms have you received since becoming Sheha?
Umepata maombi mangapi kwa mashamba mpya tangu kuwa Sheha?

6. Are there people who cut mangroves without permission? Why? What do you do about it?
Watu wanakata mikandaa bila ruhusi? Kwa nini? Unafanya nini?

7. What is the procedure for harvesting mangroves?
Taratibu kwa kukata mikandaa ni zipi?

8. Are there any social problems with salt farming? Have the salt farms affected local fisheries? Have they affected nearby farms? Have they affected erosion? How?

9. What do you think about salt farms? Are they good or bad for the people? For the environment? Why?
Unafikiri nini juu ya mashamba ya chumvi? Ni mazuri au mbaya kwa watu? Kwa mazingira? Kwa nini?

Appendix 5: Sample Calculation of Inferred Production

Farm 5: Issa Aseid Hamad

Reported Production: 800 to 1000 bags

Annual Costs From Sale of Salt: 2 148 600 Tsh or 716 bags

- Equipment: 109 000 Tsh
  - 12 spades x 3000 Tsh ea.
  - 10 buckets x 700 Tsh ea.
  - 20 rakes x 1500 Tsh ea.
  - 600 to 700 mats x 40-50 Tsh ae.
  - 8000 Tsh for cooking utensils
- Bags: 286 000 Tsh
  - 1430 bags (net) x 200 Tsh ea.
- Food: 576 000 Tsh
  - 3000 Tsh/day x 6 days/wk x 4 wks/mo x 8 months (Jun-Oct; Jan-Mar)
- Fuel: 477 600
  - 3-4 L petrol/day x 6 days/wk x 4 wks/mo x 4.5 months harvesting x 1050 Tsh/L
  - 24 000 Tsh/yr for oil
- Maintenance: 400 000 Tsh
- Government Fee: 30 000 Tsh
- Part-time Labor: 270 000 Tsh
  - 30 bags/person x 3 people x 3000 Tsh/bag

Annual Costs From Net Production/ Out of Pocket: 500 bags

- Employees: 35% of net production for 5 employees
  - Reported 100 bags/person x 5 people = 500 bags
  - Implies a net production of 1430 bags (500 bags / 35%)

Inferred Gross Production: 2146 bags

1430 bags (net) + 716 bags (sold to cover operating costs)

Inferred Owner Earnings: 1 395 000 Tsh or 465 bags

1430 bags (net) – 500 bags (employees) = 930 bags / 2 owners = 465 bags/owner
465 bags x 3000 Tsh/bag = 1 395 000 Tsh

Appendix 6: Salinity Measurements and Salt Tests

Date	Time	Location	Source	Salinity (Be)
29 Apr	11:30 AM	Shengejuu	surface runoff through salt farm	0
29 Apr	11:30 AM	Shengejuu	standing water in pan	0
29 Apr	11:50 AM	Shengejuu	water in pan: Omar Suleiman's farm	0
29 Apr	11:50 AM	Shengejuu	ocean water across from Kojani I.	2.5 to 3
29 Apr	11:50 AM	Shengejuu	water in harvesting pan	0
29 Apr	12:30 AM	Mchanga Mdogo	tidal source stream for salt farm	0
29 Apr	12:30 AM	Mchanga Mdogo	water in harvesting pan	0
30 Apr	11:40 AM	Wete	ocean water	1.5 to 2
1 May	4:45 PM	Kiuyu	tidal source stream for salt farm	0
1 May	5:20 PM	Kiuyu	tidal water in mangroves 50 paces from salt farm	0
1 May	5:20 PM	Kiuyu	water in pan	0
4 May	9:15 AM	Wete	control # 1	20
4 May	9:15 AM	Wete	control # 2	20

