FUELING THE APPETITE FOR WATER:

THE PALM OIL BIOFUEL INDUSTRY IN SAN PEDRO SULA, HONDURAS

By

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ABSTRACT

The world desperately seeks alternative fuels to eradicate its reliance upon unsustainable oil extraction; however, emerging biofuel technology is contingent on a more precious natural resource: water. Essential in all stages of biofuel production, including growing, processing, and refining oil feedstocks, water still represents a vital necessity for the surrounding population. This research assesses the immediate and long-term impacts of the expanding palm oil biodiesel industry on local water availability and privatized water management in San Pedro Sula, Honduras and the surrounding Sula Valley. Analyzing regional changes in water accessibility and quality caused by the palm oil commerce, the report also explores the reasons behind the impending water scarcity in San Pedo Sula. Finally, the study examines the potential consequences of these transforming water realities on future water provision as well as possible service adaptations required of the privatized company.

CHAPTER 1:

INTRODUCTION

The global environmental crisis is not simply rising temperatures, disappearing forests, or contaminated rivers; it is a critical turning point in the interaction between an ever growing, demanding population and natural resources that will define the future. Shifting climate patterns and worldwide political and economic instability have forced nations to search in earnest for alternative sources of energy in order to relieve the mounting pressure to stop the unsustainable extraction fossil fuels. While biofuels may represent a key component in the panacea for this international dilemma, their production and application must strike a delicate balance between innovation and conservation. In fact, the feasibility of a lasting and successful biofuel industry is contingent upon the world's most precious resource: water.

The ultimate potential of alternative fuels to alleviate environmental concerns and act as an economic catalyst for developing nations must be weighed against the danger of promoting an industry that results in the commoditization of the most essential element to human survival. As the world is already experiencing an intensifying water crisis, it is imperative to examine the impacts and tradeoffs of the biofuel business and water supplies at both a global and local level.

Research Objective

This research assesses the immediate and long-term effects of the expanding palm oil biodiesel industry on local water availability and privatized water management in San Pedro Sula, Honduras and the surrounding Sula Valley. Analyzing regional changes in water accessibility and quality caused by the palm oil biodiesel production as this commerce depends on water resources for its viability, this report also explores the impending water scarcity in the Merendón aquifer and the city of San Pedro Sula. The potential consequences of these transforming water realities on future water provision by the privatized water corporation are examined with special considerations to the political, economic, social, and environmental ramifications.

The analysis incorporates the palm oil biomass market, the viability of biodiesel production, existing regional water realities, and the local performance of an internationally-backed water privatization scheme into a global framework to demonstrate how these four issues are inextricably linked. Although this investigation focuses on the northwestern region of Honduras, emphasizing these main topics in a worldwide perspective is fundamental to fully understanding the intricacies of this arising situation. While the unique conditions found in San Pedro Sula and the Sula Valley result in an exceptional case study, the overall situation can not be considered as an isolated or specialized set of circumstances unique to Latin America or even the western hemisphere alone. This thesis endeavors to highlight the interaction between the palm oil industry, biofuels, the impending water crisis, and privatization, as they exist in San

Pedro Sula and project them onto a global scale for a deeper, more comprehensive contexualization of these dynamics.

Background

African oil palm, or *Elaeis guineensis*, is the source for the world's most produced fruit crop, and the resulting palm oil can be found in about 10 percent of every product on a supermarket shelf. From cooking oil to cosmetics to industrial lubricants, its diversified uses are seemingly endless; however, its promise as a biodiesel feedstock is garnering international attention. Global demand for palm oil is at an all-time high as corporations across every continent are becoming increasingly interested in the highest oil yielding terrestrial crop in the world (Kouchoukos 1).

The developing nation of Honduras, plagued by the highest gas prices in Central America due to no oil reserves of its own, believes that biodiesel production from palm oil could catapult it into unlimited economic development (Carson 2005). Already the third largest cultivator of African oil palms in Latin America, Honduras is extending its production capacity by another 200,000 hectares with the help of international lending institutions like the Inter-American Development Bank in order to compete on the international market (Fromm 5). Nevertheless, the agricultural growing and oil extraction and refining processes for palm oil biodiesel are extremely water-intensive. As a matter of fact, studies indicate that the typical fabrication of one liter of biodiesel from any feedstock requires a total of 900 liters of water from start to finish (Yang 2008). The nearby city of San Pedro Sula, the industrial capital of not only Honduras but also

Central America, is already facing water availability and accessibility issues while experiencing explosive population growth. The internationally privatized water consortium responsible for the city's water and sewage services called Aguas de San Pedro is already racing to keep up with the diminishing water supplies and increasing demand. This research looks at the extent to which water resources will be impacted by the palm oil and biodiesel industries while also anticipating how the water corporation will adapt to the transforming water situation without compromising the delivery of this vital resource to Honduran citizens.

Site Description

The Sula Valley, covering 6, 117 square kilometers, has been Honduras' center for economic development for over one hundred years. It is also historically known for its abundance of water and fertile soils suitable for agriculture. The largest alluvial valley in the country, it encompasses seventeen municipalities across the departments of Cortés, Santa Bárbara, and Yoro (Vásquez, Gómez and Meneses 4-5). San Pedro Sula is located at the base of the Merendón mountain range forming the backbone of the valley. Other major cities in the area include Omoa, La Lima, and Puerto Cortés, a port city about sixty kilometers from San Pedro Sula. There are three large palm oil groups operating in this region including the Hondupalma and Palcasa cooperatives and the Jaremar corportation.

Methodology

Fieldwork for this thesis was carried out in June and July of 2008. Spending most of the travel time in San Pedro Sula and the surrounding areas, participant observation as well as formal and informal interviews were completed along with literature review in order to learn about the palm oil biomass and biodiesel production processes. Tegucigalpa was also visited to conduct interviews. Two extraction plants in the Sula Valley were toured to grasp a better understanding of extraction and oil refining while a small-scale plantation was also visited to view the harvesting techniques. Interviews with employees at the Dinant Corporation, the Jaremar facility in San Alejo, and the Palcasa plant were completed in addition to talking with representatives from a national environmental protection organization and the Fundación Hondureña de Investigación Agrícola. Several of the interview participants did not wish their names to be printed in this report, and therefore will not be identified by such in the thesis.

Chapter Overviews

Chapter two explores African oil palm production and harvesting in Honduras and across the world while also examining the causes for its large-scale popularity.

Chapter three describes the emerging biodiesel industry, its environmental strengths and weaknesses, and its processing techniques in the Sula Valley.

Chapter four of the thesis contextualizes the changing water realities in the Sula Valley with major global water issues including climate change. Predictions concerning San Pedro Sula's future water supplies are also discussed.

Chapter five investigates the international water privatization scheme in San Pedro Sula. Its history, performance, and challenges are analyzed while also questioning water's role as a human right or a commodity.

Chapter six concludes the thesis, re-emphasizing the major conclusions drawn from the case study concerning the palm oil industry's impact on the Sula Valley's water supplies and quality.

CHAPTER 2:

THE AFRICAN OIL PALM

Chapter Overview

This chapter provides an in-depth understanding of African oil palms, their consequent products, and their growing importance on a global scale as well as a domestic one for the developing nation of Honduras. The general history, uses, and worldwide perceptions concerning the African oil palm are first examined before analyzing the rapidly expanding Honduran palm oil industry. All aspects of commercial agricultural production, including planting, growing, harvesting and re-planting, are discussed in order to distinguish the potential future political, economic, social, and hydrological changes that African oil palms can bring to the Sula Valley.

Elaeis guineensis

While there are several species of oil palms found around the world, the one most commonly used for industrial production is the African oil palm, *Elaeis guineensis,* native to Western Africa (Carrere 2006). Flourishing in the coastal belts of humid, tropical conditions, it typically grows between 10 degrees north latitude and 10 degrees south latitude, although it has also been found in isolated areas of suitable rainfall in Central and Eastern Africa and Madagascar, down to 20 degrees south latitude (Berger and Martin 2000). African oil palms grow best in regions characterized by a mean maximum and minimum temperature of 30 to 32 degrees Celsius and 21 to 24 degrees Celsius, respectively, and in coastal marine alluvial clays, soils with volcanic origins or those with a pH level between 4 and 6. Indigenous to areas receiving 1,780 to 2,280 millimeters (about 70 to 90 inches) of precipitation a year, the trees can tolerate short spans of flooding but thrive best in locations with a dry season of about two to four months each year ("*Elaeis guineensis* Jacq." 1996).

Elaeis guineensis grow to have tall yet relatively slender trunks in comparison to other varieties of palm trees, and are topped by several layers of large, spiky fronds. The bark, dark brown, is rough and often becomes covered with other native vegetation, such as vines or small plants, which is permissible on even oil palm plantations as it is not parasitic nor hinders overall growth and crop development. The oil palm fruit grows in large bunches between the different levels of leaves; each bunch, made up of a fibrous mass surrounding 1000 to 4000 oval shaped fruits about five centimeters in length, generally weighs between 33 to 55 pounds, although Honduran producers see bunches as large as 100 pounds (Carrere 2006; Personal Interview 16 Jul. 2008). The fruits have a smooth, firm yet oily outer casing that changes from a dark blackish-brown to red and orange upon ripening (Personal Interview 16 Jul. 2008). Like most fruits, it contains a fleshy part, the mesocarp, and the endocarp at the core, requiring two different processes to refine as well as resulting in two different types of palm oil. The red, soft tissue is generated into basic cooking oils and biofuels while the kernel is used in goods of a higher quality (Personal Interview 3 Jul. 2008). This type of oil can be employed as superior cooking oil, but is regularly found in specialty products, such as expensive chocolates due to its higher melting temperatures, in addition to trendy soaps and lotions (Personal Interview 3 Jul. 2008; Flores 2008).

History The oil giving properties of African oil palms were recognized and utilized as early as ancient Egypt as remnants of oil palm were excavated from a tomb in Abydos dating back to 3000 B.C. (Berger and Martin 2000). European travelers in the fifteenth century wrote about West Africans cooking with palm oil, and it also represented a product common to the provisioning commerce for caravans and ships involved in the African slave trade, but there was not an intercontinental demand for palm oil until the early nineteenth century. The British Industrial Revolution made it popular enough by 1900 that European-run plantations were set up in Central Africa and Southeast Asia in order to satisfy the oil requirements for candle-making and machinery lubricants. Although the invention of the hydrogenation process for fats and oils in order to market products like margarine came about in 1902, palm oil didn’t gain much appeal in Western foods until after World War II when better technology in refining and transportation made is possible to use the un-hydrogenated version in many items for consumption (Berger and Martin 2000). Today, African oil palms provide the number one harvested fruit crop and most used oil seed in the world (Butler 2006).

Products and Uses In Western Africa, oil palms are still used for foodstuffs, medicines, palm wine made from its sap, and various products created from the fibers

(Carrere 2006). In fact, red palm oil is still consumed directly in soups in basked dishes in this region; however, the rest of world ingests it only in a highly refined form (Berger and Martin 2000). The main product from oil palm is cooking oil, which represents 56 percent of the total global trade in edible oils, also making it the world's most used vegetable oil, rivaled only by soy (Carrere 2006). Due to the complex triglyceride structure, the oil pressed from the fruit can also be used in margarine or mayonnaise, a variety of other food products, as well as oleochemicals for soaps, cosmetics, waxes, detergents, manufacturing lubricants, and of course, biodiesel (Jessen 2008; Kouchoukos 1). From the fiber, sludge, and leftover nut particles, pulp and paper, animal feed, and fertilizers are common by-products (Jessen 2008).

Global Expansion Even before palm oil began to be an integral part of the promising alternative fuel business in today's global society concerned with climate change, it was still one of the most rapidly expanding crops in the tropics. From 1990 to 2002, planted areas of oil palm increased by 43 percent to a global total of 10.7 million hectares, while soybean, another crop grown in parts of Latin America, only increased 26 percent in that period ("Oil palm and soybean: Two paradigmatic deforestation cash crops" 2006). By 2005, plantations covered 12 million hectares from which 30 million tons of palm oil was produced, doubling the total land area and production in only eight years (Carrere 2006). Today, total global output has risen to 40 million metric tons of palm oil, and experts predict that global supplies may double by the year 2020 (Kouchoukos 2). Malaysia, Indonesia, and Nigeria are currently the top three palm oil producers in the world with Malaysia and Indonesia contributing 85% of the planet's supply (Fromm 4; Carrere 2006).

But the question remains: why is the palm oil industry experiencing such dynamic growth? Although little recognition is given to the importance palm oil in the United States and Europe, this product may actually represent one of the most versatile, functional, and valuable goods available on the global market. As previously stated, palm oil is the most popularly used cooking oil in the world, and as economic conditions in China and other Asian countries rise, large portions of the new disposable incomes are spent on fried and processed foods in which palm oil is a main ingredient (Kouchoukos 2). Its appeal also becomes apparent since it has significantly lower overall production costs than other oil crops, including soy, which is about 20 percent more expensive to grow and process (Fromm 2). It is also, relatively speaking, a secure investment in agriculture as the large number of diversified products that utilize the different parts of the oil palm assure its continued demand in world trade. In recent years, increased oil palm planting can be directly linked to its role as a highly sought-after biomass for the production of biodiesel. Being the most efficient terrestrial oil crop, it averages about 5950 liters of oil per hectare (or 635 gallons of oil per acre), more than three times that of its closest contender, jatropha (Addison 2001). Furthermore, developing nations around the globe have become particularly fond of the palm oil industry as it allows for technological development, modernization, and a competitive edge in the worldwide markets. Governments have been able to attract foreign investment and capital involving palm oil production while also taking advantage of being in a unique position to produce a crop that only grows in certain environmental niches (Fromm 2-3).

The Good, The Bad, The Oily Palm oil may prove to be one of the most useful products in the world, but it is also one of the most hotly debated. Its reputation in many developed nations has led to uncertainty over its ultimate benefits and role in future industries. Two of the most widely circulated objections about palm oil concern its dietary repute and its effect on animal habitats.

First, palm oil has been grouped together with other tropical oils to be thought of as extremely unhealthy and is commonly discouraged for regular consumption. In actuality, it has been endorsed by the World Health Organization as well as the Food and Agricultural Organization as a heart-healthy, trans fat free and cholesterol free oil that also contains vitamins and antioxidants including vitamin E, beta carotene, and even coenzyme Q10 (“Palm Oil is…” 2006).

The more popular reason for the rejection of oil palms and their products stems from their swift expansion into areas near orangutan territories in Malaysia and Indonesia. The large apes cannot subsist where natural forests have been replaced with this monoculture, so their survival in the wild is being increasingly threatened as the plantations continue to encroach upon traditional habitats. Mary Galdikas, famed research and expert on orangutans in Indonesia, estimates that any of this animal population outside of natural reserves will not endure another ten years due to the rate of oil palm planting (McDowell 2009).

While not as popular with media outlets around the world, there are many other critical advantages and disadvantages of palm oil production that are essential to consider in order to realistically evaluate its expansion in a global context. Obviously palm oil represents an important role at a household level in terms of fat provision; the intake of triglycerides through foods cooked in this type of oil is a key element in developing nations where undernourishment and a lack of food security is ever-present. Over three billion people rely on palm oil to curb consumption deficiencies and because it remains fresh at room temperatures for months, those lacking refrigeration can still incorporate into their meals safely ("Palm Oil is…" 2006; Kouchoukos 1). Its significance as a staple of biofuels will be discussed in further detail in chapter three of this thesis, but the value of a clean burning fuel that simultaneously reduces the reliance on petroleum extraction is incalculable. Furthermore, in addition to bringing foreign investment to nations on a broad, domestic scale, palm oil related industries provide a large number of local jobs to communities, increasing standards of living and bettering financial situations.

Nevertheless, oil palm plantations alone are responsible for a vast number of social and environmental problems that should not be underestimated. A mere few of these ecological and cultural concerns include deforestation, habitat and biodiversity eradication, and the loss of indigenous and peasant land (Carrere 2006). Also related is the displacement of racial and ethnic groups and the perpetuation of colonial modes of production and capital extraction as large companies around the world have confiscated or dominated lands used for traditional livelihoods, leaving the former residents without homes nor sources of income (Escobar 63-66, 69-72). Contamination of land and water through the application of pesticides and fertilizers is another grave problem with palm oil cultivation and is often exacerbated by erosion, leading to the sedimentation and pollution of major aquatic environments. The chemical waste from processing plants and biodiesel production facilities has the potential to be devastating to inhabitants along with local and regional natural settings (Carrere 2006). Finally, although biodiesel made from palm oil can notably reduce carbon emissions when compared to fossil fuels, the creation of oil palm plantations can be extremely harmful to the atmospheric balance. Studies done in Malaysia and Indonesia indicate that when the tropical peatland rainforests are converted to oil palm agricultural estates, a "carbon debt" of 423 years is incurred (Butler "Biofuels are worsening global warming" 2008). In other words, one ton of palm oil produced on former Malaysian peatland generates fifteen to seventy tons of carbon dioxide (Butler "E.U. may ban palm oil biodiesel" 2008). In terms of a resulting carbon augmentation for the expansion of the Honduras palm oil industry, at least a 319 year debt should factored into industry expansion plans as much of the new land being cleared is comparable to that of the Amazon tropical forests with similar carbon ramifications (Butler "Biofuels are worsening" 2008).

Sustainability Endeavors The Roundtable on Sustainable Palm Oil (RSPO) was formed in April 2004 to promote palm oil production that is "comprised of legal, economically viable, environmentally appropriate and socially beneficial management and operations" (Jessen 2008; "RSPO Principles and Criteria for Sustianable Palm Oil Production" 2). This international non-profit organization has 144 members incorporating growers, processors, consumer goods companies, retailers, and additional non-governmental agencies, and in November of 2005, delineated eight principles that must be abided by for truly sustainable palm oil production. (Jessen 2008). These principles, found in the document entitled "RSPO Principles and Criteria for Sustianable Palm Oil Production" are summarized by the following:

-Principle 1: Commitment to transparency. (Participants must provide adequate business information for effective participation and decision-making) (4).
-Principle 2: Compliance with applicable laws and regulations. (Members must obey all local, national, and international laws and regulations, including the possession of the land rights in order to cultivate oil palms) (6-7).
-Principle 3: Commitment to long-term economic and financial viability. (All management plans must be aimed for lasting economic feasibility) (10).
-Principle 4: Use of appropriate best management practices by growers and millers. (Operating procedures must be properly documented, implemented, and monitored) (12).
-Principle 5: Environmental responsibility and conservation of natural resources and biodiversity. (Participants must identify the environmental impacts of replanting, plantation and mill management while working to decrease negative effects, promote positive effects, and strive for improvement) (21).
-Principle 6: Responsible consideration of employees and of individuals and communities affected by growers and mills. (Members must realize the social impacts involved in plantation and mill management and try to mitigate any negative consequences while endorsing positive ones) (27).
-Principle 7: Responsible development of new plantings. (A comprehensive and participatory independent social and environmental impact assessment must be undertaken prior to establishing new plantings and operations or expanding existing ones. Results must be incorporated into the planning, management, and operations) (37).
-Principle 8: Commitment to continuous improvement in key areas of activity. (Growers and millers must monitor and review their practices and performance to develop and implement new ways of improvement) (45).

Despite the good intentions of the RSPO, some concerns as to the effectiveness of this organization in bringing out more sustainable measure of palm oil production should be mentioned. Since becoming a certified member is costly in terms of both time and money, the willingness and ability to join for large and small producers alike from the around the world may be limited. Memberships last two years and cost two thousand euros (about US$2,698) per year for an ordinary membership and two hundred and fifty euros (about US$337) each year for an affiliate status ("How to Apply" 2009). Moreover, it is unclear how much monitoring and enforcement is possible or carried out by the RSPO for their associates, or if being a member of the organization is truly 'beneficial' in any regard in the long run for the participant. A third issue to consider is the legitimacy of this non-governmental organization delineating guidelines intended to qualify production as sustainable or un-sustainable across the world. While certainly representing a marginal mentality, some groups related to palm oil production believe that Western nations have ulterior motives in their misgivings about the wide-scale use of this product. These factions claim that because palm oil is superior in both price competitiveness and productivity in comparison to oil seeds produced in the United States and Europe, particularly rapeseed and soy, these governments fear a loss of control of a number of existing global markets and potential moneymaking industries. Therefore, governmental entities such as the National Security Agency are thought to be collaborating with environmentally motivated NGOs including Greenpeace and Friends of the Earth, to denounce palm oil production and call for its ban in both food products and biofuels under the guise of concerns related to environmental impacts and effects on climate change (Tate 2006). This controversial and conspiratorial approach will most likely never be either confirmed or disproved, but the underlying question concerning developed nations being able to form organizations to decide the best management practices and requirements of ‘good’ production worldwide is certainly something to consider. After all, while general lessons about large-scale agricultural endeavors can be rightfully applied to African oil palms, the United States and Europe have very little expertise or experience when dealing with this monoculture, and thus should be careful not to adopt a hierarchical attitude with regards to this progressively more valuable product.

Honduras

Honduras is a fascinating case study of African oil palm in the Western hemisphere as, trailing only the production volume of Colombia and Ecuador, is the third largest producer of palm oil in Latin America and embodies some unique cultural and industrial practices alike (Fromm 4). By taking a closer look at the nation’s current operations and procedure, a deeper understanding of the vast changes prospective to this industry suggests some the radical social, economic, political and environmental changes that are possible in modern Central America.

