AquaFish Collaborative Research Support Program

SITE DESCRIPTIONS

November 2011

A Reference for Research Locations in the AquaFish CRSP

2007-2011

USAID FROM THE AMERICAN PEOPLE

Oregon State University OSU

AquaFish Collaborative Research Support Program

AQUAFISH CRSP SITE DESCRIPTIONS 2007-2011

Revised November 2011

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AFRICA

INTRODUCTION

The Aquaculture & Fisheries Collaborative Research Support Program (AquaFish CRSP) is one of several agricultural CRSPs supported by the U.S. Agency for International Development (USAID) under the authority of Title XII of the International Development and Food Assistance Act of 1975. Its mission is to enrich livelihoods and promote health by cultivating international multidisciplinary partnerships that advance science, research, education, and outreach in aquatic resources. AquaFish CRSP is charged by USAID to "develop more comprehensive, sustainable, ecological and socially compatible, and economically viable aquaculture systems and innovative fisheries management systems in developing countries that contribute to poverty alleviation and food security."

AquaFish CRSP's cohesive program of research is carried out in selected developing countries and the United States by collaborative teams of US and Host Country researchers, faculty, and students who are led by these goals:

- Increase Host Country productivity and provide return benefits to the US.
- Use innovative research to understand and remove constraints in fisheries and aquaculture faced by poorer countries.
- Build US and Host country capacity in aquaculture and fisheries management to ensure long-term impacts.
- Foster wide dissemination of research results and technologies to local stakeholders.
- Provide outreach in aquaculture and fisheries topics through short courses, workshops, and region specific Podcasts.

This edition of the Site Descriptions for the seven AquaFish CRSP projects funded in the time period between 2007-2011 represents all of the key regions called for in the original USAID RFP. As a group, they include 16 countries, 17 US universities, and over 31 HC institutions in formal funded partnerships. More than 70 other institutions collaborate in informal partnerships. The seven projects feature 57 investigations accounting for over US$2.4 million from USAID. The site descriptions are sorted by project and provide maps, information on the general location of each site, and details on each facility. Data for CRSP sites which are no longer active can be accessed in earlier editions of the Site Descriptions on the former Aquaculture CRSP website at: pdacrsp.oregonstate.edu/pubs/featured_titles/.

INDONESIA

Introduction

Aquaculture in the Philippines and Indonesia is a high food security priority particularly in the light of the countries' rapidly growing populations and their continued dependence on fish protein. The incomes from family farming, however, are generally poor with 43% of small-scale tilapia farmers in Central Luzon, Philippines falling below the poverty line. The difficult socioeconomic conditions are even more pronounced for fishers in coastal regions where traditional livelihoods have been lost, and many seek transition to milkfish farming, but with some uncertainty. In Indonesia, a tsunami eliminated shrimp-farms, and the livelihoods of entire communities continue to rebuild. In this project we develop and implement strategies that will improve the cost effectiveness, sustainability and income opportunities of farming fish in the Philippines and Indonesia and the subsequent livelihood of their people. A cluster of integrated investigations assess key areas of research and outreach that form a natural extension of the activities and accomplishments of the first phase of our AquaFish CRSP. We continue to develop methods to reduce farming costs for tilapia and milkfish, conduct an extensive supply-chain analyses to specifically address the marketing opportunities and constraints of expanding tilapia products to reach more lucrative retail supermarkets, assess the utility of integrative/polyculture systems to reduce environmental impacts of farming fish while providing additional products for market and home consumption, develop a series of short Tilapia Podcasts designed for disseminating current culture practices and cost-saving strategies to the farming community of Central Luzon, and provide training on the harvest and processing of seaweeds in the Philippines and Aceh region of Indonesia. The research and outreach activities planned incorporate specialists from Central Luzon State University (CLSU) the Southeast Asian Fisheries Development Center (SEAFDEC), Ujung Batee Aquaculture Center, North Carolina State University (NCSU), University of Arizona, and the United States Department of Commerce, their collaborators and the farming communities of the host countries.

Farmers learning seaweed-fish-shrimp polyculture after the tsunami in Banda Aceh.

Drying seaweed in Banda Aceh

Western part of Banda Aceh (before tsunami)

Western part of Banda Aceh (after tsunami)

UJONG BATEE RESEARCH STATION AND LADONG FISHERIES COLLEGE

Banda Aceh River

Banda Aceh Harbor

Participants in first workshop at Ladong Fisheries School

Discussions with the farmers regarding the prices of aquaculture products

Ujong Batee Research Station and Ladong Fisheries College

Site Status

Former Prime Sites* since at least 2006

General Location

Banda Aceh, Aceh, Sumatra, Indonesia. Ujong Batee Fisheries and Aquaculture Center is approx. 20 km east of Banda Aceh and Ladong Fisheries College is approx. 40 km east of Banda Aceh

Description of Area/Region

Overall Description

Banda Aceh, which is the provincial capital and largest city of Aceh, Indonesia, is located on the island of Sumatra. Ujong Batee Fisheries and Aquaculture Center is approx. 20 km east of Banda Aceh and Ladong Fisheries College is approx. 40 km east of Banda Aceh

Climate

Köppen-Trewartha classification Af: Tropical rainforest

Temperature

Range: 25-30°C.

Precipitation

The average annual rainfall ranges from 2,000 mm to 3,000 mm.

Humidity

The humidity varies from 65 to 75%.

Seasonality

The dry season in Aceh usually lasts from March through August. The rainy season starts in September and lasts until February. The weather along the coastal areas is usually warm. The mountains tend to be cooler. The wind from the west begins in June and continues through November, while the wind from the east begins in December and continues through May.

Topography

Coastal area with mountains running parallel.

Geology/Soils

The oldest rocks of Sumatra Island are gneiss, schist and quartzite, and the schists often contain gold. They probably belong to several geological periods, but all were folded and denuded before the Carboniferous beds were deposited. They form the backbone of the island, and crop out on the surface at intervals along the mountain chain, which runs parallel to the west coast. They are penetrated by granitic rock at several locations, which are also Pre-Carboniferous. The next series of rocks consist of slates below and limestone above. It lies upon the older rocks; and the limestone contains Fusulina, Phihipsia and Productus, indicating that it belongs to the Upper Carboniferous. These beds are found only in Northern Sumatra. The alluvial sediment group consists of clay and sand. These can be found alongside the coast and alongside DAS Krueng Aceh, including the Banda Aceh Kota. The sediment still has the character of being loose to somewhat solid, its water passing is low to average, its foundation supporting strength is low to average, and the potential fertility of the soil is low to high.

Description of Ujong Batee Research Station and Ladong Fisheries College

Map Coordinates	Elevation
5.52' N and 95.42' E (Banda Aceh airport)	< 10 m

General

The Ladong Fisheries College is about 40 km east of Banda Aceh in northern Sumatra. The College is a trade type college, training students in practical aspects of fisheries and aquaculture. The college has classroom, laboratory and workshop facilities. They also maintain several ponds and tanks for practical trials with the students. The college is supported by provincial and federal funds. Faculty at the college are interested to learn and to able to train their students in sustainable aquaculture technologies. They recognize that monoculture of shrimp has brought limited benefits to the coastal community and they are anxious to learn of improved farming methods.

The Ujong Batee Fisheries and Aquaculture Center is about 20 km east of Banda Aceh. The Center had two technology and training facilities about 1 km apart on the coast. Both facilities were heavily damaged by the tsunami. The Center is supported by the Indonesian fisheries ministry and the staff scientists are federal employees. The scientists at the Center had begun trials with more sustainable aquaculture methods, however, all of their work was destroyed in the tsunami. We will collaborate with the staff expose them and local aquaculture practitioners to more sustainable techniques which they can demonstrate when the ponds and other facilities are brought back into condition.

Water Supply

Ocean

Soils

The alluvial sediment group consists of clay and sand. The sediment still has the character of being loose to somewhat solid, its water passing is low to average, its foundation supporting strength is low to average, and the potential fertility of the soil is low to high.