Date	Time	Location	Source	Owner	Result
13 Apr	2:00 PM	Madenjani	Roadside Stand		-
13 Apr	2:00 PM	Madenjani	Roadside Stand		+
14 Apr	12:15 PM	Shengejuu	Kitchen	Idi Ali Hamad	-
14 Apr	12:15 PM	Shengejuu	Shop		-
15 Apr	3:40 PM	Shengejuu	Stock	Issa Aseid Hamad	+
17 Apr	11:05 AM	Shengejuu	Stock	Ali Juma Ali	+
22 Apr	4:00 PM	Kambini	Kitchen	Hamad Said Ali	+
29 Apr	11:30 AM	Shengejuu	Store Hut		-
29 Apr	11:30 AM	Shengejuu	Store Hut		-
29 Apr	12:30 PM	Mchanga Mdogo	Store Hut		-
1 May	3:00 PM	Kiuyu	Kitchen	Ali Bakari Shehe	-
1 May	3:00 PM	Kiuyu	Kitchen	Khamis Faki Hamad	-
2 May	3:40 PM	Chake Chake	Shop	Pujini Salt	-
2 May	3:40 PM	Chake Chake	Shop	Pujini Salt	+
2 May	3:40 PM	Chake Chake	Shop	Pujini Salt	-
2 May	3:40 PM	Chake Chake	Shop	Pujini Salt	+
3 May	4:00 PM	Machomanne	Shop--Tanga		+
3 May	7:50 PM	Pandani	Kitchen	Talib Seif	+
3 May	9:00 PM	Wete	Shop		+
4 May	9:00 AM	Wete	Kitchen	Said Mbarouk	-

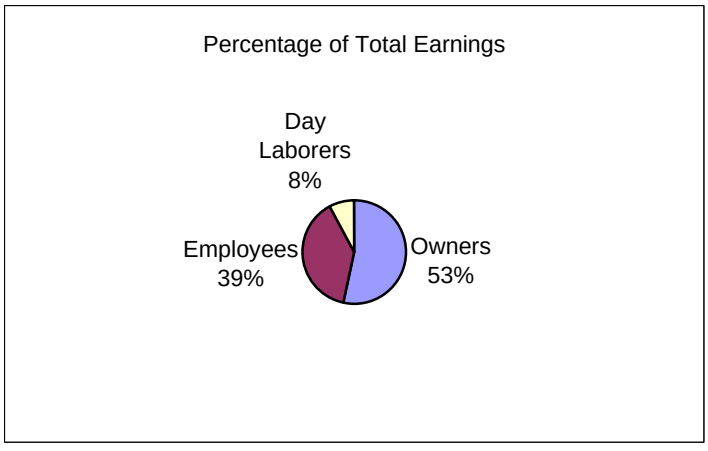
Income From Salt Farm

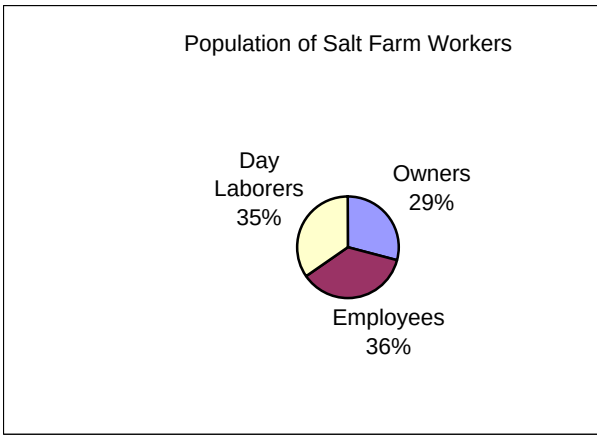
Farm	Owners	Emp 1	Emp 2	DL1	DL 2
1	975000	210000	350000	0	0
2	630000	180000	180000		
3	880000	180000	150000		
4	60000	60000	60000	21000	40000
5	1395000	300000	300000	160000	90000
6	-1101500	500000	46000		
7	255000	60000	60000	30000	72000
8	717000	399000		126000	
9	700000	210000		60000	30000
10	1938000	840000	840000	70000	
20	2691300	360000		45000	
AVG	**830891**		**278158**		**57231**
11	346500	99000		9000	9000
12	87000	81000	81000		
13	30000	9000	9000	6000	
14	24000	24000	24000	9000	
15	48000	48000		18000	
AVG	**107100**		**46875**		**10200**
16	1462500	1462500		252000	252000
17	25000	195000	200000	110000	195000
18	106000	114000	450000		
19	145000	145000	95000	39000	36000
AVG	**434625**		**380214.286**		**147333.333**
TOT AVG	**570690**		**244750**		**69958.3333**