Budding Production Although a distinct type of oil palm, *Elaeis oleifera* or *Elaeis melanococca*, is native to parts of Latin America, its poor fruit production and variable quality has prevented it from being commercially exploited (Berger and Martin 2000). It remains unclear if African oil palm was brought to Honduras in 1927 as simply an exotic plant to be added to the collection at the Lancetilla Botanical Garden and Experimental Station or if it was imported by the United Fruit Company with a more lucrative goal in mind, but the Tela Railroad Company, a subsidiary of today's Chiquita Brands International, established the first oil palm plantation in 1936 (Berger and Martin 2000; Fromm 4). Experimenting with alternative crops due to the destruction of large banana-growing areas inflicted with Fusarium wilt, the company ultimately did not attempt to expand production on a massive scale; in fact, it wasn't until 1971 when producers organized agro-industrial ventures during an agrarian reform that African palm production was commercialized (Berger and Martin 2000; Gomez 4). Since the 1970s when 11,000 hectares were planted throughout northern Honduras, a steady positive growth rate, between 2.2 percent and 7.6 percent annually, has been seen in the country (Fromm 1). By 1990, almost 20 million kilos of palm oil were produced each year, mostly used domestically, until 1999 when 30 million kilos were exported and palm oil became one of the country's major resources following the banana industry's downfall after Hurricane Mitch (Carson 2006). As of 2007, the total palm oil cultivation area covered 100,000 hectares and resulted in 300,000 metric tons of palm oil (Gomez 3).

All palm oil production runs along the Atlantic coast in the departments of Atlántida, Colón, Cortés, and Yoro (Fromm 4). Cultivation areas are broken up into three broad categories including the Aguán Valley, the Sula Valley, and the Atlántida area. Although the Aguán and Sula Valleys are the main agricultural producing areas, the Atlántida region also has received increasing attention in recent years due to concerns over oil palm fertilizers and pesticides affecting the coral reefs that lay just beyond the 1,564 square kilometer coastal zone (Fromm 8; Coral reefs 2007). This issue, along with other environmental aspects of the industry, will be explored in more depth in chapter four. The focus of this thesis, nonetheless, is the Sula Valley region, which includes the Yoro and Cortés oil palm provinces and the city of San Pedro Sula, because of its importance to the current and future palm oil industry, the ecological conditions of the area, and critical political dynamics including the privatization of water services. In 2006, the Sula Valley accounted for 45 percent of the total oil palm agriculture in Honduras and exported 22 million dollars worth of palm oil. The production has only continued to grow in size and significance in the last few years (Vásquez, Gómez and Meneses 5-6).

Production Chain There are a myriad of individual actors in the Honduran production chain of African palm oil, and they are all interrelated through a complex system of business transactions. In order to gain a fuller understanding of this web of commerce, Table 1 from 2006 found in "Integrating Small-scale Producers in Agrifood Chains: The Case of the Palm Oil Industry in Honduras", presents an idea of the general ratios of groups involved in the palm oil trade and some of their basic characteristics.

Table 1: Oil Palm and Palm Oil Production Chain

Group	Number	Additional Information
Producers	4710	Small-scale: 1 to 10 ha Medium-scale: 11 to 100 ha Large-scale: over 100 ha
Intermediaries	10	Receive credit from extractors to invest in machinery and transportation
Extractors	11	- 3 cooperatives - 8 private sector -9 export crude and refined palm oil
Refineries	4	-2 private sector -Advanced technology
Fractionation Plants	4	High production of vegetable oils and finished products
Exporters	6	Sell processed products and crude oil to mainly to Mexico and Central America
Distributors	3	Profit margin is 12 to 15% of processor's price
Local Wholesalers	3000	Profit margin is 5% of distributor's price
Local Retailers	25,000	Profit margin is 40% of wholesaler's price
Local Consumers	5 million	Products include cooking oils, pharmaceuticals, costmetic products

(Fromm 7)

The Companies Honduran small-scale oil palm producers do have the opportunity for significant growth, development, and profit within the industry. However, as they still must overcome numerous challenges including a lack of credit, insufficient training, competition, limited market access, and deficient extraction capacity and technology for refining and biodiesel production, it is large companies and cooperatives poised for the greatest overall benefits (Fromm 1).

Dinant, a leader in palm oil production, controls about 20 percent of the Honduran African palm area by owning and managing 19,000 hectares and contracting another 4,000 hectares from local producers. It currently exports about half of its produced oil, using the remaining 50 percent in processed foods, including snack items, chips, and dehydrated soups in addition to butter, margarine, lard, and cooking oil (Gomez 6; Personal Interview 3 Jul. 2008). Although its operations are based mainly in Colón in the Aguán Valley, it does maintain an extraction facility in the Sula Valley. Dinant is also the top producer of palm oil biodiesel in the country. It led the way for other companies to follow in this commerce after it supplied its biodiesel for use in the major cities during a 2005 pilot program to promote the domestically fabricated alternative fuel, as discussed in further detail in chapter three. The corporation is also looking to expand into mass jatropha production as another source of energy biomass (Personal Interview 3 Jul. 2008).

The major companies and associations based in and around the Sula Valley include Hondupalma, San Alejo, and Palcasa (Vásquez, Gómez and Meneses 12). Hondupalma, founded in 1982, comprises of thirty-one rural cooperatives and associations and is estimated to control about 8,500 hectares of oil palm plantations while also purchasing fruit from another 3,500 hectares (Fromm 8-9). Exporting about 50 percent of its palm oil to Central America, Mexico, and Venezuela, the group also expanded into biodiesel production. Hondupalma is committed to local development and is recognized for supporting health and education programs as well as community infrastructure projects (Hunt 2007).

San Alejo is the Honduran palm oil division of the Jaremar Group Corporation, which leased or purchased all the plantations that formerly belonged to the United Fruit Company/Chiquita Brands International (Vásquez, Gómez and Meneses 13). Now controlling approximately 14,500 hectares of oil palm land, the company is looking to regionally expand its capacity as 40 percent of the fruit utilized is bought from small producers. In the main processing facility in San Alejo, Honduras, both crude and refined palm oil is produced, some of which is shipped to another nearby plant in San Pedro Sula for additional processing and filtration to be sold as high quality cooking oil. While organic fertilizers and animal feed are sold from the leftover compounds and kernel remnants, San Alejo's most notable expansion in the palm oil industry is creating and selling genetically modifying seeds (Flores 2008). Gene Palm Honduras of the Viveros sector of San Alejo is crossbreeding Deli Duras mother palm trees with either Avros or Ekona father pollen so that the hybrids start to produce fruit after only 28 months, are capable of producing 30 tons of fruit per hectare, have limited vertical growth for extended harvesting, and have high oil extraction rates of 25 percent while are also more resistant to diseases and pests ("Agro Industrial Division" 2009; "GPH Deli x Ekona Certificate Oil Palm Seeds" 2009; Flores 2008). San Alejo also utilizes a biogas system to harness energy and generate electricty from the palm oil processing steps, once even being self-sufficient during its initial size and rate of production. Finally, this corporation has biodiesel production capacity since fall of 2008 but is not currently the biofuel due to economic conditions (Flores 2009).

Palcasa, located just down the road from San Alejo, is a cooperative of about one hundred nearby families and production groups. The facility is an extraction plant that produces only crude palm oil from both the mesocarp and perocarp, as exhibited by the red color of the oil samples from the factory (denoting a fairly unrefined verison of the oil) and their barely liquid state after being inside the air conditioned Palcasa offices since crude palm oil has a notoriously high solidifying point. Processing oil palm fruit from about 7,000 hectares, the expected output was 40 tons per hour after expansionary and technological upgrades were completed in the fall of 2008 (Hunt 2007; Maldonado 2008). Even if Palcasa is considerably smaller in production scope, it is actually one of the more famous palm oil institutions in Honduras as it partnered with Eecopalsa to become the first wastewater biogas plant in the world (Maldonado 2008; Hunt 2007). Instead of dumping water used in the palm oil processing phases back into the environment directly, the organic residues and water effluent are deposited into large ponds where methane production takes place through microbial reactions. The methane is then stored under pressure and burned later to make electricity, rather than be emitted as a greenhouse gas (Vásquez, Gómez and Meneses 25). Depending on the harvesting season, this biogas facility can produce between 1.2 MWh and 3.6 MWh of power (Hunt 2007).

Agricultural Production

This section will provide an in-depth account of the growing and harvesting mechansims for both corporate and independent plantations in the Sula Valley. Comprehensive knowledge of these operations is imperative for gaining a clear vision as to the benefits and risks of this industry with regards to the local community and its groundwater supply and recharge.

Seeds In Honduras, the seeds of the African oil palm must be certified in order to harvest the fruit for oil. Trees grown from uncertified seedlings risk not producing fruit at all, or the products are of very low caliber, which are unusable in factories as they can actually damage the extraction machinery (Personal Interview 16 Jul. 2008). Naturally, as every tree planted must be from an authorized seed facility, this niche of the industry promises to be very lucrative. As recently mentioned, the San Alejo division of Jaremar is focusing a lot of attention on their genetically-modified seedlings, many of which are being exported to Mexico (Flores 2008).

The licensed seeds are then germinated in special nurseries, remaining there for about a year during which time they undergo phases of altering shade, sun, and potting mechansims based on their growth and age. The newly sprouting oil palms are then sold to plantations, where they will begin to bear fruit after about three years, although the quantity and quality of such will increase over time (Personal Interview 16 Jul. 2008).

Oil Palm Cultivation Whether African oil palms are the easiest product to grow in Honduras or one that requires considerable preparation, attention, and methodic regulation as reported by two different growers, the process must begin by completely clearing the existing land for planting (Personal Interview 16 Jul. 2008; Flores 2008). The trees are positioned ten meters apart in staggered rows in order to ensure ample room for growth, sunlight exposure, and harvesting procedures, resulting in about 100 trees per manzana, or about every 1.4 hectares (Personal Interview 16 Jul. 2008).

According to the Honduran Ministry of Agriculture, African oil palms require at least 200 millimeters, or 7.87 inches, of water each month; thus, the yearly total is almost eight feet of water. During the wet season, which typically runs from June or July through November or December, areas can receive up to 500 millimeters (nearly 20 inches) of rainwater a month, but during the dry season, from about February to June, irrigation in some regions is often needed to maintain productivity levels (Fromm 11). However, because all interview participants in the Sula Valley said that they did not irrigate their plantations at all or only in extremely dry periods, this type of water use will not be factored into the final impact assessment of the palm oil biomass and biofuel industries to the Sula Valley's natural resources.

Although *Elaeis guineensis* are durable enough to withstand several days of flooding before starting to die, they do require substantial fertilization for long-term growth and production (Personal Interview 16 Jul. 2008). Plant nutrition makes up the priciest portion of the African oil palm growing business, but it is cost effective due to the longevity of the trees' fruit-bearing, and also because it reduces leaching of the soil's natural fertility, a critical agricultural component in areas of low-nutrient, tropical rainforest soil undergoing constant weathering (Vásquez, Gómez and Meneses 18-19). Common types of chemical fertilizers include urea, ammonium nitrate, and ammonium sulfate to re-introduce nitrogen into the ground as well as phosphorus, Potassium chloride, and boron in the form of Borate (19). These non-organic fertilizers can be applied one time a year, or in half doses biannually, although there are divergent ideas on the best location to lay down the nutrients. Because the older, larger roots of the tree closest to the trunk do not absorb the fertilizers, some producers put the chemicals between oil palms straight down the tree lines; others spread it between the neighboring rows as branches chopped down during harvesting are placed there, making the soil underneath increasingly humid, fertile, and receptive for the nutrients (Personal Interview 16 Jul. 2008).

Agrochemical pesticides used in African oil palm plantations in the Sula Valley address diseases and other disturbances that reduce the overall production value of the crop by lowering actual plant populations, fruit quantity, or overall tree health (Vásquez, Gómez and Meneses 19). While some producers maintain that oil palms are less susceptible to pests and plagues, Ing. Manual Flores Calidonio at San Alejo stated that epidemics can be constantly troublesome and very expensive; not only are the chemical treatments and fumigation process costly, but the overall loss of fruit production can also be very financially damaging (Flores 2008). Some pests in the region include rats, insects, nematodes, fungi, protozoan and weeds, but the two most common are leaf cutter ants and weevils. Leaf cutter ants build large mounds next to young trees, completely stripping them of their foliage and fruit, and potentially killing the saplings. Weevils that attack the bottom of the oil palms can be easily dealt with; however, another type of weevil infests the tops of the trees, causing Red Ring condition, as manifested by bright red horizontal bands that appear up and down the trunk. They not only endanger immediate fruit production, but often kill the entire tree (Personal Interview 16 Jul. 2008).

When discussing aspects of agricultural production, especially phases that include human interaction with chemicals, it is imperative to consider the health ramifications of workers who come in direct contact with these inorganic fertilizers and pesticides. Although no reports or interview participants mentioned this feature in the Honduran oil palm growing process, some documentation has begun to emerge from Malaysia that workers are suffering from acute symptoms related to chemical poisoning (Brown and Jacobson 22-23). As this phenomenon has been devastating for agricultural workers in other portions of Latin America, perhaps most famously in the cut flower industry in Colombia, serious consideration must be given to the possibility of long-term health consequences for these laborers.

Harvesting Oil palm fruit ripen continuously throughout the year with the height of season being from August through November. Every tree produces multiple bunches simultaneously, but as they mature at different times, harvesting must be done by hand. Visiting each tree about every two weeks, workers look for signs of ripeness before beginning to cut including fruit of a red, orange, and yellow nature or when a few kernels fall from the fiber mass to the ground. For younger, shorter oil palms, a "*pica*" tool, about the size of a shovel with a sharp, flat head, is used to hack off the fruit masses while taller trees are harvested with a similar tool made of a hollow metal pole with a curved, serrated sickle at the end. Once a cluster of fruit has been identified as ripe, the harvester first cuts away any surrounding branches impeding full accessibility to the bunch, or "*racimo*", and where it attaches to the trunk. The sickle saws off the cluster and it is allowed to drop to the ground, then the laborer moves on to the next tree without lowering the device for quicker cutting. As bunches can weigh up to one hundred pounds, workers must be careful to anticipate where the fruit will land. In addition, thick, poisonous spines several inches in length also grow with the fruit that prove very painful and easily cause infection if in contact with the skin; therefore, everyone on the plantations wears thick gloves and only handles the fruit with spiked rods (Personal Interview 16 Jul. 2008). As the harvester moves along, another worker cuts the thin branch that once connected the mass to the oil palm to an appropriate length since if the stems are longer than several inches, producers are penalized at the processing plants (Personal Interview 16 Jul. 2008, Maldonado 2008). In addition, yet another worker piles the fruit together for easy collection by a wagon or truck while a fourth person is responsible for stacking the discarded fronds between the rows for later gathering. Women and children, some of whom attend school in the afternoon to earn extra wages on the plantations, will amass any individual fruits remaining on the ground that were shaken off the large bunches throughout the processes. Bags of these surplus seeds are sold to extraction facilities for high prices since there is no vegetation with which to contend during the initial refining phases. The crop is taken to the processing factories within two or three days of being cut so to remain in good condition and not begin to ferment in the humid Honduran climate (Personal Interview 16 Jul. 2008).

Grower to Extractor Transactions Oil palm fruit is bought and sold by weight; the difference in the heaviness of trucks arriving full of the crop and departing after unloading is calculated in order to determine the base payment. Once the fruit is delivered, an inspector examines the harvest and decides any penalties that should be subtracted from the final transaction. Fines are incurred if the fruit have too much wood fiber attached to the bunches from the cutting process, if they are unripe or black in color as they do not give oil, or if they are overripe, which will alter the resulting oil batch after processing, making it too acidic (Maldonado 2008).

Productivity Levels The overall productivity of oil palm plantations in Honduras depends on variety of factors including the diverse micro-climates, soil types, age and genetic variability of the African palms themselves, pests, irrigation, and fertilizers. The domestic average fruit yield is 17.11 metric tons per hectare per year (Gomez 4). For small, independent producers, average yield is about 12 metric tons of fruit per hectare each year, but that output could easily increase to about 18 MT/ha with relatively small investments. In order to reduce costs and maximize profits, these growers need better education with regards to maintaining their production area in order to stay competitive within the industry. More proficiency and knowledge is fundamental to irrigation and weed control practices in addition to testing the soil to determine the type and amount of fertilizers necessary before simply applying any of the commonly used chemicals (Fromm 11). The advanced technical know-how and close-regulation approach at the San Alejo plantations results in having the highest fruit yields per year with 32 to 40 MT/ha, or about 30 to 40 metric tons of fruit harvested from each tree during a twelve month growing cycle (Flores 2008).

Eradication and Replanting While African oil palms can live up to 150 years in the wild and ascertain heights of over 80 feet, trees commercially utilized are replaced after about 20 to 25 years as they become too tall to harvest efficiently (Butler 2006; Flores 2008). The standardized maximum height for these trees is 19 meters (Flores 2008). To start the replacement process, it is very common for a young tree to be planted next to the older oil palm that it will eventually take the place of and allowed to grow for two to three years until it begins to bear fruit, thus making the production and harvesting processes seamless. Three holes are drilled into the base of the overly tall tree where a herbicide is injected; the tree turns brown and dries out over the next three weeks before finally being cut down. Although some plantations are rumored to eradicate their palms without the herbicide, this practice is so much more labor intensive that it is significantly less customary, especially over large areas, and growers see no indication that the herbicide endangers the newly planted nearby crops. One of every three rows is replaced a year, shifting the ten meter staggered lines over time, as to not affect output capacities (Personal Interview 16 Jul. 2008).

Upon discussing the long-term consequences of this continual planting cycle, companies disagree about the lasting quality and growth of the trees and fruit alike. While one corporation declared the process to be a “renewable cycle”, especially in Honduras where the land is so fertile and degradation is not an issue, another group admitted that the soil and trees become somewhat distressed by this planting and re-planting over long periods of time (Personal Interview 3 Jul. 2008; Flores 2008). With considerations to the amount of agrochemicals applied to the African oil palms over their 25 year lifespan in conjunction with the mono-cropping practices, the lack of other vegetation allowed on the plantations, and the necessity to completely clear the area before planting, it seems very unlikely if not impossible that this is a truly ‘renewable’ and environmentally sustainable production over generations.

Future African Palm Oil Potential

Profit African palm oil represents an up and coming commodity on the world market with noteworthy growth potential. As of 2006, a Malaysian oil palm plantation generated US$2000 profit per hectare, and with an upfront capital cost of about US$12,500 for each cultivated plot, the initial investment could be recovered in as little as six years. Once expenses were recouped in this short period, annual profits of US$10 million could be expected from a 5,000 hectare plantation (“Palm oil environmentally friendly" 2006). If Honduran growers experiences even remotely similar fiscal results, the industry could forever change the nation's overall economic situation.

On a global scale, palm oil prices increased by a dramatic 70 percent in 2008, shooting up US$120 per metric ton to US$1,170 on the international markets between January and February alone (McDowell 2009; Hassan 2008). Honduran export revenues garnered from palm oil surpassed US$110 million for 2007 and still have enormous potential for expansion (Banco Central de Honduras 68).

Production Sensing the augmenting possibilities and use of palm oil, the Honduran government enacted a biodiesel production plan in 2006 to expand the total area of this agriculture by 200,000 hectares, more than doubling the current land dedicated to African oil palms by 2011 (Fromm 5; 11). The Ministry of Agriculture and Livestock also identified another 440,000 hectares of land as viable for future development (Gomez 3). Much of the designed expansion will be carried out on land currently covered by tropical natural forest as well as replace existing banana plantations. In the Sula Valley in particular, 35,000 hectares has been earmarked for the advancement of oil palm (Fromm 12; 5). Further encouraging this biodiesel plan, the national government also imported one million Malaysian oil palm seeds, noted for their greater yield and shorter maturation time, to immediately cover 28,000 hectares in 2009 (Gomez 5).

Even before this biofuels-centered policy was passed, however, the oil palm industry was growing at an unprecedented rate. From 2000 to 2007, the overall fruit production increased by 100 percent to top 1.4 million metric tons and the planted areas were enlarged by 61 percent to reach 100,000 hectares. It should be observed, however, that widespread expansion will not come easily in some areas. The average age of Honduran African oil palm plantations is 14 years, so large-scale re-planting will be necessary on top of clearing and planting land for the first time (5). The 2006 palm oil initiative is expected to create some 300,000 jobs, 100,000 of which will be directly linked to the industry, but it is not clear if this will be effective in enticing young workers to remain in the rural areas instead of looking for jobs in the urban regions (Fromm 5).

Special Considerations for the Honduran Palm Industry The palm oil sector in Honduras exhibits some unique characteristics that set it apart from other, less progressive agribusinesses common to the nation as well as the rest of Central America. First, there is a high degree of knowledge about and use of technology throughout all aspects of the industry. With 60 percent of local producers having 'adequate' technology and 20 percent with access to 'basic' technology, only 20 percent of the growers rely on no modern instruments for their production (Fromm 1). The presence of advanced equipment and machinery at all levels of the palm oil commerce encourages the development of expertise in technology, increasing intellectual capital and skill sets that can lead to higher wages and steady incomes, even for workers without a formal education. It also signifies greater interaction between rural growers and other businesses in both developing and developed countries. As the technology is imported, multinational relationships are formed, laying the foundation for future investment in

Honduras as well as improved growing practices and shared procedures that can reduce unnecessary costs or damages to the environment.