Support Facilities at Ujong Batee Research Station and Ladong Fisheries College

Ujong Batee and the Ladong Fisheries College are the sites of workshops held to train both trainers (NGO's and fisheries staff) and aquaculture producers in sustainable coastal aquaculture techniques. Other workshops were conducted in more remote villages and visits were made to tambak restoration projects supported by various NGOs

Affiliations

In-Country	US
Ujong Batee Aquaculture Center Regional Brackishwater Aquaculture Development Centre (BBAP) Jalan Ujung Batee - Krueng Raya Km 14 Aceh Besar, NAD Indonesia	University of Arizona Environmental Research Laboratory Department of Soil, Water and Environmental Science 2601 E. Airport Drive Tucson, Arizona 85706-6985

Current Contacts	
In-Country	US
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PHILIPPINES

Introduction

Tilapia and milkfish are the two most prominent finfish cultured in the Philippines. They are low trophic species whose culture is expanding rapidly both in inland and coastal regions and in a more intensive fashion. Feed is clearly one of the most costly aspects of fish farming, representing as much as 80% of total production costs for tilapia and 60-70% for milkfish. Feed wastage and the escalating cost of fishmeal in commercial diets contribute to this problem; sources are rapidly declining and demand remains high. The project aims to improve management strategies and will deliver more cost-effective formulations to reduce feed usage and costs. Controlling costs is a requisite to increasing income for small-scale farmers, while also preserving the biodiversity of bait fisheries. Limiting nutrient load from feed wastage will also help mitigate the environmental imprint of fish farming and promote its sustainability. A series of studies reduce feed costs for tilapia farmers that incorporates a combination of sub-satiation feeding; decreases in feed formulation costs through reductions in crude protein, amino acid supplementation, and replacement of fishmeal with lower cost protein sources; and use of a cheaper manufacturing process that uses pellet rather than extrusion processing. This aspect of our work features a unique synergy between a Filipino feed company, CLSU and NCSU researchers, and Luzon farmers in the Philippines.

Facility at Central Luzon State University in the Philippines (Photo by Peg Herring)


Philippines
International boundary
National capital
Railroad
Road
Pan-Philippine Highway
0 50 100 150 Kilometers
0 50 100 150 Miles
Lambert Conformal Conic Projection, SP 7N/18N
FAC
BAC, Iloilo
Negros Occidental
Taiwan
Luzon
Strait
Philippine Sea
South China
Sea
Sulu Sea
Celebes Sea
Mindanao
Palawan
Mindoro
Panay
Negros
Cebu
Bohol
VISAYAN ISLANDS
CALAMIAN GROUP
BABUYAN ISLANDS
POLILLO ISLANDS
TURTLE ISLANDS
Basilan Island
Jolo Island
Tawitawi Island
SULU ARCHIPELAGO
Catanduanes Island
Biliran I.
Lake Lanao
Moro Gulf
Mindanao Sea
Manila
see inset
Basco
Claveria
Aparri
Laoag
Vigan
Bangued
Tuao
Tuguegarao
Bontoc
Tabuk
Ilagan
Planan
Lagawe
La Trinidad
Cabarroguis
Bolinao
Baguio
Bayombong
Casiguran
Dagupan
San Carlos
San Jose
Baler
Tarlac
Palayan
Cabanatuan
Iba
Angeles
Polillo
Larap
Daet
Sipocot
Naga
Pili
Iriga
Virac
Plaridel
Calapan
Boac
Mamburao
Bongabong
San Pascual
Legaspi
Sorsogon
Romblon
Matnog
Masbate
San Jose
Catarman
Calbayog
Catbalogan
Danao
Kalibo
Roxas
Culasi
Cadiz
Silay
San Carlos
Ormoc
Iloilo
San Jose
Bacolod
Bago
La Carlota
Tolo
Mandaue
Lapu-Lapu
Cebu
Anilao
Dinagat
Maasin
Pilar
Surigao
Bais
Tagbilaran
Dumaguete
Siquijor
Mambajao
Cortes
Tandag
Butuan
Cagayan de Oro
Gingoog
Prosperidad
Dipolog
Dapitan
Oroquieta
Ozamis
Iligan
Tangub
Marawi
Malaybalay
Bislig
Pagadian
Tubud
Tagum
Davao
Mati
Olutanga
Cotabato
Zamboanga
Isabella
Maganoy
Kidapawan
Digos
Governor Generoso
Isulan
Koronadal
General Santos
Jose Abad Santos
Dumaran
Puerto Princesa
Balabac
Kudat
Kota Belud
Kota Kinabalu
Sandakan
Bandar Seri Begawan
BRUNEI
Bangar
MALAYSIA
Kunak
Kampong
Balimbing
INDONESIA
INDONESIA
San Fernando
Malalos
Olongapo
Balanga
Caloocan
Quezon
Manila
Pasig
Cavite
Pasay
Laguna de Bay
Trece Martires
Tagaytay
Santa Cruz
Lake Taal
San Pablo
Lipa
Lucena
Batangas
0 30 Kilometers
0 30 Miles

FRESHWATER AQUACULTURE CENTER (FAC) AT CENTRAL LUZON STATE UNIVERSITY

The FAC has 242 earthen ponds ranging in size from 200 m^2 to 2,500 m^2.

The FAC is located in Luzon, in a vast, low-lying alluvial plain known as the "rice-bowl" of the Philippines.

Freshwater Aquaculture Center (FAC)
Central Luzon State University

Site Status

Companion Site from 1992-1998; Prime Site from 1998- Present

General Location

Central Luzon State University, Science City of Muñoz, Nueva Ecija,Philippines

Description of Area/Region

Overall Description

FAC is located at the northeastern most extension of Central Luzon State University (CLSU), 1.5 km from the main university campus. CLSU is 3.5 km northeast of the science city of Muñoz, in the province of Nueva Ecija. The Science City of Muñoz is approximately 150 km north of Manila and lies in the heart of the central valley of Luzon.

Climate

Köppen classification **Aw**: Humid tropical group (A), tropical wet-and-dry type (w).

Temperature

The average annual temperature in the province of Nueva Ecija is 27.8°C. In 1995, the maximum and minimum temperatures at FAC were 35.5 and 23.1°C, respectively.

Humidity

Mean annual relative humidity is normally in the range 74 to 78%. It is hot and dusty from March to May.

Precipitation

Average annual rainfall in the province is about 2,250 mm. Most of the rainfall occurs between the months of May and October.

Seasonality

There are two distinct seasons in this part of the Philippines. The dry season begins in about December and lasts through April or May, and the rainy seasons begins in June and continues through November.

Topography

The central valley is a vast, relatively flat lowland that stretches approximately 150 km from Manila Bay in the south to the Lingayen Gulf on the western coast of Luzon. The elevation of this lowland area is less than 40 m. The Zambales Mountain flanks the plain to the west, while the Sierra Madre range lies on its eastern side.

Geology/Soils

The Philippines archipelago is part of a major western Pacific seismic fault system. The entire region is characterized by active volcanoes (12 of them in the Philippines), and all of the Philippine islands are subject to occasional earthquakes. Many of the peaks of the rugged mountains that make up the Philippine islands are dormant or extinct volcanoes. Soils in the central valley of Luzon are largely alluvial, clayey, and alkaline.

Layout of Freshwater Aquaculture Center (FAC) at Central Luzon State University

Description of the Freshwater Aquaculture Center (FAC)/Central Luzon State University

Map Coordinates	Elevation
15°43'N and 120°54'E	30 m

General

FAC is a multi-disciplinary research unit of the University responsible for aquaculture research and development. It operates and collaborates closely with the College of Fisheries with which it shares common core staff as well as facilities. The total work force is 64. The core staff with academic rank conduct researches and teach both at the College of Fisheries for its undergraduate courses and at the Department of Aquaculture, Institute of Graduate Studies for its graduate courses. A team of technical personnel with broad range of expertise comprise the faculty members and research staff of the Center. Pond facilities include 242 earthen ponds ranging in size from 200 m^2 to 2,500 m^2. Twelve 500-m^2 ponds are assigned to the CRSP research project. Concrete tanks of varying shapes and sizes total 316 and are used as either holding tanks or for experimental purposes. FAC is the crossroad of tilapia genetics research nationally and internationally that led to the development of genetically improved tilapia such as the FAC Selected Tilapia (FaST) strain, genetically male tilapia (GMT) and the genetically improved farmed tilapia (GIFT) which are now commercially produced and available to the tilapia industry. The Center has catfish culture area and a rice-fish experimental area. It has a hatchery/wet laboratory building and maintains laboratories on soil and water quality, fish pathology, fish nutrition, fish processing, fish physiology and a general laboratory. It has established a Living Fish Museum, which showcases and maintaining about 100 species of native, introduced, and ornamental freshwater fish species in the Philippines.

Water Supply

Water comes to the station through open canals from the 8,420-ha Pantabangan Reservoir, which is located about 30 km from FAC. There is one deep well and eighteen (18) shallow wells that provide additional water for the Center.

Soils

Pond soils at the FAC have very high clay content, with an average of 62.5% for the ponds used in the CRSP experiments. In 1993 the mean cation exchange capacity for the CRSP ponds was 38.8 meq per 100 g; exchangeable base measurements were 23,7, 14.5 and 1.1 meq per 100 g for Ca, Mg, and Na, respectively. The soils are alkaline, with base saturation values of 100% and an average pH of 7.6.