Income from

Owners
0
0
600000
no data
0
0
no data
0
0
0
0
66667
0
540000
156000
733000
660000
417800
no data
0
960000
5000
321666.667
214941.176

TOTALS	77	96	92	TOTAL	77
Earnings	11413800	8321500	1679000	265	





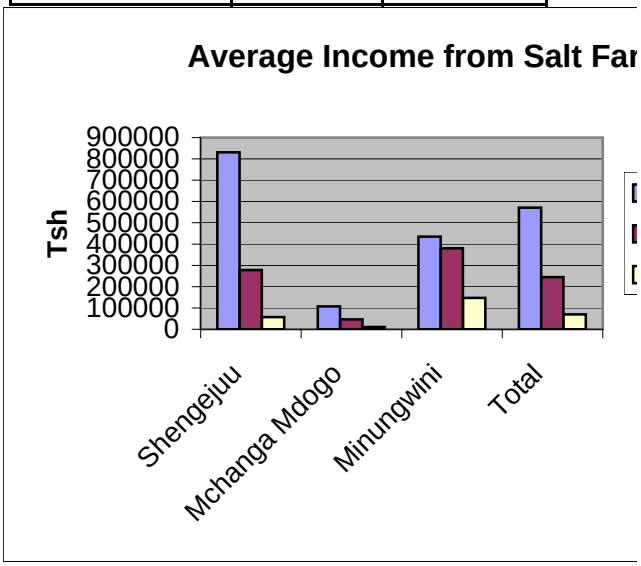
ı Other Work

Emp 1	Emp 2	DL 1	DL 2
0	0	0	0
0	0		
0	720000		
42000	0	96000	0
0	0	96000	0
0	792000		
2400000	196000	0	0
0		7000	
0		0	0
0	0	187500	
250000		0	
	231579		**29731**
0		2000	0
0	0		
36000	583500	66000	
260000	0	0	
30000		0	
	113687.5		**22000**
1344000	45000	336000	
100000	20000	0	0
0	no data		
10000	336000	105000	0
	265000		**88200**
	210720.588		**38934.78**

96 92

Average Income

Zone	Owners	Employees
Shengejuu	830891	278158
Mchanga Mdogo	107100	46875
Minungwini	434625	380214
Total	**570690**	**244750**



Vorkers

ers
%

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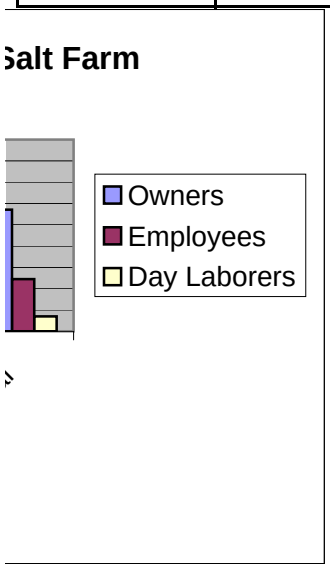
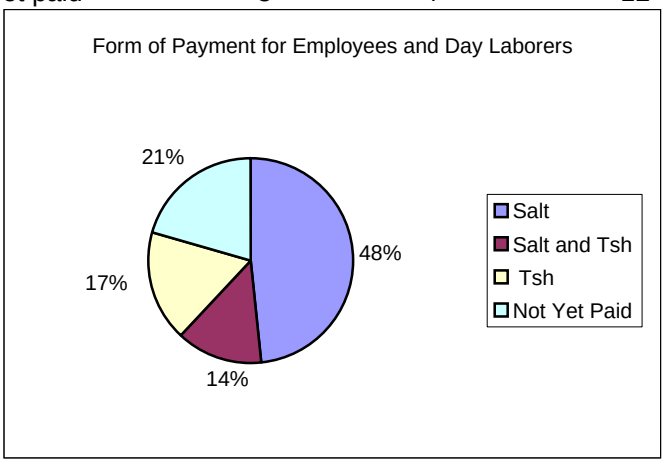
Day Laborers	Weighted Avg. Inc.
57231	364641
10200	36551
147333	349279
69958	**278775**