In addition, unlike other agri-food industries such as the banana, coffee, cocoa, and horticultural sectors, palm oil products are not exported in their raw form for processing elsewhere, but rather, a large amount of the final treatments and commercial preparation occurs domestically (1). This is an important step away from the original banana republic's historical export-reliant economy and cyclical boom and bust misfortunes in the past. In fact, considering the Honduran palm oil sector in a global context is vital to understand how monumental this shift from producing raw materials to industrialized goods really is for the country's future. Instead of Honduras investing in agriculture, the ultimate goal of the palm oil industry is technological investment and advancement. The expansion of planted hectares of African oil palm in the nation merely represents a means to an end, namely the ability to be self-sufficient in terms of producing the basic feedstock for biodiesel and other products as well as to control more of the production chain. While it is always risky to heavily invest the future economy in a single monoculture or sector of production, one that is certainly vulnerable in Honduras' case due to natural disasters given the geographic location, palm oil is a solid, long-term investment from a purely economic standpoint. The "bust" portion of the past cycles is highly unlikely, regardless of the biodiesel aspect, as the worldwide population growth and its changing dietary purchasing patterns, indicating a significant increase in the consumption of foods processed with palm oil, ensures a sustainable market. The expanding demand for products from palm oil in China and India alone in the near future guarantees certain longevity in this oilseed market.

Finally, not only does the oil palm industry provide jobs for local members of the community, but it also does not need an outside migration force from other nations to fulfill the labor requirements (Personal Interview 16 Jul. 2008). This fact stabilizes existing familial relations and kin networks, and also prevents the typical racial tensions that typically occur around the world that when constant seasonal migration for agricultural harvesting causes large influxes of foreign groups.

Nevertheless, despite many progressive opportunities for change that the oil palm industry brings to Honduras, the agribusiness is still afflicted with the predictable obstacles that regularly transpire with large-scale monocultures. This chapter has proven that palm oil and its by-products have great economic potential; however, due to the high costs of extraction and biodiesel production, a mere few will profit. Given the costs as well as the financial and time investments necessary in growing, harvesting, and transportation of palm oil, the industry naturally lends itself to corporate production. Only the largest companies and cooperatives, albeit Honduran-owned, will have the capital and access necessary to the global markets in order to ultimately receive the majority of the fiscal spoils. And while the revenues from this industry might not be widely spread, the susceptibility to the outside market will be felt by workers at every level; changes in global pricing related to palm oil could easily devastate tens of thousands of workers (Fromm 12).

Increased agriculture also intimates more fertilizers, pesticides, and other inorganic chemicals being introduced into the environment. Contaminated runoff as well as less recharge due to more rainfall being used for plant nourishment intensifies the nearby animal and human susceptibility to polluted or scarce water resources (12). The long-term effects and gravity of palm oil biomass and biodiesel production on the surrounding ecological conditions should not be undervalued and will be discussed in more detail in chapter four.

Chapter Conclusion

Palm oil and its many diversified products have deeply rooted historical and modern day significance on a global scale. The substantial positive and negative facets involved in the cultivation of this industry compel careful analysis as they do fit into much broader and complex concerns regarding prudent water use and recharge, environmental protection, and the heavy reliance upon virtual market prices for the success of this monoculture crop. In addition, it is evident after examining the growing, harvesting, and re-planting of African oil palms, these aspects are only considered to be part of the initial, if not requisite, phase in the sector's true capability. It is the potential to manufacture a "green" alternative energy, a solution to the world's growing petroleum extraction in the form of a readily available agricultural biofuel feedstock, that is driving Honduran crop expansion with little heed to the possible economic, social, and ecological consequences.

CHAPTER 3:

PALM OIL BIODIESEL

Chapter Overview

In an era dominated by concerns over global warming and environmental degradation as well as international political and economic uncertainty, the subject of alternative fuels is generating strong controversy. This chapter analyzes the promises and realities of the global biodiesel industry before examining the production, use, and policies involving palm oil as a biomass and energy feedstock unique to Honduras. Finally, the chapter concludes with projections of the possible outcomes of the Sula Valley's biodiesel endeavors in a local context with special attention given to regional water realities.

An Investment in the Future

The massive expansion of African oil palm cultivation in Honduras is not simply an investment in agriculture, but rather a venture into an industry ultimately aspiring to replace the international demand for fossil fuels. This is a serious step for any nation, much less one still utilizing firewood to generate 43.9 percent of its total consumed energy as recently as 2006 (Personal Interview 3 Jul. 2008). Nevertheless, Honduras is committed to the emerging bioenergy commerce and now is the only country in Central America to approve laws for both ethanol and biodiesel production (Gomez 1).

Despite the many advantages of this new, eco-friendly source of power, alternative fuels also exploit a wide range of natural resources, and its toll on water is becoming increasingly publicized. The current global water demand for agriculture is forecasted to double due to the biofuel industry in the upcoming years, and this massive change in necessity and usage patterns could exacerbate already worsening food and water scarcity issues (Farago 2007). Biodiesel's heavy reliance upon water resources is especially critical to take into account in the northwestern Sula Valley region of Honduras as growing populations and industrialization are already stressing the existing groundwater and aquifer resources. To evaluate the inherent tradeoffs associated with biofuel production and its environmental implications, however, it is essential to determine exactly what immediate and long-term advantages biodiesel offers to the ongoing quest to reduce global warming and international overindulgence in petroleum.

Biodiesel's Potential

Common reasons cited in favor of the biofuel industry include the opportunity to reduce dependence on oil and gas, national energy security and independence, the augmentation of commodity prices for farmers, thus supporting more rural employment, and the reduction of net emission of carbon dioxide to slow climate change (Varghese 2007). Since 27 percent of the anthropogenic carbon emission can be directly attributed to transportation alone, alternative fuels appear to be the easiest and most immediate way to reduce the human "footprint" on the Earth (Holzman A248).

As a replacement for petroleum diesel, biodiesel has remarkable environmental benefits. In addition to the eradication of unsustainably extracting fossil fuels, biodiesel made from cooking oil reportedly emits 87 percent fewer greenhouse gases than its conventional counterpart. An 80 percent reduction in these emissions can routinely be expected from biodiesel made from palm oil produced on plantations established before 1990 ("Study proves palm oil biodiesel emissions are 80% lower" 2006). Hydrocarbon emissions running on 100 percent biodiesel are 67 percent lower than petroleum and the release of carbon monoxide and particulate matters proves to be 48 percent less ("Biodiesel Helps Reduce Harmful Engine Emissions" 2007). Finally, this alternative type of alternative fuel produces no sulfates when burned and therefore could prevent 99 percent of acid rain ("Biodiesel Helps Reduce" 2007; Personal Interview 3 Jul. 2008).

Biodiesel Characteristics In order to truly be considered as a possible replacement for petroleum, biodiesel must demonstrate comparable performance. It contains 88 to 95 percent of the energy as regular diesel, but is also 30 percent more fuel efficient than both gas and ethanol, which mitigates the slight loss of power in terms of the consumer's best interest ("Biodiesel" 2008; Ellison 2007). While generally blends of biodiesel and petroleum in varying amounts are used for everyday transportation fuel, any diesel engine will run on pure biodiesel with slight or no modification. This represents a crucial aspect in biodiesel's international viability, as it does not require any major technological overhauls before its application, thus making it widely accessible to all consumers presently using fossil fuels. The main two disadvantages of biodiesel are actually quite similar to those of regular diesel: long-term storage can lead to oxidation of the product and freezing or coagulation occurs at relatively high temperatures ("Biodiesel" 2008). Palm oil biodiesel's pour point of 54 degrees Fahrenheit is caused by elevated levels of Methylpalmate, a characteristic which can either be overcome through additional processing or passing the fuel along a battery for heating purposes to ensure that fuel injection systems do not become blocked (Jessen 2007; Personal Interview 3 Jul. 2008). In addition, both of the problems can typically be solved with chemical additives ("Biodiesel" 2008).

Global Demand and Production Worldwide production of biodiesel from 2005 to 2006 was about 792 million gallons (3 billion liters), rising to an estimated 977 million gallons for 2006 to 2007 (Hancock 2005). However, the global market for 2016 is anticipated to reach 37 billion gallons, indicating the average rate of demand will grow around 42 percent annually for at least the next seven years (Sims 2007). The United States' biodiesel industry alone multiplied from 25 million gallons produced in 2004 to 250 million gallons in 2006. Over 100 refining plants are currently under construction around the country including a one controlled by Chevron that will fabricate 20 million gallons of biodiesel a year (Ellison 2007).

What is responsible for this unprecedented explosion of the biodiesel market? Nations around the world are instituting mandatory biodiesel blend requirements in order to reduce their oil consumption and carbon emissions. A leading giant in biofuels, Brazil passed a progressive initiative to require all diesel to contain B2 (or 2 percent biodiesel) by 2008 and B5 (a blend of 5 percent biodiesel) by 2012. Even with the expansive agricultural lands dedicated to biomass feedstocks, the Latin American country's demand for biodiesel will far outweigh their possible supplies (Johnson 2005). Similar bioenergy laws are cropping up around the globe; India wants 20 percent of their diesel use to be replaced by biodiesel by 2012, and the European Union and China want 10 percent and 15 percent of their supplies, respectively, to be biodiesel in the year 2020 ("Palm Oil" 2007). In short, it is reasonable to assume the biodiesel production market will only increase in value and international magnitude in the next several decades, adding to its perceived benefits for small or developing nations to join the production boom now.

Palm Oil: A Biomass and Feedstock

Palm oil is, by far, the most efficient terrestrial feedstock for biodiesel production. As demonstrated by Table 2 comparing the amount of oil yielded by each crop, palm oil is over 13 times more efficient than soy bean in terms of oil harvested (Addison 2001).

Table 2: Feedstock Comparisons: Oil Yields

CROP	Kilogram / ha	Liter / ha	U.S. gallon / acre
Soy Bean	375	446	48
Rapeseed	1000	1190	127
Jatropha	1590	1892	202
Palm Oil	5000	5950	635

(Addison 2001)

Overall production expenditures for palm oil biodiesel are approximately US$0.66 per liter, or 35 percent more expensive than petroleum diesel as the process of converting palm oil biomass to biofuel adds an additional cost of US$0.14 per liter. Comparing the fiscal expenses alone, palm oil biodiesel should not exceed US$0.48 per liter in order to remain competitive with regular diesel; however, the public may demonstrate a higher willingness to pay due to its "green" value, thus eliminating the need to change production techniques to cut the bottom line (Chisti 2007).

Palm Oil Extraction The transformation of small, red oil palm fruit into biodiesel able to power vehicle engines consists of two main processes: extraction and transesterification. While the technology and equipment to extract the palm oil ranges from rudimentary to extremely advanced, the overall procedure undergoes universal stages of production as described below after observation of these methods during fieldwork in the Sula Valley.

The first two steps of extraction process include the reception and weighing of the African oil palm fruit as it arrives by truckload. The crop is inspected for fruit that is either under-ripe or overripe before the producer is paid by weight minus any incurred penalties.

Sterilization is the third stage in production and begins as fruit is piled into large horizontal caldrons reminiscent of small railcars and rolled into extended pressure cookers. The objectives of this stage include loosening the fruit from its fibrous bunch, de-activating the acids found within them, and softening their outer shell. In addition, the cooking technique conditions the internal kernel or nut for later processing and decomposes the mucilage, or sticky compounds, that prevent the colloidal matter from forming in future clarifying stages.

Still extremely hot from sterilization, the fruit is separated from its bunch by tumbling in a large rotating drum in the fourth step of extraction. Due to centrifugal force, the vegetation and fibers rises to the top of the barrel and the fruit can be easily collected from underneath.

The fifth phase, or the digestion stage, lasts for twenty to twenty-five minutes, and the oil palm fruit is steamed and mashed until it becomes a homogenous paste. Breaking down the biomass also detaches the internal kernel and ruptures the cells so that oil is released. The newly creamy substance is pressed through a perforated surface to wring out the liquids.

The sixth step in the extraction process is that of clarification. Since the liquid from the previous stage is actually a mixture of water, oil, cellular residue, fiber material, dust and other impurities, it must go through several stages before it can be purified into a final product. First passed through a sieve to remove the larger particles, 50 percent of the fluid's oil content is captured while the remaining solution is then poured into a ninety cubic meter tank to separate into oil and water over time. After mechanically skimming out the oil, purification tanks eliminate any remaining solid contaminants. Since water was added to the liquid in the initial stages of the process, especially during steaming, vestiges of humidity still exist in the oil; therefore, the fluid is exposed to extremely high temperatures to evaporate any lingering water particles during the drying procedure.

After dehydrating the oil, it is officially a finished product, ready to be shipped out or stored (Extracción de Aceite de Palma Africana). Crude palm oil is rust-colored and opaque in nature, so additional processing is required to refine it into cooking oil, which becomes transparent and slightly yellow like other vegetable oils thanks to a powder chemical additive (Flores 2008).

The remainder of the liquid that was siphoned off during the first six stages still has a 5 to 8 percent oil content, so it is put into large tanks to once again allow centrifuge to separate the oil and water. Any oil is piped back into the clarification process while the water is released into canals called *florentinas* where heat allows remaining triglycerides to rise to the top and be skimmed off until the water has less than 0.05 percent oil content. The water then flows into oxidation ponds.

The seventh "*Palmisteria*" stage of extraction involves the rest of the oil palm material that is not made into crude oil. Using pneumatic equipment, the nut is separated from the fiber with highly pressured gas. After the outer shell of the fruit's core is pulverized, and the center kernels are amassed together while the particles from the leftover fibrous bunch, or *cáscara*, and the crushed nut casings are collected to be used in the eighth step for production energy.

Stage eight is the generation of power through burning the remaining solids as tender (Extracción de Aceite de Palma Africana). Since palm oil fruit are ¾ solids and ¼ liquids, processing the substantial material requires most of the energy needed in the entire extraction process (Flores 2008). The utilization of the surplus material to generate enough steam to maintain the necessary 300 psi required to run the turbines and cooking process reduces the amount of energy needed from outside the plant.

Meanwhile, the kernels or *almendras* are either stored for shipment to other processing areas or immediately undergo a similar extraction process. The cores are ground up and pressed for oil while the remaining particles are finely milled until they reach a flour-like consistency to be sold as an additive to animal feed.

The ninth and final stage of the extraction process is the treatment of the effluent, and the prevalent technology in the Sula Valley to complete this cleansing process is called biogas. Biogas technology uses biological organisms, mainly anaerobic bacteria, to enhance the quality of the water before it is released back into the environment (Extracción de Aceite de Palma Africana). Both Palcasa and Jaremar began employing this technique in the Honduran case study after local inhabitants and international organizations protested the massive water contamination that was occurring as the companies were not treating the effluent in any way before releasing it into the ecosystem (Maldonado 2008, Flores 2008).

The biogas wastewater decontamination begins as residual fluids from the *florentinas* pour into large cement basins where they are cooled to at least 104 degrees Fahrenheit in order to ensure the bacteria's survival. Anaerobic organisms decompose the organic materials left in the water and releases methane gas, which is then collected, stored, and later burned to produce 1.26 Megawatts of electric energy using two 633 kilowatt/hour generators. This first phase in the procedure improves the effluent by 85 percent. Next, the wastewater is moved to oxidation ponds with aerobic microorganisms such as algae and bacteria for further quality restitution. After cooling down and passing through six other filtration ponds, the water is discharged into the surrounding area (Extracción de Aceite de Palma Africana).

Transesterification After crude palm oil is successfully extracted from the oil palm fruit, it must also undergo transesterification, a chemical process in which three fatty acid molecules are esterified with a molecule of glycerol, in order to become a source of fuel. In other words, triglycerides found in the palm oil react with methanol to produce methyl esters, commonly known as biodiesel (Chisti 2007). Regardless of the feedstock, either animal or vegetable fats, combining 100 percent oil with 10 percent glycerol during transesterification results in two products: biodiesel (100 percent) and glycerin (10 percent). The quality of the biodiesel produced in this chemical reaction is dependent upon the quality of the original feedstock as well as the quality of the technology, but after the chemical processes is complete, several stages of "washing" are still necessary to obtain a usable product void of leftover contaminants. Such impurities include glycerin or soap residue, remaining oil or methanol that did not fully react, and any traces of water that remain between washing cycles (Personal Interview 3 Jul. 2008).

Honduras and Palm Oil Biodiesel

If the biodiesel industry is as successful as its rapid expansion and international acceptance indicate, the current expectations regarding its vast profit-making abilities should also be greatly surpassed. Honduras is capitalizing on its ideal climate and agricultural conditions along the coast to cultivate palm oil and join the new biofuel commerce; however the Central American nation is interested in benefits far surpassing solely the potential economic returns.

First, Honduras does not possess any oil or gas reserves to tap for its own domestic use and has historically paid the highest prices in Central America for the importation of its fuel. Utilizing biodiesel produced within its own borders would not only eliminate the nation's total reliance on foreign oil supplies—invaluable in its own right—but could also prove to be 10 percent cheaper than buying petroleum diesel (Carson 2006). In order to demonstrate the feasibility of using domestically produced palm oil biodiesel to its own population, the government launched a biodiesel pilot program in the public transportation sector in 2006. Beginning in September of that year, between 500 and 600 public buses in the major cities of Tegucigalpa, La Ceiba, Comayagüela, and San Pedro Sula started using a 5 percent biodiesel blend, which rose to a 10 percent biodiesel mixture in November and to a 20 percent biodiesel-diesel combination starting in January of 2007. The program successfully proved not only that palm oil biodiesel was a favorable diesel replacement but also that local, Honduran-owned corporations including Hondupalma and Dinant which had been supplying the biodiesel, were capable of participating in the industry and producing a quality product (Starkman 2006). To replace the nation's entire diesel demand with palm oil biodiesel, original calculations from several years ago estimated that the total oil produced from 300,000 hectares for biodiesel purposes alone would be required to fill the petroleum gap. Sacrificing such a large amount of agricultural land for palm oil production seemed impractical to many people at the time given the environmental implications of expanding the cultivation to such a level, but others argued in favor of this extension since it would only dedicate 2.67 percent of Honduras' total land area for oil palm growth (Personal Interview 3 Jul. 2008).

The second benefit that Honduras stands to gain by participating in the biodiesel industry is becoming a major political and economic player in the hemisphere and possibly the world market. Although there is significant support for using palm oil biomass for biodiesel due to its high oil yield as previously indicated, 93 percent of the global supply is already earmarked for use in the food business (Kouchoukos 2). The rise of palm oil biodiesel would therefore require massive new production areas, and very few regions around the world are capable of growing this product due to weather and soil conditions. Honduras' new international importance could forever alter many of the existing economic and social circumstances in the developing nation, if done correctly, catapulting it into a new era of prosperity and development.

Finally, exporting Honduran biodiesel manufactured from palm oil could also attract major foreign technological investment, increasing economic development, job opportunities, and technical knowledge and education for workers. In 2007, 30.3 percent of Honduras' economic growth was attributed to the agro-industrial sector, an accomplishment mainly caused by the increasing palm oil commerce (Banco Central de Honduras 12). Such notable successful expansion coupled with the extremely high global market prices for palm oil is likely to appeal to many multinational corporations interested in establishing their own claim in the biofuel industry. In addition, as palm oil biomass must first begin with fruit production, the agricultural development inherent in this industry would provide many new rural jobs in addition to the technical ones mentioned above. Each new hectare of African oil palm planted directly creates 1.5 jobs and indirectly generates 2 jobs (Gomez 9).

Current Palm Oil and Biodiesel Production Between 2000 and 2007, the production of Honduran palm oil increased 115 percent with a 500 percent increase in palm oil exports. As of 2007, the national production of this commodity topped 300,000 metric tons from 100,000 cultivated hectares (5; 3). Looking towards future expansion, the government has identified a possible 440,000 additional hectares of land that could be used for African oil palms, a possibility discussed in detail in the second chapter.

Of the recent 300,000 metric tons of crude produced in the nation, 15 percent was refined into biodiesel and the remaining 85 percent was processed into oil for cooking or use in other products. In total, 200,000 metric tons of palm oil was exported out of the country, 60 to 70 percent of which was purchased by Mexico, 30 to 40 percent of which went to El Salvador with any residual amounts being shipped to either Guatemala or Nicaragua. Although Mexico is currently dominating Honduras' palm oil exports, the nation is interested in importing three times its current amount, paving the way for a lasting market and local buyer for Honduras (5).

Promotion of Biodiesel in Honduras The use and production of biofuels, specifically palm oil biodiesel, is strongly promoted by the Honduran government and has been encouraged through three separate programs or projects over the last three years.

This first major endorsement of biodiesel by the Honduran federal administration was a 2006 palm oil biodiesel initiative aimed at expanding cultivation, using more biodiesel, and creating new jobs related to the industry (Fromm 1). The specific endeavors of this plan entailed designating 200,000 hectares of land for African oil palm development, creating over 300,000 new jobs, producing 760 million liters of biodiesel, and saving an estimated US$370 million in fuel imports. Reducing dependence on foreign oil supplies and greenhouse emissions was also outlined in the benefits of the program. To jumpstart this strategy and create the necessary domestic product demand to support the palm oil industry's intensification, the government funded rural extension services by way of the extractors, funded farmer associations, imported over a million new Malyasian seeds and created the biodiesel pilot program in public buses (5).