Support Facilities at the Freshwater Aquaculture Center (FAC)

The Center has about a total of 24 PCs. These include three dedicated CRSP computers, two notebook computers, and a computer with Internet access and email capability. Four PCs are housed in the Fisheries Information and Learning Center for students' and researchers' use. This facility was established with funds from the CRSP and it has become an important resource facility for students and researchers. Other support facilities include lecture rooms, library, conference room with multi-media equipment, experimental facilities like ponds, tanks, net enclosures and aquaria.

Affiliations	
In-Country	US
Freshwater Aquaculture Center Central Luzon State University Science City of Muñoz, Nueva Ecija 3120 PHILIPPINES	North Carolina State University Department of Zoology Box 7617 Raleigh, North Carolina 27695-7617 USA
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Iloilo, Philippines (Photo by Peg Hering)

BANGLADESH

Introduction

Bangladesh is rich in inland waters, which are suitable for growth of many species of freshwater prawns including giant freshwater prawn (*Macrobrachium rosenbergii*). FAO statistics (FAO 2000) indicate that the production of farmed giant freshwater prawns in Bangladesh had reached a substantial 48,000 mt by 1998, placing the scale of its freshwater prawn farming industry second only to that of China (New 2000).

Due to the importance of freshwater prawns as an export product, the government had declared prawn cultivation to be of primary industry status in an effort to boost production (DoF 2003). A recent survey showed that annual yields from extensive ponds are in the range of 300-600 kg/ha (Asaduzzaman et al. 2006a), which is low compared to neighboring countries. Thus, efforts should be made to increase freshwater prawn production in order to contribute to the national economy.

The former Aquaculture CRSP worked extensively with Bangladesh Agricultural University on aquaculture issues important to that country. The location, focus, and personnel at BAU are perfect for renewed collaborations to the benefit of BAU and AquaFish CRSP.

BANGLADESH AGRICULTURAL UNIVERSITY (BAU)

Site Status

Active

General Location

The campus is located on the western bank of the old Brahmaputra River, 5 km south from Mymensingh Railway Station and 120 km north from Dhaka, the capital city of Bangladesh.

Description of Area/Region

Overall Description

Mymensingh city is located about 120 km (75 mi) north of Dhaka, which is the capital of the country.

Climate

The climate of Mymensingh is moderate. However for proximity of the Himalayas, it feels much colder than Dhaka. The monsoon starts in May or June and continues till August. It rains heavily and sometimes for days and weeks. High humidity is common during the April–May period.

Temperature

During the monsoon, the temperature varies between 15 and 20 degrees. The temperature falls below 15 °C (59 °F) in winter which is spread over December and January and may well include November and February. Highest temperature is felt during April–May period when the temperature may be as high as 40 degrees.

Precipitation

The single most dominant element of the climate of Bangladesh is the rainfall. Because of the country's location in the tropical monsoon region, the amount of rainfall is very high. The winter season is very dry, and accounts for only 2%-4% of the total annual rainfall. Rainfall during the rainy season is caused by the tropical depressions that enter the country from the Bay of Bengal. These account for 70% of the annual total in the eastern part, 80% in the southwest, and slightly over 85% in the northwestern part of Bangladesh. The amount of rainfall in this season varies from 100 cm in the west central part to over 200 cm in the south and northeast. Average rainy days during the season vary from 60 in the west-central part to 95 days in the southeastern and over 100 days in the northeastern part.

Humidity

March and April are the least humid months over most of the western part of the country. The least humid months in the eastern areas are January to March. The relative humidity is everywhere over 80% during June through September. The average relative humidity for the whole year ranges from 78.1% at Cox's Bazar to 70.5% at Pabna.

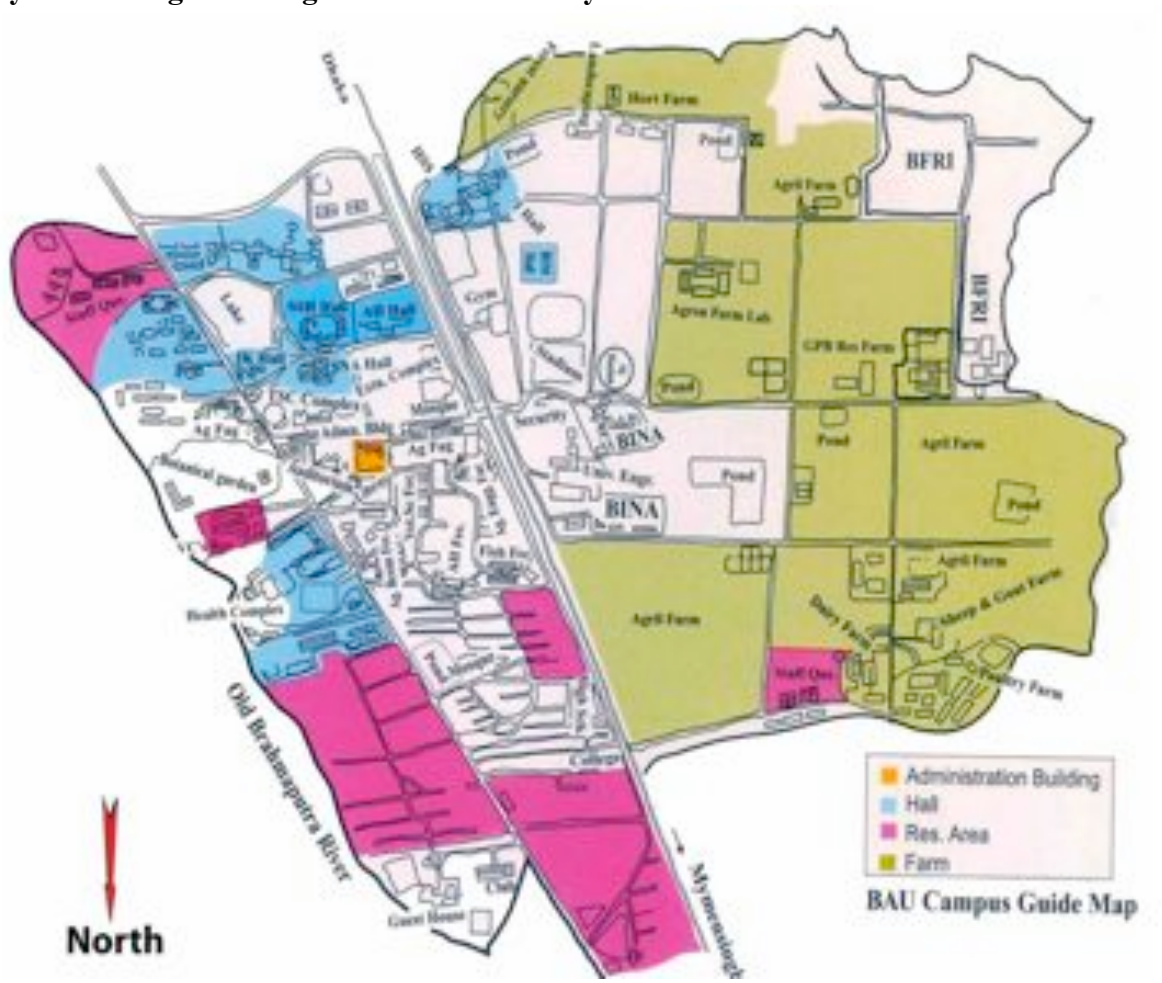
Seasonality

mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October)

Topography

mostly flat alluvial plain; hilly in southeast

Layout of Bangladesh Agricultural University



AquaFish US Lead Project PI, Jim Diana, at CRSP field site at BAU.

Description of Bangladesh Agricultural University

Map Coordinates	Elevation
The District of Mymensingh is situated between 24°02‘03" and 25°25‘56" north latitude and 89°39‘00" and 91°15‘35" east longitude.	205m

General

Bangladesh Agricultural University (BAU) is the premier seat of higher agricultural education and research in the country. Its scholastic activities cover all the domains of agricultural sciences having direct bearing on terrestrial and aquatic productivity. The University was established as the nation's only University of its kind in session 1961-62 on the basis of recommendations made by the Commission of National Education and the Food and Agriculture Commission in 1959. The main task of the university is to tone up the quality and standard of higher agricultural education and to produce first-rate agriculturists, agricultural scientists and researchers for shouldering the responsibilities of agricultural development of the country. It is a residential university mandated for offering for higher education and research in agriculture and all of its branches including conduct of examinations, conferment of degrees and granting affiliation.