Form of Payment

Mode	Employee	Day Laborer	Total
salt	15	13	28
salt and Tsh	5	3	8
Tsh	6	4	10
not yet paid	8	4	12



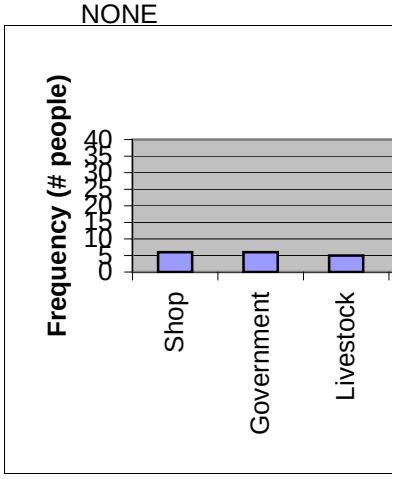
Percentage of Income from Salt Farm

Zone	Owner	Employee	Day Laborer
Shengejuu	92.6%	54.6%	65.8%
Mchanga Mdogo	20.4%	29.2%	31.7%
Minunwini	57.5%	58.9%	62.6%
Total	72.6%	53.7%	64.2%

Other Paid Work

Work

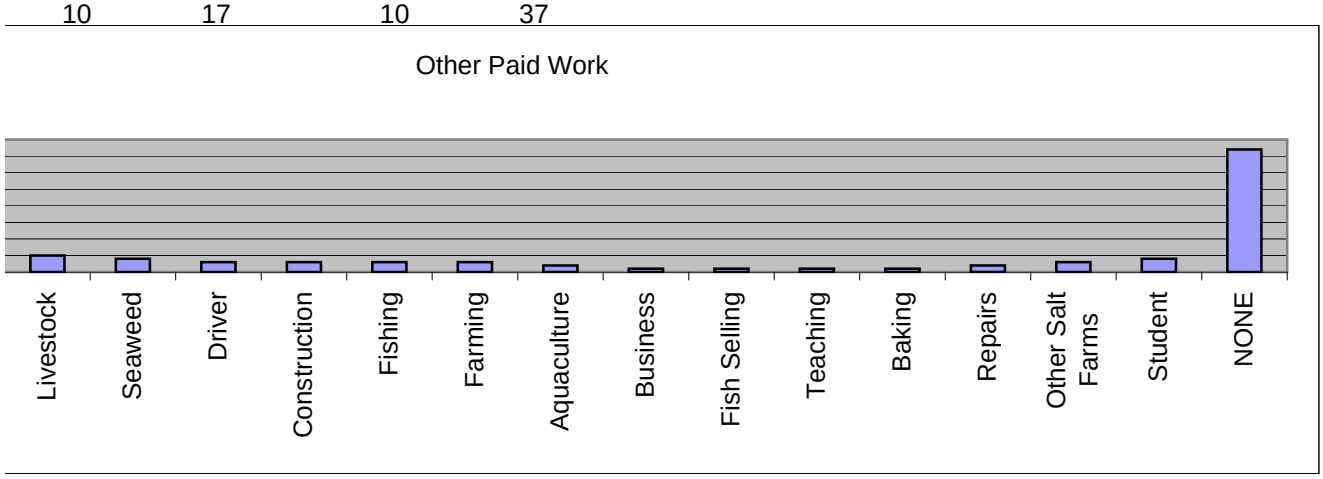
Shop
Government
Livestock
Seaweed
Driver
Construction
Fishing
Farming
Aquaculture
Business
Fish Selling
Teaching
Baking
Repairs
Other Salt Farms
Student
NONE