The initiative was closely followed by “The Law for the Production and Consumption of Biofuels” passed in November 2007. The ministries of Industry and Trade, Agriculture and Livestock, and Natural Resources collaborated together to oversee the promotion, commercialization, and distribution of biodiesel by the creation of the Technical Unit of Biodiesel. Not only did the government create programs for the research and development of sustainable biodiesel feedstocks through a system of credits and promotions, but it also incentivized the transformation of these biomasses into biofuel (8-9). Funding was directed at enabling producers to buy equipment, materials, and services related to the construction and operation of biodiesel projects and will remain exempt from tariffs, customs, and other taxes for twelve years (9). Nevertheless, the government is not directly funding the existing biodiesel-producing companies in either the Sula or Aguán Valley (Flores 2008).

The Honduran government realized the third push for biodiesel development as it accepted funding from the Inter-American Development Bank. International lending institutions like the World Bank and IMF, organizations including the United Nations Development Programme, and transnational banks are widely supporting palm oil projects across the world as financing them has proved to be very profitable (Carrere 2006). As part of the Inter-American Development Bank’s Sustainable Energy and Climate Change Initiative to support energy efficiency and biofuels programs, the organization awarded Honduras US$350,000 from its Fund for Special Operations. The grant is intended to financially support investment plans, loans, and technical development studies all related to biofuels. It also includes several pilot programs directed at improving socioeconomic and environmental conditions to advance Honduras' competitiveness in the alternative fuel market ("IDB approves $350,000 grant to Honduras for energy efficiency and biofuel programs" 2007).

Biodiesel Production By Company Overall, there are about ten extraction plants operating in Honduras, five of which have biodiesel production capacity and produce such for individual corporate consumption (Gomez 1).

Dinant, the leading biodiesel and palm oil producer in the country has most of its agricultural growth on the east coast, near the port city of Trujillo. The biodiesel refinery and main extraction plant are also located in Trujillo, but a second extractor operates in the Sula Valley (Personal Interview 3 Jul. 2008). Processing fruit from a total of 23,000 hectares, Dinant exports 50 percent of the processed palm oil and retains the other 50 percent for use in its related industries, as discussed in chapter two (Gomez 6). The company was one of the two providers of palm oil biodiesel for the 2006 pilot program and the first corporation to begin biodiesel production in the nation. After purchasing the necessary refining equipment from the United States, Dinant first produced twenty metric tons of biodiesel per day in 2005 and 2006. Today, the company's daily production capacity is 120 metric tons, or about 37,500 gallons of palm oil biodiesel (Personal Interview 3 Jul. 2008). Using B100, or pure manufactured biodiesel, in its 244 corporate vehicles and equipment, the company saved US$3.7 million in fuel costs in 2006 alone

(Gomez 6; Personal Interview 3 Jul. 2008). While most producers would consider Dinant to be the most successful example of utilizing palm oil for biodiesel purposes, the company is now looking to diversify into cheaper feedstocks, such as jatropha, as government subsidies have not kept pace with world price of palm oil, thus reducing the corporation's ability to further invest in infrastructure and production to remain competitive at an international level (Personal Interview 3 Jul. 2008).

Hondupalma was the other company responsible for contributing palm oil biodiesel for the public transportation project. Based in the heart of the Sula Valley, Hondupalma can produce forty tons of palm oil per hour at its extraction plant, 200 tons of biodiesel each day at its refinery, and its fractionation plant, which separates different types of oil, has a capacity to process 100 tons of oil every day (Fromm 8). The 30,000 gallons of biodiesel produced each month is used to operate the company's machinery. Hondupalma is also considering the use of biogas technology to clean the effluent from its various facilities, but it is unclear what type of treatment, if any, it currently use on the contaminated wastewater (Hunt 2007).

The Jaremar Group, locally referred to as San Alejo, had an extraction capacity of twenty metric tons of palm oil per hour at the time of the interview. Of their total crude oil production, 20 to 25 percent is exported while 60 percent of their refined kernel oil is transported out of the country. This corporation already uses biogas technology, but a much more modern design that what was earlier described at the Palcasa facility, and was originally self-sufficient in terms of energy before the company expanded in recent years (Flores 2008). In addition, San Alejo finished the installation and testing of a biodiesel refining plant in late fall of 2008, but because it is not economically viable to produce biodiesel with the present global oil prices, the facility will not be used until conditions prove profitable. Due the short phase of initial testing, it is unknown the ultimate production capacity of this biodiesel refinery (Flores 2009).

The Palcasa cooperative extracts forty tons of palm oil per hour after recent expansion of their operating system. In charge of managing and working the first biogas system in the world in partnership with Eecopalsa, the group now extracts 500 tons of palm oil and purifies 500 tons of water effluent each day (Maldonado 2008). Although currently not producing biodiesel, the association is exploring the possibility of doing so with an estimated 30 percent of the palm oil (Hunt 2007).

The Drawbacks of Biodiesel

It is evident that palm oil biodiesel, as a source of fuel and a possible replacement for petroleum products, has many advantages over its conventional analogue, but like all other biofuels and feedstocks, it is only as beneficial to climate change and the environment as its production process. The preceding chapter discussed the 319 year carbon debt incurred by clearing tropical forest for African oil palms plantations, and critics of this industry proclaim that the "biodiesel industry accidentally invented the world's most carbon-intensive fuel" (Butler "Biofuels are worsening global warming" 2008; Carrere 2006). Environmental degradation can also be traced back to the biodiesel business and its prolific use of toxic, inorganic fertilizers and processing chemicals as well as other waste like plastic and metal debris, broken parts, and tires often dumped in open spaces (Vásquez, Gómez and Meneses 29). Nevertheless, perhaps the most severe and long-lasting effect that biodiesel can have on natural resources is the over-exploitation and contamination of large quantities of water.

Water Implications of Biodiesel in the Sula Valley Because of the incredible water-richness of the Sula Valley caused by significant and continuous quantities of rain, the agricultural production of palm oil biomass does not require irrigation. However, water contamination issues from both the growing and extracting process of biodiesel manufacturing will greatly stress the water quality in the region and nearby coastal reef. For every ton of crude palm oil extracted and processed, 2.5 tons of effluent is consequently produced, and the pollution of nearby surface and ground water is imminent without the enforcement of mandatory environmental and discharge regulations (Carrere 2006). The purification of wastewater through the biogas technology remarkably reduces the environmental harm of palm oil production to water resources as the dangerous chemicals are removed and the grey water is allowed to return to normal temperatures before released into the ecosystem. This method of purification, nonetheless, is relatively new in the Sula Valley and completely voluntary. Any producers unwilling to invest the capital to build and run similar facilities will only continue to worsen years of past contamination.

The other major way in which biodiesel production impacts water resources is by necessitating the extraction of sizeable freshwater quantities for the refining process. Bio-refineries in the United States have a consumptive water use ratio of one gallon water to one gallon biodiesel produced; however, with consideration to the overall requirements to operate the facility, that ratio increases to three to one (National Research Council 49). Since similar equipment used in biodiesel plants in Honduras were imported from the United States and Europe, comparable quantities should also be assumed for the Sula Valley. Since no wastewater or grey water can be used for transesterification as the water is needed to wash out contaminants, biodiesel refining results in the immediate and large-scale exploitation of subterranean water reserves. The possible consequences related to this extraction in the Sula Valley is described in the following chapter, but the general concerns over adequate supplies for human consumption are shared across the world. In the U.S., states like Iowa, Minnesota, and Nebraska are extremely worried that biofuel refineries are endangering water supplies and threatening human water security now and in the future (Beeman 2007).

To put biodiesel and its water requirements into perspective, it takes about 43 liters of water to produce a liter of petroleum diesel. This may seem like a substantial amount, but in comparison, one liter of ethanol demands 4,000 liters of water and one liter of biodiesel consumes 900 liters of water over the entire life cycle of production (Yang 2008). The impacts of the extraction and refining processes of biodiesel and their overall water necessities on the natural environment should not be overlooked.

The Future of Biodiesel

The strong presence of biofuels in the global commodity market appears to be guaranteed for at least the next several decades and can rightfully be classified as a good investment for Honduras in terms of long-term demand and profit-making opportunities, especially as palm oil belongs in many diversified markets other than simply alternative energy. One potential threat that could restrain the industry as a whole, however, is the emerging criticisms over biofuel feedstocks driving up world food prices. Some nations are beginning to denounce the use of agricultural land for biomass production as well as protest its deep effect on food values in worldwide commerce, declaring it unacceptable for such products to further inhibit poor nations from being able to buy sufficient food quantities for their citizens (Dunphy 2008). If food prices continue to rise, there could be a backlash against all biofuel feedstocks despite the fact that palm oil is not directly edible.

In addition, more and more nations around the globe are becoming conscious of the ecological impacts that the growing and processing of biodiesel impress upon the environment and are consequently considering banning products that are "unsustainably" produced. While no laws have been passed yet, the European Union in particular is drafting bills to ensure only purchasing biofuels generated from crops that can prove a minimum level of greenhouse gas savings throughout their processing life cycle (Butler "E.U. may ban palm oil biodiesel" 2008). For a nation like Honduras, which is promoting the clearing of natural landscapes for increased cultivation, the threat of such measures could prove to be disastrous to its palm oil industry. In truth, however, while biofuel production should have a positive net impact in terms of the release of carbon and total energy requirements for the sake of the environment, mandating certain standards could be unrealistic at this time. With large nations such as the United States, China, India, and Brazil, as well as many others, all insisting on progressively higher blends of biofuels with petroleum sources for public use in the upcoming years, the demand for biodiesel will dramatically climb across the globe. Nevertheless, even today the world cannot produce enough alternative fuels to satisfy the current demand, and in the future, supplies will be increasingly inadequate as the rate of biofuel fabrication will not be able to keep up with rising need. In short, demand will far outpace supply, and putting restrictions on modes of production will only further reduce biofuel availability on the market, making widespread use impossible. Perhaps this situation will be vastly improved by “third generation” feedstocks such as grasses, stovers, and algae, but even these promising alternatives are still very much in the stage of research and development. In addition, it should be noted that while biofuels are not a new product, their feasibility and public interest at a global level is a modern phenomenon. Therefore, as the negative carbon impacts result from the initial clearing of land, strict standards will be much harder to meet at this time, especially for small producers in developing nations expanding agriculture, than in the future once the industry has truly been established.

Biodiesel Scenarios in the Sula Valley Based on fieldwork and literature reviews concerning the global as well as local palm oil biodiesel industry in the Sula Valley, three likely scenarios are proposed with regards to the potential future or fate of this Honduran industry.

First, if the international biodiesel industry continues to “boom” in the world market, Honduras could enjoy lasting profits. This would justify the nation’s significant technological and agricultural investment in African palm oil as well as profoundly benefit the economy, perhaps elevating Honduras to a new, higher level of general prosperity. However, over time, the domestic production would be expected to drastically decline as the nation's water supplies became increasing scarce and over-polluting, disabling competitive rates of biodiesel fabrication.

Another possible situation that could arise is the decline of the world's market demand for biodiesel, and industry prices for palm oil will correspondingly drop. Although a "bust" situation would be unlikely to occur due to the ever-growing demand for foods processed with palm oil, specifically in the Asian markets as previously discussed, Honduras would be forced to branch out into new types of export commodities (Kouchoukos 2). Agricultural production would remain in some areas while older plantations with larger trees would likely be cleared for use for another product.

Finally, a third possible scenario is that the industry continues to grow at an explosive rate across the world and the international demand for palm oil continues to escalate; however, Honduras would be pushed out of the global market by high production costs. Without proper capital available to the Honduran companies to expand their production, they will not be able to afford the necessary amplifications to processing and refining palm oil biodiesel in order to participate at a global level, as it is a very expensive process with many startup expenditures. After all, just because the country may have the capacity to produce biodiesel does not mean it will be successful on a large scale; the Honduran government must extend fiscal support to the domestic corporations to ensure their ability to join the global trade. Due to the high palm oil prices and possible lack of internal money available then, the nation could be inundated with transnational corporations interested in either purchasing or heavily investing in these operations. While this would bring desired foreign investment and technology to this Central American nation, Honduran corporations would no longer control the profits nor would the revenues be re-invested in other local industries. In short, instead of Honduras becoming a major player in the international biodiesel market, it would merely become part of another export-based economy dominated by foreign business.

Chapter Conclusion

The long-term benefits of palm oil biodiesel on global climate change are debatable; however, after investigating the overall financial investment as well as the extraction and refining processing involved in fabricating this type of biofuel in the Sula Valley of Honduras, it is indisputable that the industry will result in lasting, detrimental environmental effects, particularly on water resources. The severity and social consequences of these impacts will be explored in the next two chapters, but the potential profit of the palm oil biomass and biodiesel industries will come at a serious price.

CHAPTER 4:

GLOBAL AND LOCAL WATER REALITIES

Chapter Overview

Although this case study concerning palm oil biomass and biodiesel production in the context of water quantity, quality and privatized resource management entails conditions specific to the Sula Valley in northwestern Honduras, it is by no means unique to what is occurring with water, its exploitation, and its impending crisis on a global scale. Tragedies of epic proportions concerning water accessibility and rights are already in motion, and now exacerbated by globalization and climate change, they will only grow in number and severity in every corner of the world. This chapter demonstrates the connection between transnational water dilemmas and those found in San Pedro Sula, Honduras by exploring the current and future natural and man-made trends related to and dependent upon this changing critical resource.

Liquid Essential

It is insufficient to say that a water crisis merely looms in the future because right now the world is at a definitive turning point, and water resources are shaping its modern and forthcoming social, political, economic and ecological realms. By the year 2025, at least 2.6 billion additional people will inhabit the earth, and the need for water will exceed its availability by 56 percent (Clarke and Barlow 2004). Just five years later in 2030, 50 percent of the entire global population will be confronted with “severe” water shortages (Yang 2008). As 97.25 percent of the world’s water resources are found in the oceans, a mere 2.75 percent remains as freshwater resources. However, as the majority of this is currently in the form of ice caps and glaciers, only 0.70 percent of the Earth’s total supplies are generally available for human exploitation. Groundwater constitutes 0.68 percent of overall water aggregate, and even though it is hard to imagine that rivers and streams represent only 0.0001 percent of the water on the globe compared even to the 0.005 percent of it as soil moisture, it is not difficult to understand the perils that these reserves of freshwater face in the twenty-first century (Sachs 117).

Water is the key to human life, both directly and indirectly. Not just depended on by the human race for explicit consumption and the growth of food, industries are also hinged upon its abundance, making it a vital aspect of economic development and the most important strategic resource for financial expansion (Varghese 2007). The upcoming decades of increased globalization and climate change will only highlight the inherent contradiction that water poses as both an essential to human life and the world’s most valuable commodity.

It is imperative to realize just how inter-connected the different components of the global water system, including individual actors, physical cycles, and biological and biochemical realities, really are (Pahl-Wostl 51). Water symbolizes “hydrological interdependence” while maintaining “pervasive spillover effects” on a global scale; that is to say, water use in one area affects the water in another region (Sachs 115). In fact, twenty nations around the globe receive more than 50 percent of their water from neighboring nation-states (130). As societies in every part of the world are using more water at a faster rate than ever before, countries need to unify for comprehensive action regarding water resources for more than just for reasons of environmentalism; avoiding potentially serious trans-border violence is paramount (121). In fact, the conflict in Darfur began between Arab nomads and African farmers as competition increased for grazing land and water rights due to long-term drought and desertification, eventually expanding into a full-blown racism-based genocide (Yang 2008).

But water issues embody more than just the physical liquid and the ease of its use. They are part of an intricate web of factors that determine power structures, stability, and prosperity as well as matters of life and death (Ingham 2009). Across the continents, 3.575 million people die of water-related disease each year, 84 percent of whom are children from the ages of 0 through 14, and 43 percent are ultimately caused by simple diarrhea. Almost all of these deaths, 98 percent of them, are in the developing world. Not unrelated, statistics show that the poor living in slum communities often pay five to ten times more per liter for water than the wealthy living in the same city ("Water Facts" 2009).

Changing Water Realities

A major problem reinforcing the global water problem is a lack of understanding about how water is recycled through Earth's natural processes. Usually as schoolchildren, people are taught that the hydrological system is a closed one with the same amount of water, in varying forms, being rotated through an infinite loop of evaporation, precipitation, and recharge. Rarely discussed, however, is how much of that water is rendered unusable, most often due to contamination, or how the cycle can be disturbed by over-exploitation and water harvesting (Clarke and Barlow 2004).

Water vapors from both land and oceans rise and cool into the atmosphere during evaporation, and then are carried over long distances through wind currents, eventually condensing and returning to the Earth as precipitation. As a significant amount of water is transferred from oceans to land, the balance of the hydrological cycle depends on water from the continents returning to the oceans, either immediately as surface runoff or over a long period of time if the water infiltrates the soil and becomes part of a groundwater system that eventually empties back into the sea (Sachs 118).

The problem, then, lies not within the hydrological system itself, but rather with the fact that the quantity and availability of freshwater resources radically varies throughout the world (118). The current situation is even more precarious because the water realities that humans have depended on and utilized for centuries are now changing due to a myriad of reasons. The following analysis of why and how these new water circumstances are manifesting themselves around the globe is not inclusive by any means, but rather it is intended to acknowledge some major natural and human factors that are altering the use and accessibility of water resources.

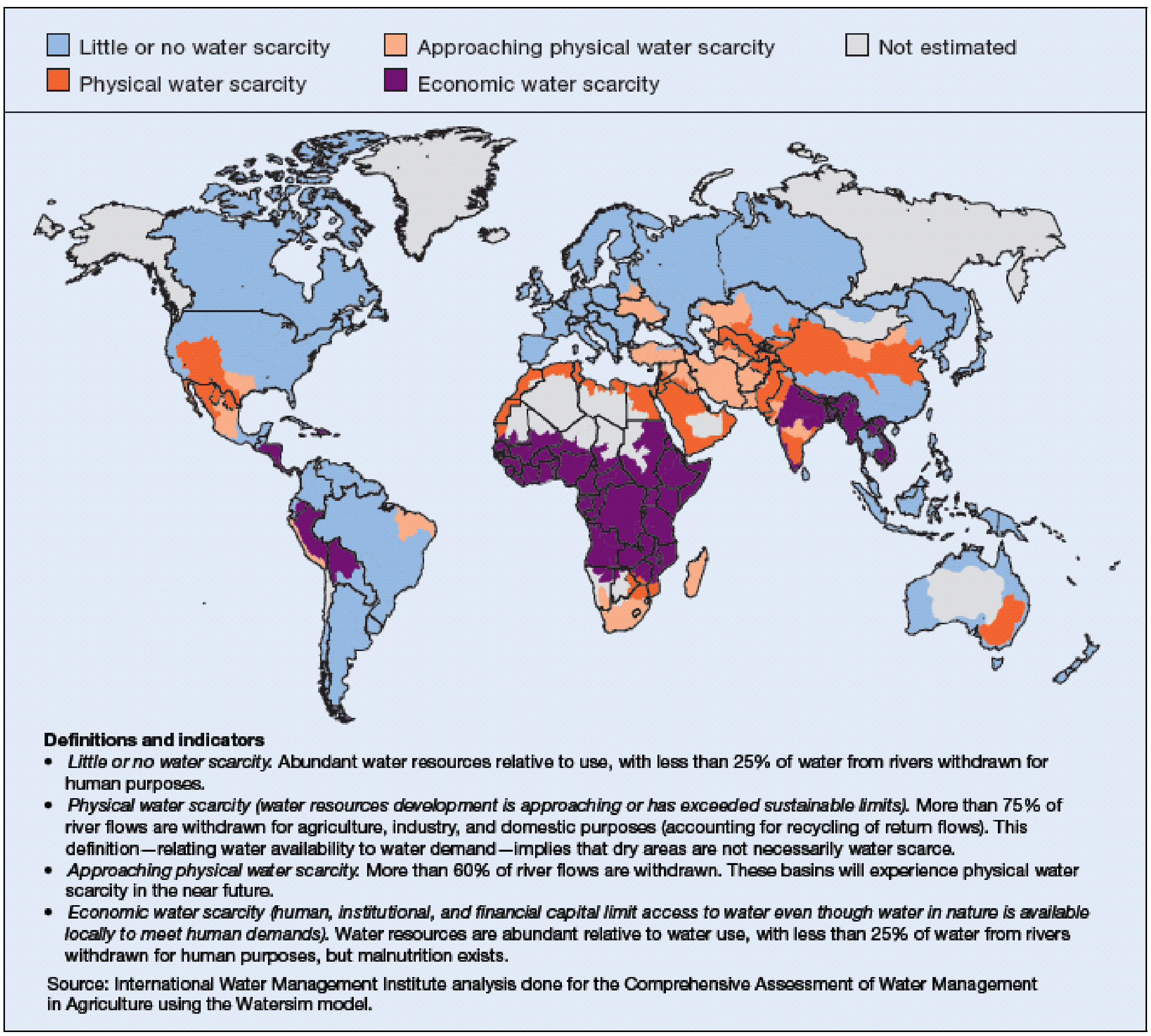
Desertification The proportion of global land classified as enduring "very dry" conditions increased from 15 percent in 1970 to 30 percent at the beginning of the twenty-first century (Sachs 125-126). There are many causes to desertification, some of which are related to climate change as discussed later in the chapter, but others can certainly be attributed to the careless overdraw of water resources for irrigation and industrial needs. Regardless of the causes, nonetheless, societies—and particularly women in many cultures around the world—are being forced to adapt to the disappearance of local water needed for daily household and agricultural needs.