Affiliations

In-Country	US
Bangladesh Agricultural University Department of Fisheries and Management Mymensingh 2202 Bangladesh	School of Natural Resources & Environment University of Michigan 128 Dana Building Ann Arbor, Michigan 48109-1041 USA

Current Contacts

In-Country	US
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CHINA

Introduction

The People's Republic of China (China) is one of the top four largest country in the world by land mass. It contains over 1.3 billion people, making it the most populous country in the world. Because of its vast population, rapidly growing economy, and large research and development investments, China is considered an "emerging superpower." It has the world's fourth largest economy, and is a permanent member of the United Nations Security Council. China is quite stable politically, and it is believed that the China-USA relationship will be stable in the long-run. Seafood is an important commodity for human consumption in China, representing about 1/3 of all animal mass consumed in the country. China is a world leader in both aquaculture and fisheries production, with combined seafood production of 60 million tons in 2005. In 2005, capture fisheries produced 17 million tons using fleets that traveled the world, while aquaculture in China produced 43 million tons, mainly in the south-central region. China has a long history of rural aquaculture, which has been rapidly developed since the 1960s, resulting from its elaborate extension network. The Chinese government has emphasized environmental issues in recent years, due mainly to rapid economic development and related water pollution.

The host country site for the AquaFish CRSP will be at Shanghai Ocean University, with secondary sites in China at Huazhong Agricultural University, Wuhan University, and Hainan University, and other companion sites in Vietnam and Nepal (see Figure 1). SOU is the oldest fisheries institution in China, with a history of 95 years. SOU is one of the first institutions in China to establish a Ph.D. program for aquaculture and fisheries, and is also the center for education and research in aquaculture and fisheries, freshwater and marine ecology, aquatic food science, and aquatic plants and animals. SOU has three aquaculture bases in Nanhui, Fenghua, and Xiangshan Harbor, with 100,000 m^2 of hatchery space for aquatic animals. SOU has 40 earthen ponds, 80 outdoor cement tanks, and hundreds of indoor plastic aquariums. Infrastructure, including communication and transportation, is very good in Shanghai, and really throughout China. With rapid economic development, the conditions related to human health have improved significantly, and working conditions for HC and US participants are adequate and comfortable. As China represents a broad geographical area with varying climates, and has introduced many aquatic species from all over the world, almost all-important species for AquaFish CRSP are available in China. In the counties of south-central China, there are a various types of rural aquaculture systems, which can be used for the purposes of on-farm trials, training, and study tours.

Map of China and the region, with all AquaFish CRSP research sites highlighted in yellow.

SHANGHAI OCEAN UNIVERSITY (FORMERLY SHANGHAI FISHERIES UNIVERSITY)

Site Status

Active companion site in China since 2005

General Location

334 Jungong Road, Yangpu District, 200090, Shanghai, China

Description of Area/Region

Climate

With a pleasant subtropical maritime monsoon climate, Shanghai enjoys four distinct seasons, generous sunshine, and abundant rainfall. Its spring and autumn are relatively short compared to summer and winter. The average annual temperature is 18.1 degrees Celsius. The city had a total sunshine duration of 1,929.6 hours in 2004 and received rainfall of 1,158 mm. However, about 50% of the precipitation came during the May-September flood season, which is divided into three rainy periods, namely, the Spring Rain, the Plum Rain, and the Autumn Rain.

Temperature

Annual averages:	17.6 ºC
Range of monthly averages:	4.3 – 27.9ºC
Absolute minimum:	-8 – -11.9ºC
Absolute maximum:	40 – 41ºC

Precipitation

Shanghai receives abundant rainfall and the average annual precipitation is over 1000 cm. The "Plum Flower Rain" season (frequent light rain) is from mid-June to early July with an average daily rainfall of 259 mm. During July and September, strong storms with torrential rain become frequent. However, it seldom snows in Shanghai.

Humidity

A warm and humid atmosphere prevails throughout the year. The annual average relative humidity of Shanghai is about 82%.

Seasonality

Shanghai is characterized by a warm spring, hot summer, cool autumn, and cold winter. July and August are Shanghai's hottest months with average highs of 27.4 ºC. January is the coldest month, with a temperature average of 3ºC.

Topography

Within the boundaries of Shanghai, the area is mainly low lying river delta with a silted alluvial plain, and an average altitude of 4 m above sea level.

Geology/Soils

Because the topography is low and level, the river, the lake, and sea water levels are high, and the land is submerged often. The soil is primarily silt and sand.

Layout of Shanghai Ocean University

Description of Shanghai Ocean University

Map Coordinates	Elevation
31°17'21"N and 121°33'08"E	10-11 m

General

Shanghai Ocean University, which was formerly Jiangsu Provincial Fisheries School, was established in 1912 and changed in Shanghai Ocean University in 2008. In 1952, it became the first fisheries college in China, and was renamed in 1985 to Shanghai Fisheries University. Since 2000, it has been jointly overseen by the Ministry of Agriculture and Shanghai government but administered by Shanghai Education Commission. It has developed into a multi-disciplinary university focusing on coordinated development in agriculture, science, engineering, economics, arts, and management.

There are 12,700 undergraduate students and 670 postgraduates enrolled in the university. Among 880 work staff members, 620 are teachers and scientific researchers, including 210 with senior titles and 88 master's and doctoral supervisors. There is one professor from the University acting as the counselor in the Academic Degree Appraisal Board of the State Council, and another was selected in the State Project of "Hundred, Thousand, and Ten Thousand Talents." In addition, 3 teachers were awarded the honorary titles of the State Distinguished Young-and-Middle-aged Expert and the Provincial or Ministerial Distinguished Young-and-Middle-aged Expert. Another 4 faculty are members in the 7th Session of the Science and Technology Commission of the Ministry of Agriculture.

Since the 1990s, the university has made great contributions to such fields as environmental protection, species protection, genetic breeding, food processing, marine resource development and utilization, aquaculture, and agricultural economy. The university has built a close relationship with universities in the USA, Japan, Russia, and Australia, as well as several international organizations. The university has exchanged overseas students, participated in the Sino-America cooperative projects on marine living resources, and established cooperation with such international organizations as the United Nations Food and Agriculture Organization, UNESCO, Fisheries Information Center, Asian Fisheries Society, and International Center for Living Aquatic Resources Management.

The university has two campuses, Jungong Road and Xuehai Road campus, and three culture bases in Nanhui, Fenghua, and Xiangshan in Zhejiang Province. SOU will move to Lingang New City in 2008. The new campus, which is located in the urban area of Lingang New City, occupies an area of 1600 mu, the planned construction area will be 586,000 m2. In the near future, this modern university with advanced facilities and beautiful environment will be completed on the shore of the East Sea and Dishui Lake.

In 2012, the centennial of SOU, it will be a world-renowned special university with distinctive advantages in such disciplines as aquaculture, marine science and technology, and food engineering, while agriculture, science, engineering, economics, art, and administration will also be important components. The university will focus on both teaching and scientific research so that it will be a cradle for cultivating senior special talents and high quality applied talents, and an important base for scientific innovation in fisheries, marine science and technology, and food engineering.

Water Supply

Supply water for the SOU pond complex comes from the Huangpu River. The pH of this source is neutral and the total alkalinity ranges from 30-50 mg/L. Ammonia-N is 0.02-0.06 mg/L, and nitrate-nitrite-N is below 0.01 mg/L. Reactive phosphorus was measured at 0.05-0.21 mg/L.

Soils

Because the topography is low and level, the river, the lake, and sea water levels are high, and the land is submerged often. The soil is primarily silt and sand.

Support Facilities at SOU

The university consists of 8 special colleges, and 4 other colleges. In addition, the Central Agricultural Training Center, SOU Branch, and the Ocean Fisheries Training Center of Ministry of Agriculture are also located at the University.

The university has a national key discipline, 7 provincial and ministerial key disciplines, an educational highland of Shanghai, and an E-Institute of Shanghai Universities. It has one postdoctoral station, 1 doctoral program of the first-level discipline, 6 doctoral programs of the second-level disciplines, a master's program of the first-level discipline, 23 master's programs of the second-level disciplines, 7 equivalent-education master's programs, 29 bachelor's programs (including 6 state-administered specialties) and several higher technical and vocational specialties.