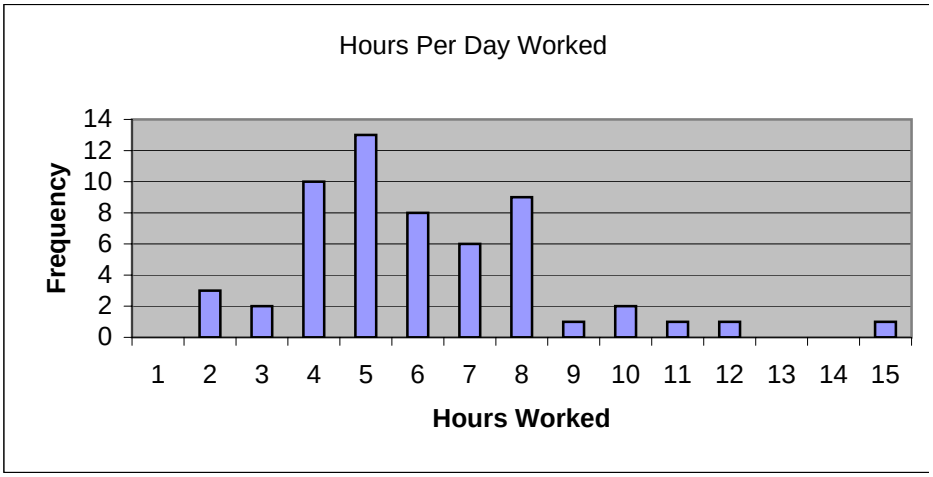


Owners	Employees	Day Laborers	Total
2	4	0	6
5	1	0	6
1	1	3	5
0	3	1	4
1	2	0	3
0	1	2	3
0	1	2	3
0	2	1	3
1	1	0	2
1	0	0	1
1	0	0	1
0	1	0	1
0	1	0	1
0	2	0	2
0	0	3	3
0	0	4	4
10	17	10	37

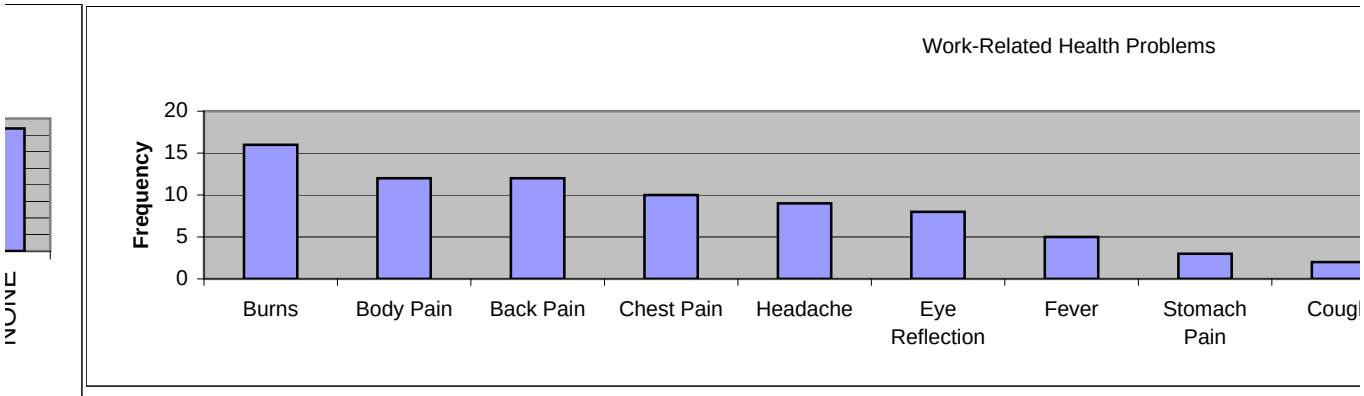
Hours Per Day Worked	
1	0
2	3
3	2
4	10
5	13
6	8
7	6
8	9
9	1
10	2
11	1
12	1
13	**0**
14	0
15	1

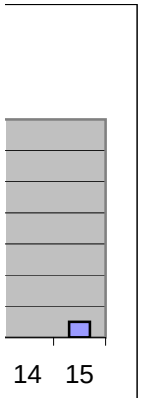
Health Pro
Burns
Body Pain
Back Pain
Chest Pain
Headache
Eye Reflec
Fever
Stomach P
Cough
Leg Pain
Fatigue
Diziness
Open Sore
None





blems	Usage of Mangroves	
		Yes
16	Do you use mangroves near the salt farm?	61
12	Do you use other mangroves far from the salt farm?	33
12	Did you use mangroves near the salt form before working there?	18
10		
9		
8		
5		
3		
2		
1		
1		
1		
1		
16		