Access to Drinking Water Access to clean, drinkable water includes issues of both actual water supply and the ability to afford such resources. As of 2007, there were 2.8 billion people worldwide facing water scarcity. More than 1.2 billion, or 20 percent of the world's population, lived in areas of physical water scarcity while the other 1.6 billion were confronted with economic water scarcity and the inability to financially develop or obtain water despite the adequate natural supplies. Aspects of water accessibility also include a lack of fiscal assets, human capability, and good governance and management practices (Molden et al. 62).

Deficient capital will also represent a major challenge for the maintenance of drinking water infrastructure and accessibility in the future. Between $92.4 billion and $148 billion are needed each year around the world for investment in the upkeep and construction of systems of water supply, sanitation, and irrigation (Ingham 2009). Furthermore, the anticipated global population growth will not ease the demand or the cost for water infrastructure and services expansion.

While most analyses quantify the estimated population which has access to drinking water supplies according to statistical information regarding service hook-ups or the proximity to and use of wells—basically the constructed networks or man-made means by which water is delivered—it is important to recognize that often what these sources of drinking water are providing are, in fact, not fit for regular consumption.

Figure 1: Areas of Physical and Economic Water Scarcity



(Molden et al. 63)

Contamination, poor piping systems and leaks, a lack of water treatment, and the absence of service reliability are just a few ways in which "drinking" supplies translate into more water-related vulnerabilities.

Growing Population The Earth's population is growing by 80 million people a year, and the subsequent annual demand for water is escalating by 64 billion cubic meters, or about 51.9 billion acre-feet (Ingham 2009). Shifting concentrations of people from rural to urban centers only further intensifies the water-related issues springing up from the on-going population explosion. As of 2008, 50 percent of worldwide population was living in cities, and while the future population trends are still uncertain, some models predict that only 40 percent of the world will be residing in rural areas by the year 2030. Furthermore, the United Nations estimates that almost all of the population growth occurring in the next 21 years will not only be in urban centers but those located in developing nations (Sachs 27).

This phenomenon will drastically impact the ever-growing stress on existing water infrastructure and services provision in regions already lacking sufficient financial as well as physical resources to ensure adequate and clean water to its citizens. The main question for many of these cities will be: Where will the additional water come from? Often with regards to changing water realities and the issue of population growth, the manner in which humans directly influence the terrestrial water systems receives far less attention than some of the indirect demands (Vörösmarty et al. 284). The dependence on pumping out groundwater resources for future supplies will only worsen the water scarcity conditions in the long run.

Changing Production Demands on Water In addition to global population growth, the other main factor contributing to water stress and vulnerability in the twenty-first century is economic development (285). This is manifested in several ways, but most commonly through new production demands on water resources related to large-scale agriculture. The world and its many industries, particularly crop growing, are using more water in different ways than ever before, resulting in the rate of per capita water consumption to double every twenty years (Clarke and Barlow 2004). Agriculture has accounted for 70 percent of the world's surface water use compared to just 10 percent consumed for household needs, and consequently, irrigation is also responsible for 70 percent of the world's water pollution (Sachs 116; Johnston 135). These trends, however, have been firmly established for many years, so what is the difference now?

First, there are more industrial, non-food types of agriculture severely over-taxing water supplies around the world. Non-native yet extremely profitable species continue to be exported and planted in regions not equipped to handle the vegetation's appetite for water. Eucalyptus, native to Australia, is being grown around the world and in developing nations such as India where it quickly strips away soil moisture and strains groundwater resources (Shiva 4). Bamboo is another common example of this type of intentional plant invasion that results in major water issues in many countries, despite this crop being planted under the guise of being "eco-friendly" as a wood alternative for cutting down traditional forests.

Second, with the increase of humans around the world, more agriculture for the requisite food demands should also be expected; more significant than the total gross production of food, nonetheless, are the modern-day human consumption patterns. Improved economic development around the globe has resulted in wealthier populations able to buy diverse foodstuffs, particularly meat and dairy, which have a large indirect water footprint due to animal feed considerations (Molden et al. 78). The consumption of fruits, vegetables, and animal products have increased the global per capita daily intake from 2,400 to 2,800 kilocalories from 1970 to 2000, leaving water resources struggling to keep up—all this without even the inclusion of the more thirsty genetically modified crops (58). Water extraction from rivers, lakes, and aquifers has tripled in the last fifty years in order to meet the food demands of the world and its increased buying power (Ingham 2009).

In the future, both industrial and food-related agricultural production demands on water will result in some important environmental and social aspects. Currently, about 80 percent of the water used in agriculture is still green water, or rainwater stored in soil moisture, but more blue water, or that from other surface or groundwater sources, will have to be utilized in the upcoming years to satisfy the global water needs (Molden et al. 67-68). This increased reliance on blue water will indubitably raise the costs associated with water provision on every level, taking a toll on the poorest populations first. The increase in raw food prices in the midst of the growing dairy and biofuels industries, which increased 22 percent from 2007 to 2008 alone, will further perpetuate the stratification of social classes as well as economic water scarcity and the ability to obtain adequate amounts of basic nutrition (McMullen 2008).

International Water Trade The transnational trade of commodities, both agricultural and industrial, is resulting in lasting changes to regional water systems around the world through the exportation of virtual water (Chapagain and Hoestra 19). Virtual water, or the volume of water required to produce a commodity, thus remaining effectively embedded in it, is a relatively new factor considered in national water security and scarcity issues, but one of vital importance (20). Studies now indicate that 16 percent of worldwide water use is for generating products for export, and this is only likely to increase with continued global trade liberalization (29). Whether these commodities and industries are historic to the region or represent more of a forced commerce, like that of the fresh flower production in developing nations, entire routes of economic trade will be affected by lessening water supplies. International water dependences are no longer simply in the form of raw water resources such as shared water tables or river runoff, but rather are now borderless (29).

Over-exploitation and Recharge In many parts of the world, people are simply pumping out more water from aquifers and rivers than is sustainable, simultaneously creating an imbalance between water removal and recharge and endangering the reliability of future supplies (Sachs 122). Moreover, as resources are harvested beyond their physical limitations, the quality of the water can also rapidly decrease as the concentration of foreign particles, contamination, or salinity levels rise in proportion to the smaller water quantities in which they are found.

Contamination Pollution is rendering even areas of abundant water resources into situations of shortage. Generally speaking, it takes very low quantities of contaminants to pollute large bodies of fresh and salt water, and it is exceedingly difficult and costly to remove these contagions from the water supply, much less ensure they are not re-introduced back into the environment during their disposal. Industrial toxic waste is an overwhelming international water issue as is contamination from agriculture including nitrates and phosphates found in fertilizers, both of which have insufficient degrees of regulation around the world. Humans are a third major source of water pollution; 85 to 95 percent of sewage in developing nations is returned to coastal regions and rivers untreated (Sachs 124).

Commoditization Water realities are forever being changed as prevailing capitalist perspectives are redefining water not as a natural resource, but as a valuable commodity. The commoditization of water has developed in two distinct, but equally profitable, manners: the bottled water industry and the privatization of water services.

The bottled water industry is a water crisis in and of itself; not only is it selling a product (usually no different than what comes out of the tap) at ruthlessly trumped up prices, but it has also cemented a cultural affinity to “specialized” water as a vogue, generating and rationalizing untold environmental damage from water extraction, water table destruction, and un-recycled plastic waste. Five international food and beverage giants—Nestlé, Coca-Cola, Unilever, Anheuser-Busch, and Danone—guzzle enough water each year, almost 575 billion liters, to satisfy the entire planet's daily water needs ("All Bottled Up: Nestlé's Pursuit of Community Water" *i*). Nestlé, controlling 19.2 percent of the global bottled water market with sales amounting to $9.93 billion in 2007, is the world's largest purveyor of bottled water and operates one hundred such plants in over thirty-eight nations (*i*-2). Forty-nine of this Switzerland-based corporation's total 481 factories are operating in areas considered to be "extremely water stressed" (1). Coca-Cola, another major player in the bottling business, has faced increasing scrutiny on a global level due to its draining entire areas of their water supplies. In 2000, a bottling plant was set up in Plachimada, India, and in less than seven years, the company had succeeded in completely depleting the underground aquifers in the region and polluting the scarce remaining water supplies so that the entire region's livelihood dependent on agricultural production was ruined (Varghese 2007).

As the idea of water shifts towards being a private good rather than a common property, many free market proponents are declaring the privatization of water services, another manner in which water accessibility is commodified, as the only (and more efficient) substitute for the bureaucratic management of water resources and sewage (Shiva 19). Increasing water demand for public consumption will present substantial challenges in the future as the economic costs of staggering proportions will have to tackle issues such as infrastructure, construction of new treatment facilities, water pricing mechanisms, technology, and overall administration of service. After all, the provision of drinking and waste water duties will involve not only locating, exploiting, and transporting additional water resources to urban areas, but also ensuring that is clean enough to minimize health problems, the latter being the biggest issue in water-rich developing nations (Vörösmarty et al. 287). Most governments around the world, in both developed and developing nations, will find these costs to be overwhelming, if not downright impossible to meet. Corporations that take control of all aspects of water services will only have increasing bargaining power in the upcoming years among the domestic political bodies with which they work. More issues and water realities with regards to privatization will be discussed in the next chapter.

Global Climate Change and Water Impacts

The line between global climate change and water issues is indistinguishable. While the world begins to realize the extent and gravity of the existing water crisis, with its many manifestations as described above, climate change will only act to accelerate problems of water quantity, quality, and service provision with no nations being spared from the effects, regardless of wealth. The book *Water Wars: Privatization, Pollution, and Profit* best summarizes the connection between these two concurrent phenomena by saying that the "impacts of climate crisis on all forms of life is mediated through water…" (Shiva 40). The changes in rainfall, evaporation, and water flows are not temporary in nature, but rather demonstrate the beginning of a systemic alteration of water actualities that will endure to some degree regardless of any action taken now to mitigate the effects of global warming (Sachs 89).

Climate change is most closely associated with the effects of carbon emissions and greenhouse gases in the atmosphere, resulting in changing temperatures which, in turn, bring about intensified cycles of evaporation and precipitation (125). The process of evapotranspiration, the combination of evaporation and transpiration of water through the leaves of plants, will increase with rising temperatures and lessen the amount of water available for human and agricultural use before becoming water vapor (89). Shifting precipitation patterns are expected to make dry regions even drier and wet, equatorial areas even more wet with shorter and additionally intense cycles of rain. Needless to say, stronger storms and higher levels of vulnerability are subsequently expected as well. In fact, there is already evidence of global warming creating natural disasters with magnitudes previously unseen in history. In 1999, a super-cyclone hit the eastern Indian state of Orissa and killed around 20,000 local inhabitants and 300,000 cattle, damaged 1.83 million homes, and contaminated or salinated an estimated 15,000 water sources (Shiva 39). This natural disaster was set apart from its predecessors as the super-cyclone's wind speed was recorded at over 260 miles per hour, an astonishing number compared to the average wind speed of 73 miles per hour with past cyclones. Some scientists point to this as just one of many examples of how natural disasters are no longer simply "natural" but greatly influenced by changing climatic conditions fueled by industrialization and deforestation (43).

Finally, rising temperatures and differing precipitation and evaporation will also work together to reduce water security in areas directly and indirectly affected by rapid glacial and buffering snow melt. These increasingly common water-thawing occurrences on land, especially in mountainous regions, result in immediate flooding with long-term drought and agricultural destruction. Any significant melting of polar ice bodies into the sea will not only be catastrophic for populations living in coastal regions due to rising water levels, but the escalating oceans will contaminate 40 percent more of the potable reserves with high salinity concentrations than estimated in the past (Oberman 2007).

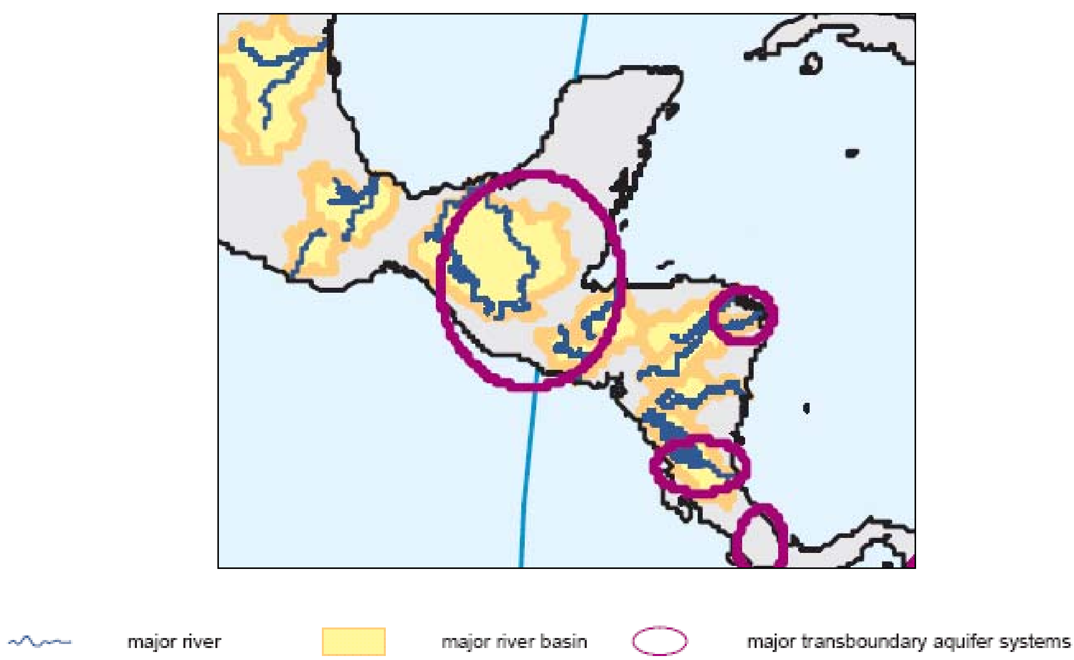
Honduras: Water Today and Tomorrow

Honduras' water situation will invariably be transformed by global climate change and new conditions brought about by different rainfall, temperature, and weather patterns. Main industries including agricultural, livestock, fishing and manufacturing will be perhaps most greatly impacted by the nation's precarious geographic location with regards to natural disaster and its vulnerability to intensifying storms, especially in the coastal regions. However, Honduras is already facing serious water issues today. The country as a whole is incredibly water-rich, maintaining six times more water per capita than all of Europe, yet 1.5 million Honduras, or about 13 percent of the population, still do not have access to potable water (Cross 2006; "Millón y medio de hondureños sin agua" 2008). This section of the chapter will discuss in detail the water realities of the Sula Valley and San Pedro Sula in northwestern Honduras in order to depict the complex set of potential problems in the area that will potentially jeopardize their future water security.

Water in the Sula Valley

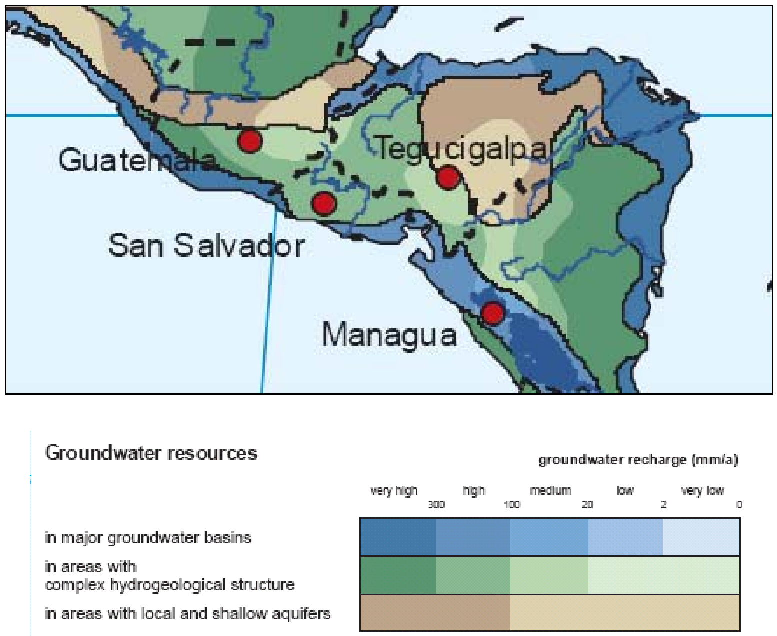
The Sula Valley represents a very unique area in terms of water resources. The region is both part of a critical transboundary aquifer system and major river basin as well as the location where three different classifications of groundwater resources meet (see Figure 2 and Figure 3). The Merendón mountain range is one of the primary sources of water for the country of Honduras, and the main supply of freshwater for the city of San Pedro Sula, which is located the at the base of these mountains (Baide "Pronostican escasez de agua para el año 2040" 2009). Now a protected area, the Merendón reserve

Figure 2: River Basins and Transboundary Aquifer Systems in Sula Valley



(River Basins and Transboundary Aquifer Systems 2008)

Figure 3: Groundwater Resources in Sula Valley



(Groundwater Resources of Central and South America 2008)

constitutes 40,000 hectares of land that include nine principal water basins, fifty-three sub-basins, and 213 micro-basins of freshwater (Meza 83). Two major wellfields, the Chamelecón and Sunceri, are also located in these protected lands (Meeroff 2). The Santa Ana, Río de Piedras, Bermejo, Río Blanco, El Zapotal, and the Manchaguala rivers all flow from the Merendón Mountains and are used for surface water by the city of San Pedro Sula, but since the water arrives enriched with organic minerals, particular iron and manganese, it requires significant treatment to remove the consequent taste and orange-brown coloration (Saldañas 2008; Meeroff 2).

The Sula Valley is said to be the most monitored area in all of Honduras due to its population density, climate vulnerability, and industrial importance, contributing close to

50 percent of the nation's total GDP, although such supervision is not highly apparent in the majority of this region. However, because it is part of the Mesoamerican Reef (MAR), which extends over 1,000 kilometers on the Mexican Yucatán Peninsula, Belize, and Honduras coastlines, some international groups have taken specific interest in trying to preserve this area's extremely diverse and rich aquatic biodiversity (Vásquez, Gómez and Meneses 8). As previously mentioned in chapter three, a memorandum was signed between the World Wildlife Fund and regional palm oil producers to better protect this fragile ecosystem from harmful chemical runoff (Flores 2007).

Water in San Pedro Sula

During the fieldwork for this research, it became evident that the inhabitants of the San Pedro Sula and the Sula Valley were living in a socially constructed and cultural tradition of water abundance. Because of its location at the foot of the Merendón mountain range covered with tropical rainforest, San Pedro Sula experiences constant rainfall, even during the 'dry season' and maintains extremely high levels of humidity. In short, the region is perpetually green and seemingly always wet. Participants and interviewees living in this region were typically dismissive of the notion that the city could suffer water quantity shortages, as the only water concerns had always been based solely upon sufficient drinking supplies and water quality.

In January of 2009, however, this perceived water confidence was shaken when the local newspaper first reported that the director of the *Unidad de Concesiones* estimated that the city only had twenty years of guaranteed water supplies (García 2009).

Other reports, printed in the following months, revised this prediction, declaring that San Pedro Sula would face water issues in three decades without proper conservation measures and assuring the people that there was sufficient water for the next fifty years (Baide “Pronostican escasez” 2009). There was no discussion of what would occur for the city’s population after those fifty years. In truth, manifestations of water shortages have been already slowly emerging, and even now there are water shortages and availability problems at the water collection sites during the dry summer months of April and May (Saldañas 2008). It is critical to note that the calculations made about impending water crisis did not include factors outside the city limits, such as the palm oil industries that will certainly also impact water issues in the nearby city.

As an overview at an urban-concentrated level then, what factors are contributing to these newly discovered water quantity limitations? First and foremost, the city is consuming only 25 percent surface water and 75 percent groundwater to meet its daily water needs (Saldañas 2008). This is over-extracting and heavily exploiting the subterranean water resources that are fundamental to the possible longevity of sustained supplies for the city. In addition, there are several other factors that are affecting long-term water reserves including population growth rates, water usage, contamination, and reduced water recharge back into the environment.

Population Growth Based on the last municipal census taken, San Pedro Sula had about 800,000 citizens and 101,091 potable water users, or those hooked-up to the central water system. This represents a 50 percent increase in the number of city water consumers in just six years, otherwise equating to 30,000 new users (García 2009). The population in the city, due to its significance as a major industrial hub, has grown at a 5 to 7 percent rate annually and is expected to continue to do for long periods of time in the future (Meeroff 2). In fact, maintaining a 6 percent growth rate will result in the population reaching one million people in just two years, a significant milestone for a city in Central America that is not a national capital (García "Rebasamos los 800,000 habitantes en SPS" 2008). Although the privatized water services company, Aguas de San Pedro, maintains five treatment plants and wells that process four million cubic feet of water twenty-four hours a day, it has not been and will not be possible for the company to reach 100 percent service coverage due to this extremely high pace of population growth despite its contractual obligations to have done so within the first three years of taking over (Baide "Pronostican escasez" 2009; García 2009).