Enjoying good facilities for education, complete laboratories and special experimental equipment, the university owns the Key Open Laboratory of Aquatic Genetic Resources Exploration and Utilization of the Ministry of Education, the Key Open Laboratory of Aquatic Genetic Resources and Aquaculture Ecology of the Ministry of Agriculture, and the Bank and Refrigeration Center of Aquatic Animals and Plants Pathogens of the Ministry of Agriculture. The university has established such special laboratories as Laboratory for Freshwater Fish Processing and Utilization Research, and Oceanic Fishery Remote Sensing and Information Research Center as well as 7 research centers at the university level. The university also owns the Agriculture Research Institute of SOU, Research Institute of Public Administration, Research Institute of Chinese Ichthyology, Museum of Chinese Ichthyology, Ichthyology Research Institute and Specimen Laboratory, and Museum of Whales, which is the largest in Asia. The library has a total storage of 685,000 books and 360,000 electronic books featuring fisheries, marine sciences, and food. Owning a modern campus network, the university has established a platform "China Fisheries Network," serving the fisheries industry of the country. Journal of Fisheries and Journal of SFU sponsored by the university are listed as key Chinese journals, China key scientific and technological journals and China scientific and technological papers citation source journals. Journal of Fisheries has been awarded the title of the first and second session of "one hundred excellent academic journals of China."

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HAINAN UNIVERSITY (HNU)

Site Status

Active companion site, China, since 2005

General Location

No. 58, Renmin Road, Haikou City, Hainan Province, China. Hainan University is located on the north of Hainan Island, Hainan Province, at the southern tip of China. It is the second largest island of China, with a land area of 38,000 km^2, population of approximately 78 million, and 1,528 km of coastline. The island has three large rivers: the Nandu River, from middle island to the northern sea; the Changhua River, from the mountainous middle island to the west sea; and the Wanquan River, from the middle island to the east.

Description of Area/Region

Climate

Hainan Island is situated in the tropics and has a tropical marine monsoon climate. It enjoys abundant sunlight, with the annual solar radiation totaling 110-120 kcal/ cm^2 and annual duration of sunshine averaging 1,700-2,000 hours.

Temperature

Annual averages for the area:	23 – 26ºC
Range of monthly averages:	17 – 30 ºC
Absolute minimum:	7 – 20ºC
Absolute maximum:	37 – 39ºC

Precipitation

Rainfall varies from 10.5 – 526.5 mm per month and 956 – 2,976 mm annually; low months are November to February, with an average of 4 days of precipitation, and high months are June to September, with an average of 13 days of precipitation.

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 80-85%.

Seasonality

Hainan Island has dry and rainy seasons. The rainy season is from May to September, the cool dry season is from November to March, and the hot season is from April to September. The hottest month is generally July, and the coolest is January.

Topography

Hainan Province has an area of 38,000 km^2 and is situated 108°37’ to 111°03’east longitude and 18°10’ to 20°10’ north latitude. The proportion of various landforms to the total area of the province is as follows: mountains, 38.7%; hills and hillocks, 49.5%; and plain areas, 11.2%. The elevation varies greatly; Wutzushan Mountain, located in the middle of island, is 1,811 m above sea level, while the coastal area is only 0-20 m above sea level.

Geology/Soils

The coastal area has soils of sand and silt, the interior area of red loam, and the river estuary areas were formed by continual deposition of clay, silt, and sand.

Layout of Hainan University

Hainan Province map

Haikou city map

Description of Hainan University

Map Coordinates	Elevation
20°05'N and 110°10'E	5-6 m

General

Hainan University, financially supported by both the Ministry of Education and Hainan Provincial Government, is the only comprehensive and key university in Hainan Province. It is located in the beautiful seaside city of Haikou. It covers an area of 500 acres and borders the sea on the north in a setting that is characterized by picturesque scenery and amiable climate. Hainan University has a relatively large scope and strength with a balanced multi-level system of graduate, undergraduate, higher vocational education, as well as adult and foreign student education. The university has 14 colleges and two general teaching departments. Hainan University currently offers 44 graduate programs including MBA, MPA and JM programs, 34 undergraduate programs and 10 higher vocational education programs. The school has a modern library and a well-equipped information center with internet access. It has a faculty numbering over 1,300 and on-campus student enrollment over 20,000. About 62% of the 661 full-time teachers hold a master's degree or above, while 104 hold doctoral degrees. Since its establishment, the university has produced about 30,000 graduates of different specialties. Hainan University attaches great importance to international exchange and cooperation. Consequently, it has established an inter-university relationship with universities in the U.S., the U.K., Canada, Japan, Australia, and Singapore. Thousands of international students from Asia, Europe, America, and Oceania have studied at the university.

Water Supply

Supply water for the HNU pond complex comes from Haikou Bay. The pH of this source was neutral and the salinity ranged from 15-25. Ammonia-N was 0.02-0.05 mg/L, and nitrate-nitrite-N was 0.005-0.01 mg/L. Reactive phosphorus was measured at 0.05-0.20 mg/L.

Support Facilities at HNU

HNU has closely followed the tracks of international scientific development and the spread of aquaculture science and technology. HNU's scientific and technological network comprises three principal systems: (1) basic theoretical research of modern biology, which centers around Molecular Biology, Cell Biology, Developmental Biology and Environmental Biology; (2) applied research, which combines genetic improvement technology of traditional animals, botany and microbiology with bioengineering technology; and (3) application development research, which integrates with improved varieties, better farming methods, effective cropping systems, farm produce processing and technical extension.

HNU has a close working relationship with national universities, research institutes related ministries and department and local offices to enhance opportunities for collaboration, exchange, and facility sharing. HNU has established linkages with many major international organizations, as well as training and research institutes worldwide. International cooperation at HNU comprises many facets: cooperation with international organizations and governments, twinning programs with universities and research institutes, and sharing knowledge with other institutions. HNU has been innovative in developing new concepts in training as well as new approaches to doing research.

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HUAZHONG AGRICULTURAL UNIVERSITY (HAU)

Huazhong Agricultural University (HAU)

Site Status

Active companion site in China since 2005

General Location

No. 1, Shizishan Street, Hongshan District, Wuhan City, Hubei Province, China. Huazhong Agricultural University is situated in central China, extending across two major river systems—the Yangtze and Hanjiang. It is approximately 1,120 km south of Beijing.

Description of Area/Region

Climate

Hubei Province has a subtropical monsoon climate. It enjoys abundant sunlight, with the annual solar radiation totaling 85-114 kcal/cm2 and annual duration of sunshine averaging 1,200-2,200 hours.

Temperature

Annual averages: 15 – 17°C
Range of monthly averages: 4 – 28°C
Absolute minimum: -3 – -14.9°C
Absolute maximum: 40 – 41°C

Precipitation

0.8 – 327.5 mm per month and 974 – 1,115 mm annually; low months are November to February, with an average of 1 day of precipitation; high months are May to August, with an average of 15 days of precipitation.

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 78-80%.

Seasonality

In the Yangtze River Basin, Hubei Province has four seasons, with great temperature variation throughout the year. The rainy season is from May to August, the cool dry season is from November to February, and the hot season is from June to August. The hottest month is generally August, and the coolest is January.

Topography

Hubei Province lies in the middle reach of the Yangtze River with an area of 186,000 km2. Situated 108°21'-116°07' east longitude and 29°05'-33°20' north latitude, it is located in the transitional region from the second to the third terrace in the terrain of China, thus having a variety of landforms. It is surrounded by Wuling, Wushan, Daba, Wudang, Tongbai, Dabie, and Mufu mountains on the west, north, and east. Lying in the central and southern parts is the Jianghan Plain which extends to Hunan Province to link with the Dongting Lake Plain. Except for the hills on the fringes of the plain, the altitude on the plain is 35 m or lower above sea level. The proportion of various landforms to the total area of the province is as follows: Mountains, 55.5%; hills and hillocks, 24.5%; and plain and lake areas, 20%. The elevation of different parts varies greatly. Shennong Summit, the highest peak of Shennongjia in west Hubei, which is known as the "Roof of Central China," is 3,105 m above sea level, while Tanjiayuan of Jianli County on the eastern plain has an elevation of zero.

Geology/Soils

Hubei Province was formed by the continual deposition of clays, silts, and sands by the Yangtze River during annual flood periods, resulting in depths of alluvial material exceeding 30-70 m, depending on the area. Heavy clay soils are typical in the surface layer, then an organic matter layer at 30-80 cm depth, and then acid sulfate soil layer.

Description of Huazhong Agricultural University (HAU)

Map Coordinates	Elevation
30°33’52”N and 114°15’45”E	50-51 m

General

Huazhong Agricultural University, directly administrated by the Ministry of Education of P. R. China, is one of the national key universities. It is located in Wuhan City, the capital of Hubei Province and “a thoroughfare to nine provinces” known in history. Enclosed with emerald tree-covered Lion Hill and fascinating waters on three sides, the campus featured by its beautiful surroundings serves as an ideal place for education and scientific research. The university covers an area of 4.95 km2. HAU comprises 13 colleges, 2 affiliated departments, and has 48 undergraduate specialties, 59 master’s specialties, 44 doctoral specialties, and 6 post-doctoral mobile stations, 6 national key disciplines and 18 ministerial and provincial key disciplines. In addition, there are 9 national engineering research centers, a national basic sciences research training center for teachers of biology, 2 national key laboratories, 7 ministerial and provincial key laboratories, 24 research institutes, as well as 8 other centers.