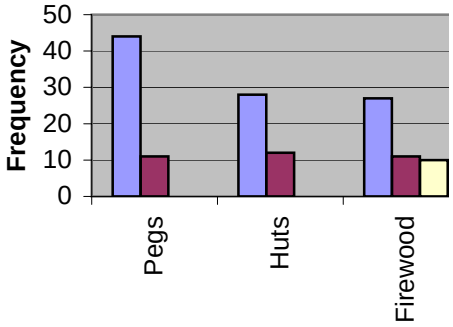


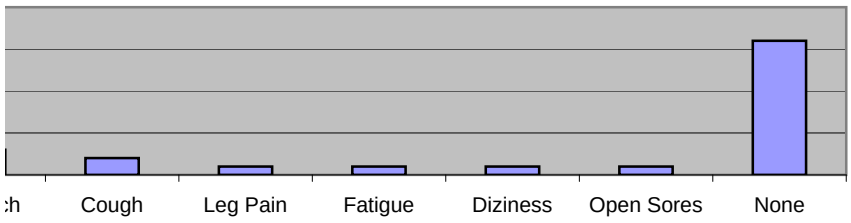


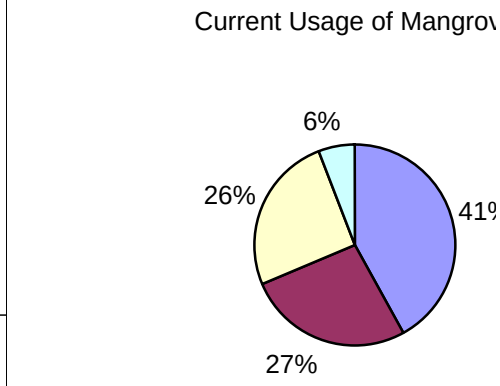
No	Number asked	Percent Responding "Yes"
17	78	78%
34	67	49%
42	60	30%

Usage of Mangroves

Use	ear Salt Fa	from Salt F
Pegs	44	11
Huts	28	12
Firewood	27	11
Building Ma	6	13







fore Salt Farm
0
0
10
9

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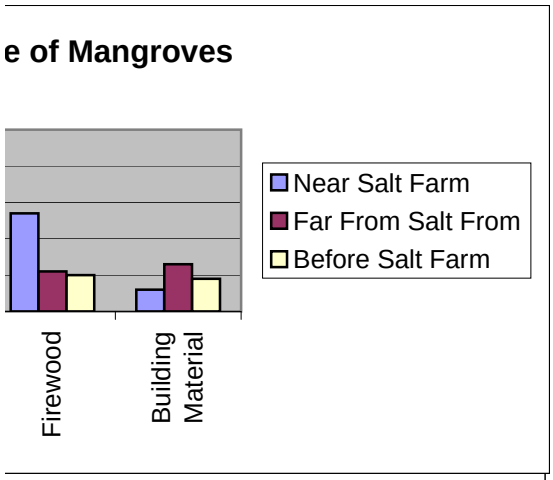
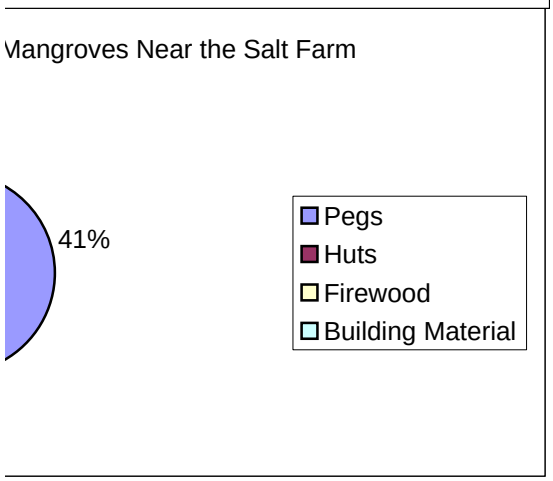
Total	**570690**	**244750**





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10200	36551
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69958	**278775**

Do you use mangroves near the salt farm?
Do you use other mangroves far from the salt farm?
Did you use mangroves near the salt form before working there?

Yes	No	Number asked	Percent Responding "Yes"
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33	34	67	49%
18	42	60	30%