High Levels of Water Usage Many industrialized countries around the world, including the United States, consume on average 70 gallons of water per person per day, but the citizens of San Pedro Sula are using a hefty 120 gallons of water per person each day. That equates to an estimated 58 gallons of "wasted" water for every man, woman, and child for each twenty-four hour period (Saldañas 2008)! Due to the large amount of industrial plants and factories, the city has always used water at a higher rate than other regions; in 2000, San Pedro Sula was demanding 55 percent more water than Tegucigalpa despite its population of only 452,000 people. Nevertheless, during this time, citizens were also only consuming 66.5 cubic meters every day, meaning that their daily consumption has almost doubled in the last eight years along with the number of inhabitants (Meza 83). Aguas de San Pedro is relying on people to learn to conserve water resources, motivated perhaps through either pricing mechanisms and metering or general education, and have started to see some improvement as of 2008 with a reduction in wasted water which had reached levels as high as nine million cubic meters (Baide "Pronostican escasez" 2009). During this endeavor to reduce water consumption, however, indications of finger-pointing for the water usage rates have begun to materialize as Aguas de San Pedro has directly and indirectly implicated that the city's public do not value their water resources, resulting in their lack of care about conservation and the subsequent degradation of the water itself (Saldañas 2008). This may turn out to establish important precedent concerning relations during the initial stages of the thirty-year contract period by pitting the foreign corporation against the local citizens.

Contamination Most of the contamination that threatens San Pedro Sula's water supplies originates from factories that dump residue waste directly into the rivers, although these problems are compounded by a general lack of wastewater treatment infrastructure (Saldañas 2008). As recently as 2003, there was no treatment for wastewater collected in most areas, thus turning water sources downstream from discharge points into literal open sewers. All of major sources of surface water, including the Santa Ana, Bermejo, Piedras, Zapotal, and Chamelecón rivers are contaminated by a myriad of sources, everything from agricultural runoffs to industrial chemicals to mine tailings. Wellfields and aquifers are also polluted with untreated chemical discharge, high levels of minerals, and are not protected from open contamination from human or animal fecal matter at the sources of intake (Meeroff 4-5). The Chamelecón River alone immediately receives 80 percent of the city's *aguas negras*. With intentions to address the lack of sewage treatment, Aguas de San Pedro formulated plans to build cheap yet effective oxidation ponds in three different areas around the city, but those stalled when they experienced difficulty getting the lands appropriated by the municipal government (García "No hay tratamiento de las aguas residuales" 2008). The related petition to build a laboratory in town to test contamination levels instead of sending off samples to Tegucigalpa, and thus waiting for the results, also has not come to fruition due to the lack of financial support (Saldañas 2008). Of course, issues of contamination, whether by human or industrial polluters, represent not just a water-related problem but also human health concerns, which can be the difference between life and death, particularly for the elderly and the very young. Organizations in and around the region are looking to alleviate the major problems of contamination with increasing public concern and political involvement ("Millón y medio de hondureños sin agua" 2008). Aguas de San Pedro, too, is making clean-up progress as more protection for the Sunseri, Chamelecón, and Chotepe aquifers is underway as well as increased city planning considerations against promoting infrastructure developments close to the sources of water collection around the city (Baide "Pronostican escasez" 2009; García 2009).

Reduced Recharge As previously discussed in this chapter, the pumping of groundwater and aquifer resources has serious long-term implications. The removal of the water from many of these deeply located sources may never be compensated for by the infiltration of rainwater, and the unexpected drying up of these liquid storage areas can lead to volatile social desperation (Sachs 116). The lack of recharge near San Pedro Sula due to the overuse of groundwater is further intensified by rampant deforestation in the Merendón mountain range by communities dwelling in this protected area. Calls to remove these groups have fallen by the wayside as the economic and social costs are too high to enable their re-location, and few other solutions seem viable. As part of a social program, Aguas de San Pedro initiated the planting of one million trees in the Merendón, but this is only a very small portion of the action and re-planting needed to slow the ramifications of the deforestation on water recharge (Saldañas 2008).

Conservation in the Sula Valley Region

Conservation efforts for natural habitats and areas critical to major sources of water have spread across the Sula Valley. The nearby municipality of Choloma as well as the cities of Omoa and Puerto Cortés are working together to protect the Río Tulián area located about fourteen kilometers south of the coastline. As the basin and river flows have a superficial extension in an area of 46.7 kilometers squared, the communities have delineated its protection as a vital element in their assurance of long-term water supplies. Working to restore, conserve, and responsibly manage the Río Tulián through wise agricultural practices, forest restoration, and community education, the municipality of Puerto Cortés is accompanied by the Canadian government, the energy corporation Elcosa, and the Fundación de Desarrollo Muncipal and several other Honduran conservation organizations in funding this project (Cuenca del Río Tulián).

San Pedro Sula's conservation efforts are likely to endure many more challenges than its neighboring towns as the combined industrial and growth factors will hinder proof of any immediate headway made towards environmental preservation. Figure 4, Figure 5, and Figure 6 compare the possible outcomes for long-term daily water consumption with considerations to water demands and population. The first graph demonstrates a 5 and 7 percent population growth rate scenario, starting with a base population of 800,000, over the next twenty-one years assuming that water demands remain constant. Figure 5 then contrasts a 5 and 7 percent growth rate situation, again starting with a base population of 800,000, with a reduced rate of water consumption until 2030. This graph depicts the daily water demands of the population gradually reducing from 120 gallons to 70 gallons per person per day through about a 2 percent annual rate of reduction, a fairly optimistic endeavor considering historical water use patterns. Lessening water demands are assumed to be caused by either conservation efforts or rising prices. Finally, Figure 6 combines the first two models for easy comparison. It is evident that while water conservation efforts can certainly reduce San Pedro Sula's daily water intake over the next twenty-one years, the population alone will continue to significantly increase the overall demand. In fact, only a small difference in daily usage would be seen by 2030 with a 7 percent growth trend and reduced water demand when compared with a 5 percent growth circumstance without any conservation whatsoever.

Figure 4: Water Demand with Constant Consumption Rates

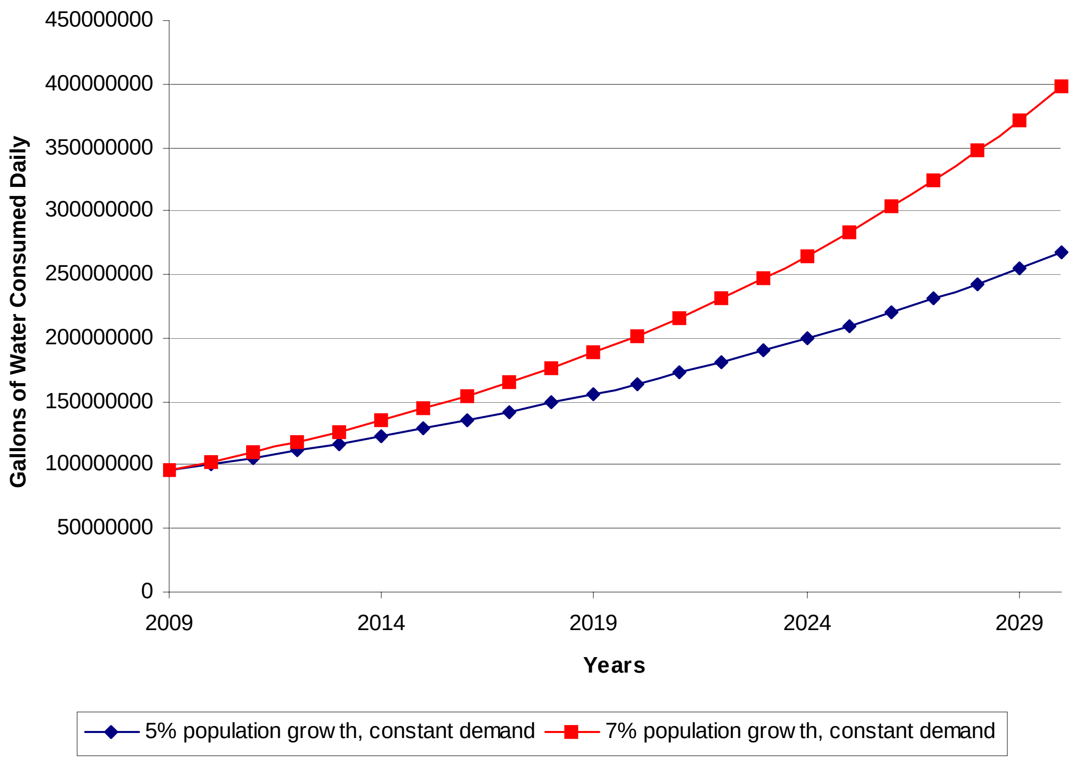


Figure 5: Water Demand with Declining Consumption Rates

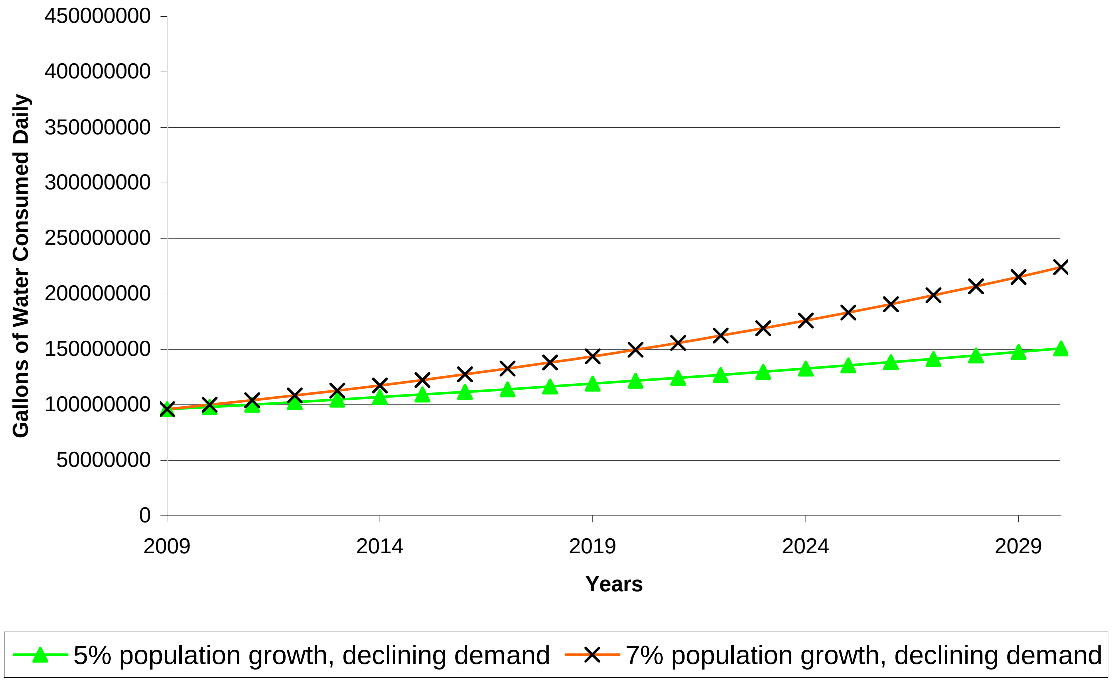
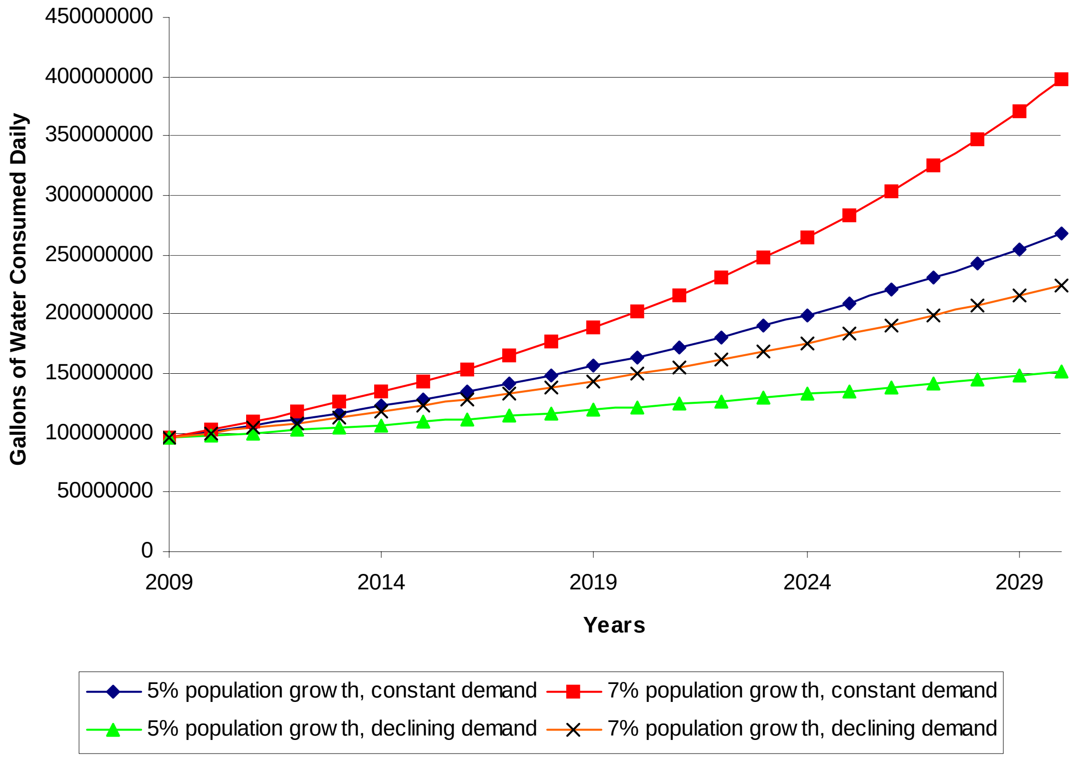


Figure 6: Overall Projected Water Demand



Chapter Conclusion

This chapter has given a broad overview of the current aspects involved with the global water crisis as well as those to be expected from climate change and the effects of warmer temperatures, rainfall patterns, and evaporation rates on water resources. The complex water realities of San Pedro Sula, Honduras and the Sula Valley cannot be properly understood without placing them into this larger context of what is occurring across borders and continents around the world. Physical water scarcity is often perceived as a problem in only very arid regions, but as this wet, tropical region is also suffering from diminishing supplies of this essential resource, it becomes evident how widespread and interconnected the global water crisis truly is. Palm oil biomass and biodiesel production create their own set of complications to the modern resource-strapped region while the privatized water services aspect, discussed in the next chapter, will also contribute specific intricacies that will test the political, economic, social realms as water supplies continue to dwindle.

CHAPTER 5:

THE COMPLICATIONS OF WATER PRIVATIZATION

Chapter Overview

San Pedro Sula and the Sula Valley may be demanding increasing quantities of freshwater supplies due to the expansion of the palm oil industries as well as population growth, but it is the city's internationally privatized water consortium controlling this precious resource that will actually determine the adequacy and quality of its future water supplies. This chapter discusses the global trend of water privatization and questions surrounding its validity, power, and long-term implications based on past and present-day patterns of worldwide management. The history, goals, and emerging role of the privatized company, Aguas de San Pedro, in northwestern Honduras will also be examined to better analyze what kinds of water challenges the area will face in the upcoming decades.

Undiluted Reality

Water resources that are privately owned or water services that are corporately operated do not, by any means, represent a new concept. However, the changing global water conditions coupled with present-day economic practices have created previously unforeseen opportunities for large, transnational companies to become sovereign decision-makers in water-related facets across political, economic, and social arenas.

Although climate change and drying conditions in different regions around the world affect people's accessibility to drinking supplies, often times even in the most dry of locations, water for households is determined less by sheer availability and more by infrastructure investments and their limitations (Sachs 116). That is to say, shortages are rarely just about the physical resources and always about who controls the allocation of the water.

But, of course, water is inherently more than simply a natural resource that humans' depend upon; it is a basic necessity, it is the key to economic and industrial development, and it is the single most decisive factor of human survival. Furthermore, while the presence of water is always important, the presence of other things within that supply is equally critical. People across every continent are forced to drink contaminated water because they usually lack the capital to purchase adequate and clean quantities, consequently suffering from debilitating diseases, bacteria, and parasites. There seems to have been a paradigm shift in this globalized world "from the idea of health as a human right to one that elevates economics as the determinant of health" (Whiteford and Whiteford 3).

Natural Right or Commodity?

The privatization of water, in its many forms, raises seemingly mutually exclusive ideas about economics and ethics, and the most debated question surrounding exclusive ownership and service continues to be: is water a human right or a commodity to buy and sell?

As a natural right, water privileges belong to everyone, cannot be owned by anyone or any institution, and embody usufructary principles which include enjoying the advantages of this resource without damaging or impairing its future use for others (Shiva 21). International grassroots organizations have proposed the Community Environmental Bill of Rights upholding the idea of "water democracy", or the right to clean water for all citizens. The nine principles of water democracy include:

1). Water is nature's gift.
2). Water is essential to life.
3). Life is interconnected through water.
4). Water must be free for sustenance.
5). Water is limited and can be exhausted.
6). Water must be conserved.
7). Water is a commons.
8). No one holds a right to destroy it.
9). Water cannot be substituted (34-35).

Identifying water as a natural right reflects the intangible values, such as its cultural and environmental significance, that it also symbolizes in addition to its role as basic human need. The commoditization of water, on the other hand, reduces its worth to a commercial value alone, and one that is determined by virtual markets and the trading of invisible money, stocks, and bonds (137).

The notion of water as a private property, following the rule of appropriation "*Qui prior est in tempore, potior est in jure*" (He who is first in time is first in right) is thought by some to have been cemented as "cowboy" truth in the Western world after the establishment of the mining camps in the United State's frontier (22). The fiscal merits of this vital resource on a transnational scale, nonetheless, have only increased over time;

in 2000, after the collapse of technology stocks, *Fortune* magazine named the water business the new most profitable industry (88).

Investment in the water commerce is not simply buying conventional property or direct water rights, but also encompasses water certificates, water-related hedge, index and exchange-traded funds as well as shares in water technology and engineering corporations, private water utilities, and international and investment banks (Yang 2008).

When discussing the privatization of water, there are three distinct manners in which water becomes privately commoditized. First, investors or corporations can purchase the actual rights to surface and ground water found in rivers, lakes, or aquifers in order to use, extract, or tap them as they see fit, effectively owning the water as any other raw material. The control of water utilities, or the contracted service provision of drinking and household water and sewage, is another way in which privatization occurs and is probably the most commonly discussed idea relating to the transfer of water from public to restricted control (Yang 2008). Finally, the bottled water industry completes the last component of the privatization ternary. Commoditizing water withdrawn from either natural resources or, 40 percent of the time, simply from pre-existing taps, companies sell their bottled product for 240 to 10,000 times as much as the price of household drinking water despite the fact there are no nutritional or purification advantages ("All Bottled Up" 17). The consumers, however, only feel these high costs. In McCloud, California, the Nestlé Corporation attempted to broker paying one cent for every 123 gallons of ground water, or $0.000018 per gallon, extracted and packaged in a newly-proposed bottling plant with the intention of selling it on the open market for

US$10.32 per gallon. The average price for municipal use in the state, obviously also heavily subsidized, is one cent per 40 gallons of water (*i*).

Yet, it is not just private utility companies and beverage giants buying the rights to water and water services. Wall Street, multinational banks and their corporate partners including Goldman Sachs, JPMorgan, Chase, Citigroup, Morgan Stanley, Deutsche Bank, HSBC Bank, Alinda Capital, and the Allianz Group are just a few examples of organizations that are aggressively investing in water and its related technology, services, and infrastructure industries all over the world (Yang 2008).

Privatization as a Neoliberal Policy

The policy recommendations known as the "Washington Consensus", based on the economic theories of Friedrich Hayek and Milton Friedman along with colleagues at the University of Chicago, were quickly endorsed by the two world powers at the time, Reagan in the United States and Thatcher in Great Britain. This set of principles was internationally applied across countries by global lending institutions, namely the World Bank and International Monetary Fund (IMF), and constituted fiscal discipline in terms of reducing public spending, tax reform, attraction of foreign investment with the reduction of tariffs, and privatizing many state-run industries. Rather than neoliberal policies denoting an era of deregulation, however, they launched a period of re-regulation by replacing absolute control of the market by single entities with rules that ensured a smoothly operating system of collaborative economic and political forces. These new regulations proved to be beneficial in some ways, like securing certain laws to protect the quality of production or universal environmental standards, but the majority of such appeared to dominate nations' sovereignty in a new wave of imperialism (Liverman 329).