Presently, the number of full-time students is about 16,000, 3,000 of whom are postgraduates. Adult education students total over 10,000. HAU boasts a highly qualified teaching contingent of 954 teachers, 165 of which are full professors, and 354 associate professors. Moreover, embodied in the teachers’ rank are academicians, 2 from the Chinese Academy of Sciences, 2 from the Chinese Academy of Engineering, 5 members of the Academic Degree Commission of the State Council, 140 doctorate advisors, and 56 young and middle-aged state-level, province-level or ministry-level experts.

HAU is very active in international exchange and cooperation and has established inter-university exchanges and technological cooperation with more than 30 universities and scientific institutions abroad. Every year, more than 100 teachers are sent overseas for advanced studies, visits, and cooperative research. Meanwhile, HAU invites over 100 scientists, technologists, and cultural experts from abroad to lecture and teach. Every year HAU organizes or co-organizes international symposiums or conferences. In the last ten years, HAU has received over 100 foreigners from 32 countries for advanced studies and technical training.

Water Supply

Supply water for the HAU pond complex comes from Yangtze River. The pH of this source was neutral and the total alkalinity ranged from 30-50 mg/L. Ammonia-N was 0.01-0.05 mg/L, and nitrate-nitrite-N was 0.01 mg/L. Reactive phosphorus was measured at 0.05-0.20 mg/L.

Soils

In the Yangtze River Basin, HAU has heavy clay soils in the surface layer, an organic matter layer at 30-80 cm depth, and then an acid sulfate soil layer.

Support Facilities at HAU

In accordance with the research guiding ideology of "strengthening basic research and highlighting high and new technology, its industrial research and application development research," HAU has closely followed the tracks of international scientific development and focused on agricultural science and technology. HAU's scientific and technological network comprises three principal systems: (1) basic theoretical research system of modern biology, which centers around Molecular Biology, Cell Biology, Developmental Biology, and Environmental Biology; (2) applied research system, which combines genetic improvement technology of traditional animals, botany and microbiology with bioengineering technology; and (3) application development research system, which integrates with improved varieties, better farming methods, effective cropping systems, farm produce processing and technical popularization.

HAU has a close working relationship with national universities, research institutes, related ministries, and department and local offices to enhance opportunities for collaboration, knowledge, and facility sharing. HAU owns 9 national engineering research centers, a national basic sciences research training center for teachers of biology, 2 national key laboratories, 7 ministerial and provincial key laboratories, 24 research institutes, as well as 8 other centers. Key labs at national level include National Key Lab of Agromicrobiology, National Engineering Research Center of Microbe Pesticides, National Research Center of Plant Genes, National Research Center of Livestock Engineering Technology, National Research Center of Rapeseed Engineering Technology, National Crop Molecular Breeding Center, National Center of Rapeseed Genetics Improvement (Wuhan), National Indoor Conservation Center for Virus-free Germplasms of Fruit Crops, and National Citrus Breeding Center. Key labs at ministry level include Key Lab of Pig Genetics Improvement of Ministry of Agriculture, Key Lab of Food Security of Ministry of Agriculture, Lab of Preventive Veterinary Medicine of Hubei Province, Research Center of Rapeseed Engineering Technology of Ministry of Education, Research & Development Center of High Quality Hybrid Rapeseed of Central China, Verifying & Inspecting Center for Agromicrobiological Products of Ministry of Agriculture, Base of Rapeseed Breeding of Ministry of Agriculture, Key Lab of Microbiology of Ministry of Agriculture, Key Lab of Soil Resources and Environment for Subtropic Zone of Ministry of Agriculture, Lab of Standard for Rudimental Veterinary Examination of Ministry of Agriculture, and Center of Swine Control of China (Wuhan). Besides the usual labs and academic buildings, the main campus includes housing, sports, and medical facilities, an international conference center, and a library with over 7,300,000 volumes and 80,130 print and on-line periodicals.

HAU has become a leading regional institution and is actively working with public and private sector partners throughout the region and with some of the top universities in the world. Research at HAU is oriented toward the sustainable development of the region, strengthening knowledge, development, and business capacity of the region, and supporting communities and their economic development and integration into the global economy. HAU has also built a broad network of international cooperation. It has established linkages with many major international organizations, as well as training and research institutes worldwide. To this end, HAU is striving for a distinct profile in agricultural areas.

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WUHAN UNIVERSITY (WHU)

Site Status

Active companion site in China since 2005

General Location

LuoJiaShan Street, Wuchang District, Wuhan City, Hubei Province, China. Wuhan University is situated in central China, extending across two major river systems—the Yangtze and Hanjiang - and is approximately 1,120 km south of Beijing.

Description of Area/Region

Climate

Hubei Province has a subtropical monsoon climate. It enjoys abundant sunlight, with the annual amount of solar radiation totaling 85-114 kcal/cm2 and annual duration of sunshine averaging 1,200-2,200 hours.

Temperature

Annual averages: 15 – 17 ºC
Range of monthly averages: 4 – 28ºC
Absolute minimum: -3 – -14.9 ºC
Absolute maximum: 40 – 41ºC

Precipitation

0.8 – 327.5 mm per month and 974 – 1,115 mm annually; low months are November to February, with an average of 1 day of precipitation; and high months are May to August, with an average of 15 days of precipitation.

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 78-80%.

Seasonality

In the Yangtze River Basin, Hubei Province has four seasons, with great temperature variation throughout the year. The rainy season is from May to August, the cool dry season is from November to February, and the hot season is from June to August. The hottest month is generally August, and the coolest is January.

Topography

Hubei Province lies in the middle reach of the Yangtze River with an area of 186,000 km2. Situated 108°21'-116°07' east longitude and 29°05'-33°20' north latitude, it is located in the transitional region from the second to the third terrace in the terrain of China, thus having a variety of landforms. It is surrounded by Wuling, Wushan, Daba, Wudang, Tongbai, Dabie, and Mufu mountains on the west, north, and east. Lying in the central and southern parts is the Jianghan Plain which extends to Hunan Province to link with the Dongting Lake Plain. Except for the hills on the fringes of the plain, the altitude on the plain is 35 m or lower above sea level. The proportion of various landforms to the total area of the province is as follows: Mountains, 55.5%; hills and hillocks, 24.5%; and plain and lake areas, 20%. The elevation of different parts varies greatly. Shennong Summit, the highest peak of Shennongjia in west Hubei, which is known as the "Roof of Central China," is 3,105 m above sea level, while Tanjiayuan of Jianli County on the eastern plain has an elevation of zero.

Geology/Soils

Hubei Province was formed by the continual deposition of clays, silts, and sands by Yangtze River during annual flood periods, resulting in depths of alluvial material exceeding 30-70 m, depending on the area. Heavy clay soils are typical in the surface layer, an organic matter layer is at 30-80 cm depth, and then an acid sulfate soil layer.

Layout of Wuhan University

Description of Wuhan University

Map Coordinates	Elevation
30°33’52”N and 114°15’45”E	50-51 m

General

Wuhan University, directly administered by the Ministry of Education of P. R. China, is one of the national key universities. It is located in Wuhan City, the capital of Hubei Province and “a thoroughfare to nine provinces” known in history. Since it has a beautiful landscape and an atmosphere of humanity, the university has been renowned as “one of the most beautiful universities in the world” and “the cradle of innovative talents.”

Approved by the State Council and founded on 2 August 2000, the new Wuhan University is an amalgamation of the original Wuhan University, Wuhan University of Hydraulic and Electrical Engineering, Wuhan Technical University of Surveying and Mapping, and Hubei Medical

University. The new Wuhan University (named Wuhan University hereinafter) has vast potential because it is a combination of 4 first-rate universities in China or in the province. Wuhan University of Hydraulic and Electrical Engineering was the country's best university of comprehensive strength, Wuhan Technical University of Surveying and Mapping was the best university in the disciplines of survey and cartography in the world, Hubei Medical University was the province's one key medical university and was established before 1949. The new university is a natural whole with the disciplines of philosophy, economics, law, education, literature, history, sciences, engineering, agriculture, medicine, and management. Its 45,000 students include 12,000 postgraduates. It has been authorized by the State Council to set up graduate schools, with 143 doctoral degrees, 217 master's programs, and 15 post doctoral circulation stations. Another 20 stations have been evaluated as state-level key disciplines, and 20 are listed as "211 Project" key disciplines to be constructed by the state.

The university now has 5,000 teachers, including 3,000 professors and associate professors, 570 doctorate supervisors, 4 academicians of Chinese Academy of Sciences, 5 academicians of the Chinese Academy of Engineering, and 2 academicians of the international Eurasian Academy of Sciences. The university has also 22 disciplines offering "the Changjiang River program awarding scholars" for posts with the specially appointed professors.

Water Supply

Supply water for the WHU pond complex comes from Yangtze River. The pH of this source was neutral and the total alkalinity ranged from 30-50 mg/L. Ammonia-N was 0.01-0.05 mg/L, and nitrate-nitrite-N was 0.01 mg/L. Reactive phosphorus was measured at 0.05-0.20 mg/L.

Soils

In the Yangtze River Basin, WHU has heavy clay soils in the surface layer, then organic matter at 30-80 cm depths, followed by deeper acid sulfate soil.

Support Facility at WHU

Wuhan University boasts a campus which covers an area of 5,508 mu and it has an area of 2.42 million m2. There are large modernized teaching buildings, laboratory buildings, gymnasiums, sports grounds, swimming pools, archive buildings, and a specimen building with more than 200,000 animal and plant specimens. The university's libraries have a collection of approximately 5.2 million volumes, subscribe to more than 10,000 kinds of Chinese and foreign periodicals, are the central-China center officially decided for "211 Project" documents—the ensuring system of Chinese universities and colleges. It now has two key state-level laboratories, three state-level discipline laboratories, two state-level research centers in engineering, six national research bases for humanities and social sciences, and seven national bases for fostering basic science personnel. Over 20 academic periodicals, *Wuhan University Journal* included, are published by the university, which has its own presses including an audiovisual material publishing house, colleges for foreign student education and adult education, East Lake branch school, and three attached hospitals which are all of first-class.

The university's course over the past 100 years has been closely bound with the prosperity and decline of the motherland. It always has regarded China's rejuvenation as its own responsibility and made contributions to the prosperity of China and the progress of mankind. On the occasion of its centennial celebration in 1993, Jiang Zemin, Li Peng, and other party and state leaders

presented their inscriptions of congratulations, while 47 colleges and universities aboard including Harvard University, Yale University, Tokyo University and various fraternal colleges and universities at home either sent representatives to attend the celebration or sent letters of congratulations. In November 1995, Wuhan University was listed as one of China's most celebrated universities by the journal *Science*. In the meantime, the university also successfully passed preliminary qualification assessment for the "211 Project" and was included in the priority project for the development of national key universities.

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NEPAL

Introduction

Nepal is a companion site for the work AquaFish CRSP in Asia. The program is affiliated with the Institute of Agriculture and Animal Science in Rampur. The focus of current work is on increased production and improved aquaculture productivity by incorporating tilapia and the native fish sahar (Tor putitora) into carp polyculture.

Inland aquaculture and fisheries are the only source of fish production in Nepal. Total fish production is 48,230 mt, with 21,500 mt (about 45%) coming from capture fisheries (DoFD, 2010). Current annual fish production of Nepal aquaculture systems is about 3.3 t/ha (DoFD, 2010). Increasing fish productivity as well as total production in country is a challenging task and necessary in order to provide for increasing demand for fish as food without increasing import from neighboring countries. Nile tilapia (*Oreochromis niloticus*) was introduced in Nepal in 1985 (Pantha, 1993), however, it remained in government control for more than 10 years (Shrestha and Bhujel, 1999). We have worked on tilapia and sahar (Tor putitora) combinations in polyculture to control excessive recruitment of tilapia and also to provide additional species to increase productivity and to promote culture of high value fish that are indigenous.

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Shrestha, M.K., and R.C. Bhujel, 1999. A preliminary study on Nile tilapia (*Oreochromis niloticus*) polyculture with common carp (*Cyprinus carpio*) fed with duckweed (*Spirodela*) in Nepal. Asian Fisheries Science, 12: 83-89.

INSTITUTE OF AGRICULTURE AND ANIMAL SCIENCE (IAAS)

Site Status

Active companion site, South Asia, since 2001

General Location

Rampur, Chitwan, Nepal. IAAS is located near the town of Narayangarh, in the southern portion of the Nepal's central plain and approximately 160 km southwest of Kathmandu.

Description of Area/Region

Climate

Humid sub-tropical, wet-and-dry type, distinct dry and rainy season.

Temperature

Annual averages: 24.7ºC
Range of monthly averages: 18.0 – 30.6 ºC
Absolute minimum: 7.8 ºC
Absolute maximum: 37.9 ºC

Precipitation

0.6 – 626.5 mm per month and an average of 2,323 mm annually; low month is January, with an average of 1.5 day of precipitation; high month is July, with an average of 29 days of precipitation.

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 85%.

Seasonality

Nepal has clearly defined wet and dry, hot and cool seasons, with wide temperature variation throughout the year. The rainy season is from June to October, the cool dry season is from November to February, and the hot dry season is from March to May. The hottest month is generally April, and the coolest is January.

Topography

Chitwan is a valley surrounded by Silwalik Range in north and Churiya Range in the east, west, and south.

Geology/Soils

The area is the watershed of Narayani River. The soil is sandy loam.

Layout of IAAS

Description of IAAS

Map Coordinates	Elevation
27°38’14.1” N and 84°21’25.2” E	257 m

General

The IAAS, Rampur campus occupies an area of approximately 210 ha near the town of Narayangarh, southwest of Kathmandu. IAAS’s research pond complex is one of several aquaculture facilities operated by its Aquaculture Department. It includes 38 earthen ponds ranging from 100 to 450 m2 in size, 18 concrete tanks of 24 m2 in surface area, and an area for growing terrestrial crops that may be of interest as fish feed components. An adjacent area is used for rearing livestock and poultry (ducks) that can be used in integrated aquaculture research. Other facilities include a laboratory complex that houses instruments for measurement of the biological, physical, and chemical parameters of importance in aquaculture, and a covered hatchery area. The hatchery facility includes indoor tanks and a well water supply system.

Water Supply
Supply of water for the IAAS pond complex comes from underground water having pH of 8.3 and total alkalinity of about 130 mg/L as CaCO3.
Soils
Sandy loam.

Affiliations	
In-Country	US
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Current Contacts	
In-Country	US
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Cage cum pond facility in Nepal.

VIETNAM

Introduction

Vietnam is a companion site for the work AquaFish CRSP in Asia. The current program is affiliated with the University of Agriculture and Forestry in Ho Chi Minh City. The research program will be conducted at Tri An Reservoir, which is about 75 km northeast of Ho Chi Minh City.

The southeast of Vietnam is characterized by uphill geography. To support agriculture in this area, more than 50 small reservoirs (from 10 to 50 ha) and about 10 medium reservoirs (200 – 400 ha) were built for irrigation. In Binh Phuoc and Dong Nai provinces, many surrounding communities make use of the large water area (<50 ha) by stocking cultured fish species into reservoirs. This has been hypothesized as damage to natural fish populations, but there are no formal analyses about that and no evidence on reasons for these changes. Moreover, there has been no evaluation of the impact of water quality from reservoirs used for fish culture on the use of that water for irrigation.

UNIVERSITY OF AGRICULTURE AND FORESTRY (UAF) FACULTY OF FISHERIES (FOF)

Site Status

Active companion site, Southeast Asia, since 2001

General Location

Located at Linh Trung ward, Thu Duc District, Ho Chi Minh City (HCMC), Vietnam. UAF started as an agricultural institution catering mainly to the eastern part of South Vietnam, the northern part of the Mekong Delta, and the Western Highland.

Description of Area/Region

Climate

The climate and weather are dominated by the tropical monsoon regime with a hot, rainy season (May to October) and a warm, dry season (November to April)

Temperature

Annual averages: 23.5 – 28.2 °C
Absolute minimum: 13 – 22 °C
Absolute maximum: 34 – 40 °C

Precipitation

1500mm–2400mm annually; the low month is February, with an average of one day of precipitation; while the high month is September. There is sunshine for about 2,000 hours a year.

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 78-80%

Seasonality

Vietnam has a single rainy season during the monsoon (May-October). Rainfall is infrequent and light during the remainder of the year. The hottest month is generally May; the coolest is January. Occasional typhoons from May to January produce extensive flooding.