Arguably, the most significant means by which corporations expanded their foothold in the international water market was through global trade agreements. NAFTA (North American Free Trade Agreement), GATT (General Agreement on Trade and Tariffs), and the World Trade Organization (WTO) all characterize water as a commodity, thus subjecting it to the same body of trading rules as other natural resources like oil and natural gas. This commoditization of water also results in the inability for nations to refuse or limit their exportation of this vital resource without repercussions enforced by the WTO (Clarke and Barlow 2004). Another global trade treaty, GATS (General Agreement on Trade and Services), was passed after international resistance to the originally proposed Multilateral Agreement on Investment (Shiva 96). In spite it being touted as a progressively "bottom-up" accord that gave nations more freedom to deregulate systems over time, it, too, undermines domestic democratic power as governments preventing the entry of free-market enterprises can be sued in international court (93).

The Inter-American Development Bank (IDB) is now the largest international lender in the Caribbean and Latin America, surpassing the World Bank's work in the region with cumulative loans of over US$136 billion and a yearly credit capacity of US$8.5 billion ("Going Thirsty: The Inter-American Development Bank and the Politics of Water" 1). From 1993 through 2005, the IDB provided a total of US$634 million for thirty-four different water and sanitation loans in Central America and the Caribbean.

Out of these money advances, 74 percent included privatization requirements and 47 percent stipulated consumer rate increases as “cost recovery” obligations (3).

It is imperative to understand the extreme power that privatization corporations gain when they are backed by international lending institutions and global treaties. The result of this alliance of neoliberal actors with free-market principles is typically significant liberty, if not contractual promises, for these companies to make a hearty profit from their investments. In Chile, part of the loan conditions agreed upon between the nation and the World Bank included a guaranteed 33 percent profit margin for one of the largest water privatization corporations in the world, Suez Lyonnaise des Eaux (Shiva 91). The twelve month operating period between 2006 and 2007 for Merrill Lynch’s ML China Water Index outperformed any historic benchmarks with a 102.2 percent profit return. Naturally, if the companies are making such staggering revenues despite the high cost of investments in technology, service maintenance, and infrastructure, it is the consumers who are literally paying the price. Once water resources are expropriated for private earnings, a new form of colonial-like control often occurs as powerful interests concentrate solely on financial development and forget about the seriousness of their commitments (Liverman 333). In 1995, the World Bank instructed the nation of South Africa to implement a “full cost recovery” dogma for all of its publicly run operations in order to generate satisfactory revenues in preparation for the eventual transfer of these services to privatized groups. “Full cost recovery” later became a staunch condition for all aid received from the World Bank, IMF and other lending organizations for the nation. Consumers suddenly expected to pay full price for their household water in 1998 were forced to spend upwards of 40 percent of their monthly income on this utility alone. Over the next several years, 10 million South Africans had their water services cutoff, 2 million lost their homes due to defaulted payments from their water bills and by 2002, over 250,000 citizens were sickened with cholera after utilizing any available water they could find (Johnston 146). The phenomenon of extreme jumps in water utility bills is not restricted to developing nations alone; citizens of the United Kingdom are dealing with increases in their water charges by 17.5 to 62.2 percent and, in the next five years, could be spending UK£1,000 per household each year (Yang 2008).

Of course, Friedman and his cohorts did not extend their scope on neoliberal economic ideology to specific examples involving the natural environment. With today's "green conscience" however, arguments are being made both in favor of and against privatization as a tool to help preserve the environment (Liverman 330). Proponents of private responsibility claim that privatization and even monetization of natural resources encourage their conservation and efficient development, rejecting Ostrom's suggestion that community groups can competently manage common resources (330; 333).

However, reduced state intervention may also lead to less legislation and enforcement of environmental laws. In addition, critics agree that the free-market cannot construe a high enough value for ecosystems, biodiversity, and the maintenance of natural resources (330). The neoliberal assumption that environmental quality can or will ever be properly indicated through investment interests is unrealistic since long-term sustainability has few immediate fiscal returns (332).

Water Privatization in Latin America

In Latin America, the implementation of the Washington Consensus' neoliberal policies not only included free trade agreements, curtailed public expenditures, privatization, and reduced labor and environmental regulations, but also coincided with strict democratic stipulations for national governments (Liverman 330). In short, as economic crises and toppling dictatorships gave rise to new governments in urgent need of financial aid, the IMF and World Bank were able to ensure privatized investments would be securely upheld by governing bodies that supposedly represented their people's interests. Nevertheless, water privatizations schemes in Latin America did not go accordingly to plan, and two different circumstances in Cochabamba, Bolivia and Buenos Aires, Argentina heavily influenced the rest of the hemisphere's reaction to such privatization suggestions, forever shaping public opinion against the neoliberal policy.

Cochabamba, Bolivia In 1999, the World Bank recommended that Bolivia privatize its water services in the city of Cochabamba, and by October of that year a concession was signed with International Water, a subsidiary of Bechtel, to create Aguas del Tunari. Almost immediately, the price of water utilities rose to about US$20 per month, and in a town with a minimum wage of less than US$100, the citizens were forced to choose between water and food. The local alliance *La Coordinación de Defensa del Agua y la Vida* was formed in January of 2000 and succeeded in shutting down the city for four days in protest of the new water situation, garnering support by residents across social classes. Within the next month, millions of Bolivians from across the nation marched to Cochabamba for a massive strike, shutting down all transportation in their wake. The Cochabamba Declaration, which proclaimed water rights to be universal, was penned during this time, and the Bolivian government promised to reverse the price hikes so that water would once again be affordable. Unfortunately, such pledges were not fulfilled, prompting Bolivians to orchestrate another peaceful protest demanding the repeal of the contract with Bechtel and the establishment of a new water resources law that would be written in conjunction with public participation. Once again, the government rejected the requests, so in April of 2000, yet another protest took place, this time resulting in martial law, the jailing of activists, the censorship of the media, and even death on the streets. Met with mounting international pressure, Bechtel and Aguas de Tunari were ousted from Bolivia on April 10th, 2000 (Shiva 102).

Buenos Aires, Argentina The nation of Argentina, also encouraged by the World Bank, IDB, and others, signed a thirty year contract in 1993 to privatize the water and sewage services of Buenos Aires through Aguas Argentinas, an international consortium in which the French conglomerate Suez maintained a 46 percent share ("Going Thirsty" 3-4; "As Suez packs up, the locals dive in" 35). Despite international organizations and multinational banks supplying 97 percent of the US$1 billion needed for the privatization program, Aguas Argentinas raised household utility rates by 88 percent from 1993 to 2002 although the national inflation rate only increased by 7 percent (Clarke and Barlow 2004; "Going Thirsty" 4). In fact, the company was receiving a 20 percent profit, triple that of the water schemes in the United States, United Kingdom, and even France at that time. To make matters worse, the corporations could not meet its contractual obligations, especially pertaining to treatment services, exemplified by seven districts in Buenos Aires that had water with nitrate levels too high for human consumption regardless of the reported improvements. The IDB stepped in with an addition loan of US$300 million in 1999 to enable Aguas Argentinas to reach 100 percent water connections and sewage treatment rates along with providing 95 percent of the city with sanitation hook-ups. The situation, however, grew worse instead of better over time, and the contract between the city and Aguas Argentinas was voided in late 2006 ("Going Thirsty" 4). Commonly speculated reasons for Suez's withdrawal of support included Argentina's President Kirchner's refusal to raise tariffs anew, the rejection of sharing some of the company's debts, and tougher restrictions on new investment programs ("As Suez packs up, the locals dive in" 35). Currently, a new water firm called Aysa, with 90 percent of the shares owned by the government and 10 percent by the workforce, is operating the quickly-abandoned service responsibilities, but Suez is still suing Argentina in international court for between US$19.5 million and US$32.5 million in unpaid bills and expenses ("Going Thirsty" 4).

Reactions to Privatization Failures These two case studies in Cochabamba and Buenos Aires depict some serious potential problems with the privatization of water services. Whether the resulting issues included governmental violence towards its own people during peaceful protest or an unexpected breaking of an international contract because of dwindling profits, the rest of Latin America paid attention. International lending institutions like the World Bank, repeatedly criticized for such happenings around the world, admitted to some inherent problems with forcing this type of structural adjustment onto a nation as part of their financial funding, but the general practice and encouragement of such has not substantially changed.

Central America's public as a whole is now staunchly against privatizing water in such a manner, and in the past when governments have be pressured to do so, mass protests have prevented similar privatization schemes to be enacted. However, these mobilizations still cannot solve the current and expansive problems with the existing water and sewage management. As recently as last year, 58 percent of the rural population and 13 percent of the urban population in Central America did not have access to water ("Millón y medio de hondureños sin agua" 2008). The governments simply do not have the capital, the technological knowledge, or the administrative specialization to replace and improve upon the existing systems. Instead, there are many instances in which local governments are allowing short-term water concessions to take place, but because these only last for periods of generally a year to three years, no serious investments are being made to enhance the region's water quality, delivery, or reliability. The lack of significant change in these necessary areas is attributed back to the companies, and a vicious cycle of blame is created, truly just delaying an inevitable water crisis. Also common is the denial that privatization is actually occurring in these instances, and even in the case of San Pedro Sula, some falsely conclude that it is not technically privatization unless the corporation owns the actual water supplies (Personal Interview 1 Jul. 2008).

All of these factors together make the privatization of San Pedro Sula's water and sanitation services that much more unique. One of the few examples of such in Central America characterized by a long-term contract, the city actually proactively invited the private bids with the hopes that their dire water situation would improve with outside participation.

Water Management in Northwestern Honduras

Understanding the water and sanitation systems and who controls them in several of the cities in the Sula Valley is critical in order to also comprehend their importance in terms geographical context and economic implications.

First, San Pedro Sula obtains its water from the extremely important trans-boundary Merendón aquifer, as described in chapter four. The city's patterns of extraction, use and consequent contamination are all passed downstream, eventually emptying into the Atlantic Ocean; therefore, the entire Sula Valley, in terms of both agriculture and human use, will be directly impacted by San Pedro Sula's water situation and private decision-making.

Secondly, although a thirty-year privatized water contract is extremely unusual in the region of Central America, San Pedro Sula is also flanked by several other cities that are approaching water management in alternative ways. Choloma, a city known for its large number of multinational maquila factories, flanks the outskirts of ever-growing San

Pedro Sula and now maintains a public-private arrangement with regards to its water services. The important coastal port city of Puerto Cortés also has a “mixed capital” company called Aguas de Puerto Cortés that was set up by the residents in 1994 after Hurricane Gert left the area, built barely above sea level, with polluted and salinated water supplies and leaking sewage tanks. The municipal administration petitioned the national government for the transfer of the water and sanitation rights to the city itself and received money from the United States Agency for International Development (USAID) to begin their own operation of the water system. Puerto Cortés retained the rights to all physical assets and now leases them to the company for service purposes; in turn, Aguas de Puerto Cortés pays rent back to the city in order to finance the infrastructure and original loans while an independent body ensures water obligations are being met. This tactic towards water services seems to be working effectively despite the city initially doubling the water rates and warning its inhabitants that the costs will keep pace with any inflation in the future (Constance “Service worth the price” 2004). In fact, Aguas de Puerto Cortés is actually expanding their potable water services by almost twice the current infrastructure. The municipality is funding the development in conjunction with the World Bank, which pledged US$30 million beginning in 2009 (Ejecturarán nuevos proyectos de agua” 2009).

In summary, the three cities of San Pedro Sula, Choloma, and Puerto Cortés are all operating water services that are either entirely privatized or partly so and heavily dependent on outside fiscal support from international institutions. They all are also located in one of the most important economic regions in Central America. The main highway alone that connects Tegucigalpa to San Pedro Sula to Puerto Cortés has received a total of US$80 million from the IDB since 2004 in order to link the political capital, the economic headquarters, and the only deep-sea port in Central America ("IDB approves $30 million for main highway in Honduras" 2007). It can be concluded that a significant amount of outside interest, investment, and financial leverage is already occurring in the Sula Valley and will only increase if the palm oil industries continue to be successful. However, as the economic potential for this region can only come to fruition with adequate amounts of water as well as proficient services for inhabitants and workers, the impending repercussions of the success or failure of the privatization scheme in San Pedro Sula should not be underestimated for either the region or for international lending bodies.

Water Privatization in San Pedro Sula

This section of the chapter will discuss the history, contract obligations, strengths and weaknesses of the water privatization scheme in San Pedro Sula, Honduras. The case study is particularly interesting not only because of the city's importance in terms of its economic role for the nation and its rapidly growing population, but also because its water supply is so closely yet seemingly invisibly tied to the palm oil biomass and biodiesel industries.

History San Pedro Sula's publicly run water and sanitation services were reasonably successful until the mid-1980s when the population began to outgrow the existing system, especially exacerbated in the early 1990s as the boom of maquiladora industries attracted tens of thousands of workers to the region. The management of these services was said to be brought to a point of collapse as "political interference" to efficient management included overstaffing, the refusal to raise rates to cover costs and growing inflation as well as mounting debts. The municipality is said to have owed US$42 million with another US$150 million needed for capital investments for the future decade (Constance "Glass half full" 2004). After the widespread effects from the Hurricane Mitch disaster in 1997, the municipal water agency, DIMA, decided to begin the process to solicit private responsibility for the services (Meeroff 3). In 1999, the city received a grant from the Multilateral Investment Fund, a member of the Inter-American Development Bank Group, in order to hire officials and prepare for the concession process.

Wishing to ensure the entire process was conducted with "integrity and openness", the Municipal Transparency Commission was founded and constituted representatives from civil society, the university, the Catholic Church, labor unions, and the Dutch consul in Honduras (Constance "Glass half full" 2004). Citizens of San Pedro Sula also claimed in informal interviews during the fieldwork that a large, wealthy Honduran sugar corporation offered to privately operate the water system, but that the municipality refused, wanting to award the contract to an international corporation. It was not clear during these conversations if the city rejected this offer because they wished for outside, unbiased participation in the new privatization scheme, or if they were interested in the large amount of funding available from several international organizations and banks that were supporting this privatization endeavor.

Three international consortia made formal bids for the water and sanitation services contract, and the municipality awarded the concession for 2001 based solely upon the lowest estimated tariff. The winning group led by Acea, the company which controls the water and sewage system for Rome, actually proposed rates that were lower than the public system's at that time (Constance "Glass half full" 2004). In addition, the IDB approved a loan to Aguas de San Pedro for expansionary purposes in the amount of US$13.7 million in 2002 with a promised US$42.2 million for the company over the following five years. Concurrently, the IDB also approved another US$36 million in loans to the city of San Pedro Sula for general development projects ("Water Utility Loan" 2003).

Aguas de San Pedro (ASP) began making immediate improvements with repairs to pipelines and new wells, but the utility rates also began to rise. Since the public water services agency had been reluctant to increase prices for many years despite the mounting inflation, citizens were paying less than US$2 per month for over 20,000 liters of water—while others without installed meters were using even more water while still only paying the baseline cost. According to the signed contract, ASP was authorized to charge the customers the true cost of the water with semiannual adjustment capabilities for inflation. Furthermore, after operating for two years, the company was also allowed a single 20 percent tariff increase (Constance "Glass half full" 2004).

Contractual Obligations The total coverage area of San Pedro Sula included in the privatization contract was 837.6 square kilometers, or about the size of Dallas, Texas, 25 percent of which was considered urban in 2001 and 75 percent which was rural ("San Pedro Sula Due Diligence" 2001; Meeroff 3). When ASP undertook the public duties in 2001, an estimated 85 percent of the city had water hookups and about 65 percent of the population had sewage services. By the end of the third year of the contract, 100 percent of the population were required to not only have water services, but also enjoy twenty-four hour availability and strong water pressure. Sewage coverage was expected at 100 percent by the end of the sixth year, and 25 percent of the connections were supposed to have some form of treatment. Overall, the value of the entire water and sewage system was agreed upon to increase in value by 50 percent by the eighth year and 85 percent by year ten, maintained at these standards for the remainder of the thirty-year contract (Meeroff 3).

Unfortunately, due to the city's 5-7 percent sustained population growth and high demands on water, sanitation, and treatment services, ASP has been rendered incapable of meeting all of its original commitments (2). Although it claimed to have reached 100 percent water coverage throughout the city, many neighborhoods still lack the proper number of hookups, and sewage connections are increasingly lagging behind the city's growth with little waste treatment in most of the region. In fact, the main focus of the sanitary network is to simply remove the effluent from residential areas. It is then released back into nearby rivers or canals at approved discharge points, thus contributing to the major contamination in the region discussed in the previous chapter (4).

The obvious failure to fulfill these contractual promises did not go unnoticed by the people, and tense relations between the company, the government, and the public peaked in February 2006 when the Bloque Popular movement led a mass protest. Made up of twenty different domestic organizations formed to protect Honduran water, Bloque Popular denounced ASP for their inability to realize their contractual agreements. The protest was also staged to rally against the municipality's protection of the company's actions as ASP retained the ability to raise tariffs or even possibly devalue the currency in order to make certain that costs were covered ("Graves denuncias contra empresa privada de agua en Honduras" 2006). Although some disapproval of the company's policies remains even today, the citizens now generally accept the presence of ASP as some improvements have been made and the price of water remains affordable.

Current Projects by Aguas de San Pedro The privatized water consortium is currently maintaining eleven groundwater extraction wells including the Chamelecón and Sunceri wellfields, surface water collection facilities from the Santa Ana, Piedras, Zapotal, and Manchaguala Rivers, and three wastewater treatment plants (García 2009; Meeroff 2). ASP is also continually replacing underground piping and infrastructure around the city, as the existing network is outdated, crumbling, and sometimes even contains lead and other contaminant buildups. However, the new underground pipes that are being laid only have an estimated service lifespan of about twenty years, which could pose significant re-construction costs in the immediate future for the city ("Baide "En marcha cambio de tuberías en el centro" 2009).

In terms of future goals, ASP planned to reach 50 percent wastewater coverage for San Pedro Sula sometime in 2009, but current reports indicate this will not be achieved due to disputes over land appropriations, incoming population, and a tight budget. In fact, the ASP costs are continuing to mount as the city expands, and now even the indirect costs of wastewater treatment alone for both household and industrial waste is at least US$4.1 million (“García “No hay tratamiento de las aguas residuales” 2008). It is unclear what will occur during the end of the contract, but if both parties agree, it can be renewed for an additional ten years after the current thirty years are completed (San Pedro Sula Due Diligence” 2001).

Success and Failures The water privatization scheme in San Pedro Sula has been a successful endeavor in many ways as well as one with unremarkable and even alarming results with consideration to other aspects of the original stipulations. Although it appears that the opposing outcomes have balanced out due to ASP’s continued uncontested operation in the city, it is essential to analyze the present-day consequences in order to better anticipate possible issues that may arise in the future.

First, a significant and undeniable achievement by ASP is the increased number of water connections throughout the city. While 100 percent coverage may never be reached, the company was able to install more hookups than the public utility was able to achieve with over 10,000 new households receiving water in the first few years (Constance “Glass half full” 2004).

In addition, the overall water service quality, as well as that of the natural resource itself, has vastly improved under ASP's command. Despite the lack of comprehensive wastewater treatment facilities in the city, the proportion of drinking water undergoing proper purification rose from 22 percent to 80 percent, and now there is reliable pressure and service around the clock (Constance "Glass half full" 2004). The public utilities, DIMA, had not been able to promise continuous water since the early 1990s, after which water often flowed from taps only a few hours of the day, a few days a week (Meeroff 3).

Finally, ASP has been noteworthy for keeping down its prices. In spite of initial increases in water tariffs, the rates are not only still affordable for the widespread public, but are also some of the cheapest prices in all of Central America. Tegucigalpa's water, still publicly run, costs 50 percent more than that of San Pedro Sula's as of 2004 (Constance "Glass half full" 2004).

With respect to some of ASP failures, the company inherited several significant hardships that made vast improvement of the water system that much more challenging. First, the existing pipelines and infrastructure in the majority of the city was over forty years old; the cement network was even sporadically collapsing upon itself in some districts. The entire system for the 1,202 customers living in just the Fesitranh community had to be replaced for a total of cost US$4.2 million for the twenty kilometers of new water pipes and sixteen kilometers of sewage ducts (García "Colapsado el sistema aguas de la Fesitranh" 2008). In short, ASP could not simply build upon the previous infrastructure, but rather had to replace everything in addition to constructing brand new treatment plants and additional collection sites. However, as previously mentioned, the new pipelines replacing their archaic counterparts don't appear to be of durable quality as they are only expected to last around two decades, so questions surrounding ASP true commitment and investment level with these new changes could reasonably be raised as well.

The historical presence of poor pipes and unclean water also put ASP at a disadvantage because the citizens don't have confidence in tap water for drinking purposes. There were several incidents during the first several years after the takeover in which citizens claimed the water was not potable and received massive media attention as the situation escalated to the public even rejecting lab results, believing them to be doctored by the industry. Buying bottled water for consumption needs, while its relatively cheap in Honduras, still adds up to a large annual expenditure in a nation where close to 50 percent of the urban population lives on about US$2 a day (Constance "Don't drink it!" 2004). The reluctance to accept and use the tap water certainly perpetuates an attitude of distrust towards the internationally-privatized corporation, and this sentiment is further conveyed to even outsiders as hotel guests are immediately given bottled water with which to brush their teeth. Naturally, the population has a right to be guarded about their drinking supplies as they do not know if the water being piped into their homes is traveling through new or old networks, and any contamination can greatly impact their overall health or economic security, but the wariness to consume water in even the most basic of ways further ostracizes ASP from the local community.

Another area of contention for ASP and the public was the installation of water meters. The city never invested in regulation at the household level for water use before the privatization scheme, so initial resistance was fomented by many families experiencing exorbitant bills due to leaks and wasted water when ASP formally took charge (Constance "Glass half full" 2004). Although such issues have long been resolved, people are still suspicious of water metering and ASP receives monthly reports of the meters somehow being tapped into and robbed, thus lessening supplies and driving up prices for others (Pineda 2008).

The final hardship that contributed to the reduced effectiveness of Aguas de San Pedro was delays in service expansion due to remnants of bureaucratic control. Not only did the company face inaccurate maps and information as to the exact whereabouts of pipelines and system infrastructure, but it also was forced to undergo long governmental reviews and "red tape" to acquire the private land rights for building pumping stations and additional wells (Constance "Glass half full" 2004). While these processes arguably kept ASP's power in check, the company did not expect such time-consuming obstacles when designing their plans, and thus were forced to either postpone or discard such proposals altogether.

Lessons for Aguas de San Pedro Reflecting back upon the first several years of its control of the water and sewage services, ASP delineated aspects in which it would approach the city's water management in a different way. These so-called "lessons" could be instrumental for other, similar privatization schemes in Central America or even for the city of San Pedro Sula once the original contract draws to an end.

ASP maintains that it should have established a strong, independent regulatory body at the preliminary stage of the contract signing. This would ensure transparency and put the citizens more at ease with the future changes made to their water utilities. Also, the consortium-run group would work with public officials to coordinate a pro-active campaign to shape public perceptions of the alliance. Involving community leaders in the creation and implementation of more flexible plans would also be advisable; therefore, the installation of water meters, especially in low-income regions of the city, would not be as abrupt and drastic for the inhabitants. Furthermore, ASP would avoid the delays accessing ownership rights for private areas by working closer with the government to expedite the declaration of critical areas for expansion as public lands. Finally, the privatized service corporation would also invest in making noticeable improvements to the city's water and sewage services before increasing the consequent tariffs. The initial inflation of consumer costs is thought to have further alienated the public from ASP and prevented a more beneficial relationship ("The lessons of San Pedro Sula" 2004).

Future Possibilities for Aguas de San Pedro

Given the rapid over-exploitation of water resources, the growing population, the widespread contamination, and the expanding palm oil biomass and biodiesel industry in the Sula Valley, San Pedro Sula will experience severe changes in water availability and accessibility over the next two decades. While many of these aspects are detailed in chapter four, this chapter should also examine the most likely impacts of these transforming water realities with regards on the internationally privatized water system.

If the city of San Pedro Sula continues to extract water at a rate that leaves both subterranean and superficial sources vastly reduced (if not altogether dry) as soon as the next twenty to thirty years, the region will not have to wait long to start seeing noteworthy indications of the impending water scarcity. As water is removed from the underlying aquifers and the natural reserves are not replenished by sufficient recharge, the water table will drop, making existing infrastructure, pipes, and pumps useless over time. The first likely consequence of this phenomenon will be the deterioration of water services as the necessary amount of water to satisfy the city's demands will no longer be within easy reach. Mexico City's private water corporation faced a similar situation as its worsening utility services had to be attributed to the overuse and disappearance of groundwater, stretching its available budget beyond its means (Wilder and Lankao 1984). If the water availability issue becomes severe enough in San Pedro Sula, ASP will also be forced to extend their networks and update their technology in preparation for even less water supplies in the near future. These changes will be extremely costly, more so than the privatized consortium will be able to absorb; therefore, these supplementary expenditures will be passed down to the consumers in the form of increased water tariffs. Heightened prices for water in an era of physical scarcity will, no doubt, also bring about economic water scarcity for the majority of the populace dependent on small monthly earnings. In addition, other industries in the area, mainly the textile factories which also depend on large quantities of water, may be forced to relocate to a more water-abundant area to secure their production levels, leaving thousands of citizens without a steady paycheck, only further contributing to economic water scarcity and its inherent dire consequences.

The company's reaction to these mounting hardships will also be a critical determinant for the future success or failure of the private water management scheme. As previously mentioned the last chapter, there are indications that the water company is beginning to blame the citizens for the diminishing aquifers, specifically citing their excessive use of the resource and assumed under-valuation of its importance as the underlying problem (Baide "Pronostican escasez" 2009). In reality, the nation of Honduras exhibits a great push for better environmental awareness, even branding their national license plates with the slogan, "*Cuidamos los bosques*" to promote the preservation of forests and their delicate biodiversity. The public's comprehension of the integral link between water quality and deforestation is less certain, but there does appear to be active participation and incentives by several municipal governments and national organizations to educate the residents about the connection between agro-forestry practices and watersheds (Personal Interview 1 Jul. 2008; Meza 82). The consortium's immediate critical response, however, certainly sets a precedent for future relations between ASP and the Honduran public; after all, blatantly accusing the citizens of being nothing more than water-wasters does not imply positive interaction in the forthcoming circumstances. Certainly conservation is an essential component to properly prepare for the next several decades of water use, but regardless of how the water situation arose, it should be ASP's responsibility to become the main facilitator in adaptive water management. The private company, regardless of the international roots of the consortium, needs to be a leader in the region's capability to adapt and respond to the water realities. It is imperative that the water system is shaped to respond to present and future resources stresses rather than simply reacting to the aftermath (Pahl-Wostl 52).

In actuality, ASP does not have any obligation to assume such a role in Honduras' Sula Valley. While the corporation has the right to use ground and surface water, the responsibility to maintain, protect, and conserve these resources still belongs to the municipal division of water, DIMA (Meza 85). An assessment by the IDB before the original contract even declared the Merendón Aquifer to have sufficient water supplies for the duration of the concession, only noting its pollution might complicate water quality issues alone (Larrea et al. 7). Therefore, Aguas de San Pedro has been operating with a false understanding of water resources since the first day of the contract. A primary question, then, is whether ASP will work with the people to mitigate the potential long-term problems associated with decreasing water reserves despite the lack of social and cultural investment or if it will remain detached from the situation other than its corporate duties. A different issue to consider is if the company will renew its contract at the beginning of 2031 or return the network and service responsibilities back to the local government. After all, environmental degradation and its resulting social and ecological costs, according to prevailing economic theory, are not part of the anticipated costs of production but represent only unprofitable externalities to be tolerated (Liverman 331).

Although it is certainly possible that the corporation will continue its service provision in the region for another ten years beyond the current service agreement, it seems that given the current water situation and its constant rate of use, the city of San Pedro Sula will not represent a lucrative investment for the Acea y Otros conglomerate in the years to come. Based solely upon economic rationality, San Pedro Sula should prepare for Aguas de San Pedro to be renounce its duties by the time the contract is available for renewal.

The corporate titans in the Sula Valley, the internationally contracted water company and the leaders of the palm oil biomass and biodiesel industry, will inevitably compete against one another for the remaining water resources. However, because of the emphasis by the national government on palm oil biodiesel production through heavy economic investment as well as the vast amount of financial support and funded social projects in the region by international lending institutions also supporting the privatization, this report predicts that the two entities will not directly confront each other about their water necessities. Too much is at stake and the situation is too complicated for head-on opposition. Instead, it is most likely that both groups will appeal to the Honduran federal government to resolve the reduced production and service capacity due to decreasing water supplies, placing the government in a difficult position as no easy nor immediate solution can be achieved. Public pressures, especially against the private water corporation as the decline in the quality and provision of household water becomes unavoidable, will only add to the tension concerning who is responsible for this crisis.

Final Thoughts on Water Privatization

Private interests currently control about 8 to 10 percent of the global water utilities and this number is expected to double by the year 2015 (Yang 2008). This chapter has discussed viewpoints from both sides of privatization practices and specifically analyzed the Aguas de San Pedro case study, but the real question remaining is: what sets water privatization apart from other industries controlled by non-public entities?

To begin with, corporations may only dictate water services for a small fraction of the world's entire population right now, but their power, influence, and network will only expand in the future in both developing and developed nations. Companies and banks, many of whom were recently involved in globally crippling poor economic practices, have the right to manipulate water provision and prices as they see fit as well as govern the terms for accessibility and availability. As previous examples demonstrate, these same companies have very little accountability to their customers as international lending institutions and global trade agreements mitigate their risk of financial failure. In short, the economic principles set forth by a few developed nations and perpetuated by only a handful of institutions are being reinforced on such a large-scale that no part of the world will remain untouched.

The economic practices of these global forces, in addition to being supported by some prevailing national governments, are also upheld by the societies of the so-called "first world". So entrenched in the capitalist mentality, these populations dwelling within the richest countries in the world not only accept water privatization, but also rationalize it as a better alternative. Rhetoric in favor of privatized water rests upon the notions that it reduces big-government corruption, increases technological know-how and efficiency, expands the provision and services of water and sewage not achieved by public funds bogged down in bureaucracy, and ensures longevity of proper management. In fact, privatization is even advertised to promote conservation of the planet's most precious resource by motivating populations to reduce consumption through pricing mechanisms. This capitalist faith in the supremacy and capability of prices only further proves that real value is only considerable quantifiable in terms of dollars and cents.

And yet, societies are not completely immune to the gravity of total water control, especially in nations with overwhelming poverty. The idea that water should be a human right, rather than a privilege commodity, has remained deeply embedded in community mindsets regardless of economic rationality, perhaps because this resource represents a matter of life and death. Instead of disapproval for water privatization, though, the populace passively consents to the corporate takeover of water responsibilities and endorses their right to make a profit (after all, they are providing an indispensable service) while also projecting a perceived sense of morality upon these transnational companies. Rationalizing under the belief that these investors will realize the enormity of their power and its potential impact on humankind, it is widely presupposed that the industry giants will be compelled through ethical obligation to honor their contractual promises and provide clean, affordable, and reliable water quantities.

In reality, these corporations are no different than those that own, extract, or sell other natural resources like oil, gold, silver, copper, or precious gems for profit on the open market. So often vilified by “watchdog” agencies around the globe for their environmental carelessness or lack of local investment, these businesses are not even controlling determinants of health and existence but rather only components of modern conveniences. In truth, water companies are holding all of the proverbial cards for a product that will be infinitely profitable, never decline in demand, and can never be replaced. Water will remain the ultimate commodity if the world allows water privatization to continue its slow yet constant endeavor for lasting political, economic, social, and ecological dominance.

Chapter Conclusion

By examining global trends in the privatization of water, this chapter evaluates the current and potential reactions of the company Aguas de San Pedro to the Sula Valley’s emerging water crisis. The general conclusion for the long-term implications of these challenges based in physical and economic water accessibility is that the Italian consortium’s private corporation will mostly likely leave San Pedro Sula in 2030 when the original contract expires, if not before that time.

CHAPTER 6:

CONCLUSION

This research assesses the immediate and long-term impacts of the expanding palm oil industry on local water availability and internationally privatized water management in San Pedro Sula and the surrounding Sula Valley situated on the northern coast of Honduras. The four major topics analyzed in this report—the palm oil commerce, biodiesel production, the international water crisis, and water privatization—are all immense and complex issues within their own right. While it is impossible to comprehensively take into account the endless themes involved in each of these foci in one document, the underlying purpose of this thesis is to show the intricate network of connections that inextricably links these four very different subjects. In fact, the findings from the local case study of San Pedro Sula, Honduras were reflected in a global context in order to prove that the situation occurring in the Sula Valley is not an isolated incident, but rather an intercontinental phenomenon with serious political, economic, social, and environmental consequences.

This concluding chapter is meant to re-emphasize the imminent effects of regional palm oil biodiesel production on overall water quantities and the future management of the private consortium, Aguas de San Pedro. In addition, it will also delineate possible political, economic, and social circumstances that may be created by the changing water realities in this Honduran community.

Biodiesel Production and Water Resources

The growing palm oil biomass and biodiesel industries in the Sula Valley will contribute to and exacerbate the existing conditions of water stress by means of both agricultural expansion and oil processing. While these two components of the palm oil industry have very little in common, they have become integrally conjoined and now represent the two-headed cash cow upon which the Honduran government is relying for the nation's future economic development. However, the ultimate effects on water resources by these co-dependent phases of the biodiesel industry may be the region's social and ecological undoing.

Agricultural Expansion The extension of the palm oil biodiesel industry hinges on increased agricultural production to supply adequate quantities of African oil palm fruit for processing. Requiring new spaces in which to plant new plantations, the clearing of natural forest will result in erosion, sedimentation, and the loss of biodiversity. The widespread sowing of African oil palms will also alter the water recharge system in the region, and although no-till agriculture can reduce the evaporation of soil moisture compared to other types of crops, the overall water implications of clearing the land remains unknown (Sachs 133). In addition, the growing of such water-intensive crops may also affect underground water tables over long periods of time. In neighboring Nicaragua, the increased clearing of land and planting of sugarcane for the ethanol market have caused nearby subterranean water levels to drop, leaving many community wells dry and citizens in water crisis (Munguía 2007).

The most drastic and immediate manner in which increased agricultural production will take a toll on water quantities, however, is by the substantial amount supplementary inorganic fertilizers and pesticides that will contaminate surface and ground water. Issues of water quality for local and regional aquifers are just as, if not more important, than reductions in actual water quantities for the future of the useable water supplies. Not only will these chemicals contribute to making water resources non-potable for human consumption, but they will also disrupt the fragile aquatic environment of the coastal reef as the polluted water runoff may eventually cause widespread hypoxia in the area.

Biodiesel Processing The fabrication of biodiesel from palm oil feedstock entails both the extraction of oil from the raw fruit crop and a chemicals reaction called transesterification. These two stages of processing generate significant effluent, and this wastewater is contaminated with toxic and ecologically destructive substances. Although new water treatment technology, like that of biogas, may mitigate some of the contamination of surrounding water sources, the lack of enforced environmental regulations concerning this type of discharge will ensure that industrial contamination will be a lasting issue in the Sula Valley.

Processing biodiesel also requires immediate and intense extraction of freshwater from existing reserves. The three to one water to biodiesel ratio from the refining procedure will result in pervasive over-exploitation of water, especially as the industry continues to grow at a rapid rate and more companies invest in this technology.

Water Scarcity and Privatization

The growing palm oil industry in the Sula Valley is going increase the demand for water downstream of the Merendón Aquifer and from underground water tables in the region; in turn, this commerce will also decrease the quality and usability of this extracted water due to chemical contamination. The intensified stress on the Merendón's resources, which are located underneath San Pedro Sula, will only contribute to the already present water crisis unfolding in the city. Despite the seemingly abundant reserves in the aquifer, the combined rapid population growth, high water usage rate, industrialization, and contamination are over-taxing the water supplies to the point that a physical water scarcity may occur in the next twenty to thirty years. The internationally privatized corporation, Aguas de San Pedro, will be forced to extend their investment in infrastructure and extraction technology to compensate for the dwindling supplies or face serious breaches in contractual service provision stipulations. Any water network and machinery upgrades will be costly, and those extra tariffs will be passed on to the consumer, creating additional economic water scarcity in the developing nation as some citizens will not be able to afford the rising water expenses. In 2031 when the privatization contract becomes eligible for renewal, the municipality of San Pedro Sula must be prepared for Aguas de San Pedro to not recommence its water and sewage responsibilities. If the consortium refuses to continue service provision due to the decreased profitability of the endeavor, the city will have to immediately find a replacement to control and maintain the water system, ensuring both sufficient quantity and quality standards. In the future, the citizens of San Pedro Sula will surely experience higher water costs as the supply and demand of this natural resource will react to the growing population and the receding aquifer levels. The effects of climate change and global warming on the water realities in the Sula Valley will only augment the overall human and industrial uncertainty. In addition, further vulnerability to weather and storm patterns may also prove destructive to the large concentration of African oil palms in the coastal region as the monoculture could be easily wiped out.

Ramifications of Decreasing Water

The transformation of existing water supplies and the consequent reaction to such by Aguas de San Pedro, as described above, will impact the political, economic, and social realms of the Sula Valley. These three sectors will all face different repercussions related to the alteration in local natural resources and their management, ultimately requiring cooperation across the divisions in order to optimize their future water use and conservation.

Political Sector The political institutions in San Pedro Sula will endure notable hardships in deciding upon and adopting the most beneficial policies for their constituents. Strategies to encourage conservation, alleviate the impacts of higher water costs for consumers, choose the best management practices for the city' water and sanitation system, and regulate the lands declared as public domain for further water extraction will rarely be simple as the water crisis fast approaches. Political bodies will also have to endure strained relations with both international lending groups promoting continued privatization and local inhabitants as water conditions worsen. Furthermore, the public domain must be responsible for coordinating significant efforts to reduce water consumption through both widespread education as well as promotion of water-saving technologies. Currently, Honduras only utilizes about 5 percent of its rainwater despite its constant precipitation; infrastructure and equipment to endorse renewable water sources must be fiscally supported by this entity (Personal Interview 1 Jul. 2008).

Economic Sector A decrease in water availability and accessibility in the Sula Valley could result in the forced shrinking of the palm oil and biodiesel production industries. Reducing the fabrication of these commodities would affect the entire palm oil production chain, including consumers, as well as eliminate many crucial jobs in the region. Overall, economic development depends upon and requires water in order to thrive. The Centre for Economic and Social Investigations, a national group formed by the Honduran National Business Council, has even begun promoting specialized economic activity in the different regions of Honduras based around the presence of large water basins (Cross 2006). This sector must prepare for any resource or climatic variability that will affect the oil palm output and began to explore diversification options that are less water intensive.

Social Sector The social sector will bear the brunt of the challenges and difficulties resulting from the reduction of water resources in the northwestern valley of the Honduras. In addition to the looming increase in water utility prices, the continually growing population of San Pedro Sula will create more stress on the present water infrastructure and sewage system, leaving increasing numbers of people without acceptable levels of service provision. Drained water supplies will also result in a higher concentration of contamination in the remaining water reserves, and without even the chance for some of the pollutants to be washed away or diluted, the occurrence of water-related illnesses and mortalities will rise.

Final Thoughts

Despite the mounting evidence indicating that San Pedro Sula and the Sula Valley will undergo serious water quantity and quality problems in the next several decades, the likelihood for the reduction or cessation of oil palm cultivation and biodiesel production to help preserve the precious remaining water supplies is virtually non-existent. Given the extremely high market prices and exploding biofuel demands on a global scale, Honduras will most likely continue to expand its palm oil industry, myopically focusing on economic development rather than long-term ecological investment. The nation cannot be too harshly criticized for its enthusiasm to participate in the biofuel industry in spite of its substantial resource exploitation, however, because the historical “boom and bust” patterns have left the country in cyclical financial despair. After all, the biodiesel industry is believed to have the potential to forever end the unstable export-based economy characteristic of so many struggling developing nations. It is unfortunate that this industry is not compatible with the existing water supplies in the region, and it can only be hoped that the critical importance and value of water in the Sula Valley is recognized before the damages prove irreversible.

APPENDIX A:

GROWTH CALCULATIONS

Calculations Used for Figure 4, Figure 5, and, Figure 6.

	Population growth		Water usage (gallons) w/ constant use rate		Decreasing water usage per person (in gallons)	Water usage(gallons) with decreased demand	
year	5% pop growth	7% pop growth	5% pop growth	7% pop growth		5% pop growth	7% pop growth
2009	800,000	800000	96000000	96000000	120	96000000	96000000
2010	840,000	856000	100800000	102720000	116.772	98088480	99956832
2011	882,000	915920	105840000	109910400	113.6308	100222394.9	104076752.7
2012	926,100	980034.4	111132000	117604128	110.5742	102402733.1	108366484.3
2013	972,405	1048637	116688600	125836417	107.5997	104630504.5	112833025.6
2014	1,021,025	1122041	122523030	134644966.1	104.7053	106906741.2	117483664.5
2015	1,072,077	1200584	128649181.5	144070113.8	101.8887	109232497.3	122325988.7
2016	1,125,680	1284625	135081640.6	154155021.7	99.14791	111608850.3	127367898.9
2017	1,181,964	1374549	141835722.6	164945873.3	96.48083	114036900.8	132617621.6
2018	1,241,063	1470767	148927508.7	176492084.4	93.88549	116517773.6	138083722.1
2019	1,303,116	1573721	156373884.2	188846530.3	91.35997	119052617.8	143775118.9
2020	1,368,271	1683882	164192578.4	202065787.4	88.90239	121642607.5	149701098
2021	1,436,685	1801753	172402207.3	216210392.5	86.51092	124288942.4	155871328.1
2022	1,508,519	1927876	181022317.7	231345120	84.18377	126992848.3	162295876.7
2023	1,583,945	2062827	190073433.5	247539278.4	81.91923	129755577.8	168985225.8
2024	1,663,143	2207225	199577105.2	264867027.9	79.7156	132578410.4	175950289.9
2025	1,746,300	2361731	209555960.5	283407719.9	77.57125	135462653.7	183202433
2026	1,833,615	2527052	220033758.5	303246260.3	75.48459	138409643.7	190753487.7
2027	1,925,295	2703946	231035446.4	324473498.5	73.45405	141420745.5	198615774.2
2028	2,021,560	2893222	242587218.8	347186643.4	71.47814	144497353.8	206802120.5
2029	2,122,638	3095748	254716579.7	371489708.4	69.55538	147640893.8	215325883.5
2030	2,228,770	3312450	267452408.7	397493988	67.68434	150852821.4	224200970.5

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