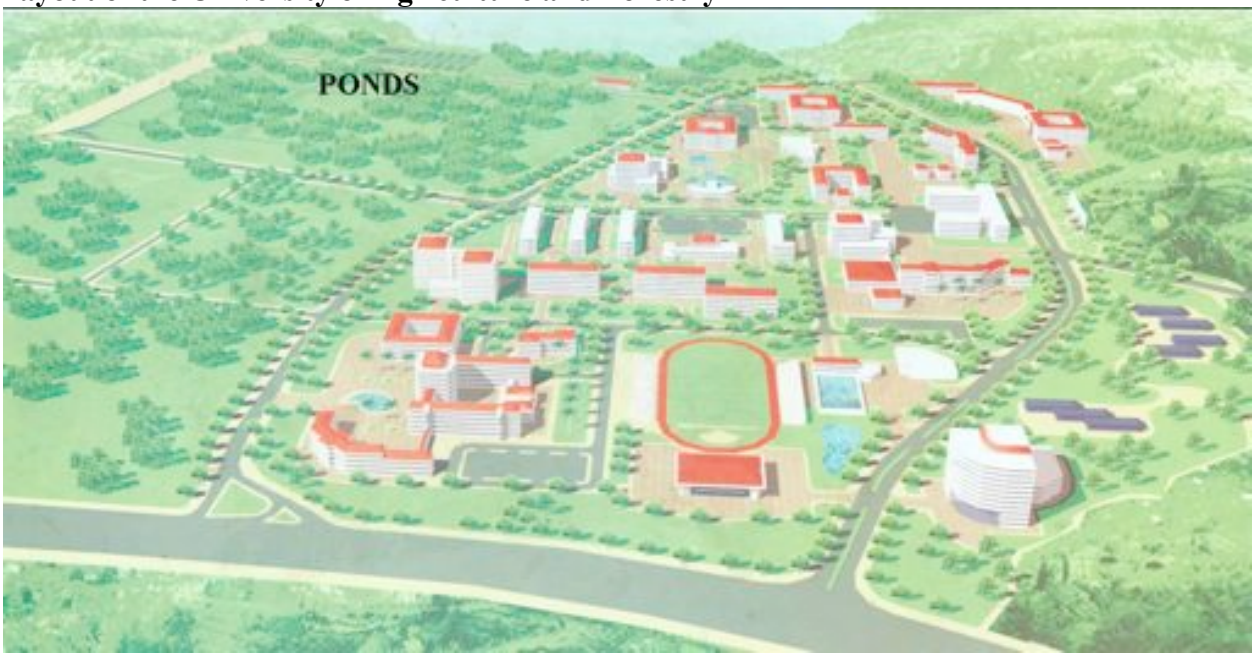
Topography

Thu Duc, where UAF is located, is in the floodplain next to Saigon River. The region was formed by continual deposits of silts and clays by Saigon and Dong Nai rivers. The undulating area is not far from the lowland between the two rivers.

Geology/Soils

Acid soil: 2091 ha, to occupy 44% of the density
Gray soil: 1180 ha, to occupy 25% of the density
Gray-yellow soil: 1130 ha, to occupy 23% of the density

Layout of the University of Agriculture and Forestry



Description of the University of Forestry and Agriculture

Map Coordinates	Elevation
10o49' N and 106o47'86" E	1.4 – 14 m above sea level

General

The Faculty is located on the second floor, left wing of the main building of the University of Agriculture and Forestry, with offices, working rooms for lecturers, classrooms, and laboratories. The Faculty has four 150 m2 laboratories for hydrobiology, ichthyology, fish processing, and aquaculture.

The experimental farm has a 5,000 m2 surface area, with 30 concrete tanks (2-6 m3) for experiments, and a circular tank for spawning of Chinese carps. The Faculty also has a 3-ha farm for experiments with fish. A laboratory is under construction there.

Most of the equipment for conducting experiments is in fair condition. The Faculty has had a lack of adequate equipment in the past, but has been cooperating with Asian Institute of Technology in collaborative research and in improving technical capacity for seven years (from 1994). Over that time, the facilities of the Faculty havegradually improved.

Water Supply

Supply water for the pond complex comes from a network of rivers, canals, irrigation, and hydroelectric reservoirs. Ground water sources are affected by acid. In 1999, the pH of this source was 6-8; dissolved oxygen was 6.25 mg/l; turbidity was 3.5 cm.

Soils

The pond soil is laterite, relatively acidic and porous to water.

Support Facilities at UAF
To enhance teaching and research capabilities and to upgrade staff, the Faculty has established academic linkages with several foreign universities, institutions, and NGOs such as Asian Institute of Technology (Thailand) in the field of aquaculture and curriculum development; CIRAD & ORSTOM (France) in the field of exchange of research and staff members; Auburn University in the field of information exchange and SAREC and Antenna Technology (Switzerland) in the field of extension.

Affiliations	
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TRI AN RESERVOIR

Fish buying station on the shore of Tri An Reservoir. (Photo by Peg Herring)

Fish market area.

Tri An Reservoir

Site Status

Tri An Reservoir was constructed in 1984, and has been generating electricity from 1988 to present.

General Location

Tri An Reservoir is located in Dongnai Province, on the Dongnai River, approximately 75 km northeast of Ho Chi Minh City.Tri An Reservoir is the largest reservoir in Vietnam, with 324 km2 surface area and 15.05 billion m3 of water storage capacity. It has an electric capacity of 420 MW, generating an average of 1.7 x 109 KW hour year-1.

Description of Area/Region

Climate

Köppen classification **Aw** Humid tropical group (A), tropical wet-and-dry type (w). Distinct dry and rainy seasons are observed.

Temperature

Annual averages: 25.4 ºC
Range of monthly averages: 23.7 – 27.2 ºC

Precipitation

Annual total rainfall for the area: 2,428 mm
Lowest rainfall data: 10 mm in January and April
Highest rainfall data: 585 mm in July

Humidity
The annual mean relative humidity: 82%. Range of monthly averages: 70.2 –88.9%
Seasonality
Vietnam has a single rainy season during the monsoon (May-October). Rainfall is infrequent and light during the remainder of the year. The hottest month is generally May; the coolest is January. Occasional typhoons from May to January produce extensive flooding.
Topography
The overall region was formed by continual deposits of silts and clays by the Dong Nai River. The reservoir is in a hilly region not far from the lowland between the two rivers.
Geology/Soils
Acid soil: 2091 ha, to occupy 44% of the density Gray soil: 1180 ha, to occupy 25% of the density Gray-yellow soil: 1130 ha, to occupy 23% of the density

Description of the Tri An Reservoir

Map Coordinates	Elevation
11°10'N and 107°9'E	50 m
General	

Size of reservoir

Catchments area: 15,400 km2
Mean reservoir length: 43.5 km
Mean reservoir width: 7.5 km
Maximum depth: 28 m
Total volume 2.76 km3
Mean area 323.4 km2

Water quality

Water temperature 24.5-30.3ºC
pH 6.6-7.5
DO 6-8 mg/L
Total nitrogen < 1mg/L
Nitrate 0.1-0.5 mg/L
Ammonia 0.006-0.5 mg/L
Total phosphorus 0.02-0.1 mg/L

Aquaculture activities

There are two basic methods of reservoir-based aquaculture in Tri An Reservoir: open stocking and the use of cages, pens, and coves. Culture-based fisheries were set up in Tri An Reservoir soon after flooding, and supplied from 2,000 to 2,500 tons of fish production for 1,234 fishing households in 1997. Cage culture began in 1995, with 598 cages, contributing 400 tons of table fish. Pen and cove culture have developed in recent years.

Support Facilities

Tri An Reservoir is within driving distance of the UAF campus. It has numerous cages used for aquaculture purposes, coves used in cove culture, and a wild fishery that harvest fish for sale near Dong Nai. There are limited research facilities in the area, but good access to boats and other logistic support for field collections. Research facilities are available at UAF.

Affiliations	
In-Country	US
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CAMBODIA

Introduction

Site Selection

The research site selected in **Cambodia** is based on the following criteria:

1. Fishery and other aquatic resources to be investigated are major sources of food and income for the population living along the Lower Mekong River Basin of Cambodia;
2. The primary Cambodia Lower Mekong River Basin site is representative of the ecological zone of fisheries and other aquatic resources; the primary site could serve as the activating nucleus of a scientific network for information and technology transfer and exchange, depending on the fishery resources to be investigated;
3. The Royal Government of Cambodia (RGC) is interested in participating in the AquaFish CRSP and is willing to make adequate commitments to support the research and assist the neighboring network countries (especially Lao PDR, Thailand and Viet Nam);
4. There exists in Cambodia the basic institutional research capacity needed to make collaborative research viable; this capacity would be found at Inland Fisheries Research and Development Institute (IFReDI) where it has responsibility for research in areas related to the AquaFish CRSP activities;
5. The RGC policies and plans are very supportive of fisheries research, extension, and production; and
6. There is reasonable assurance of political and economic stability and ability to sustain a viable research program.

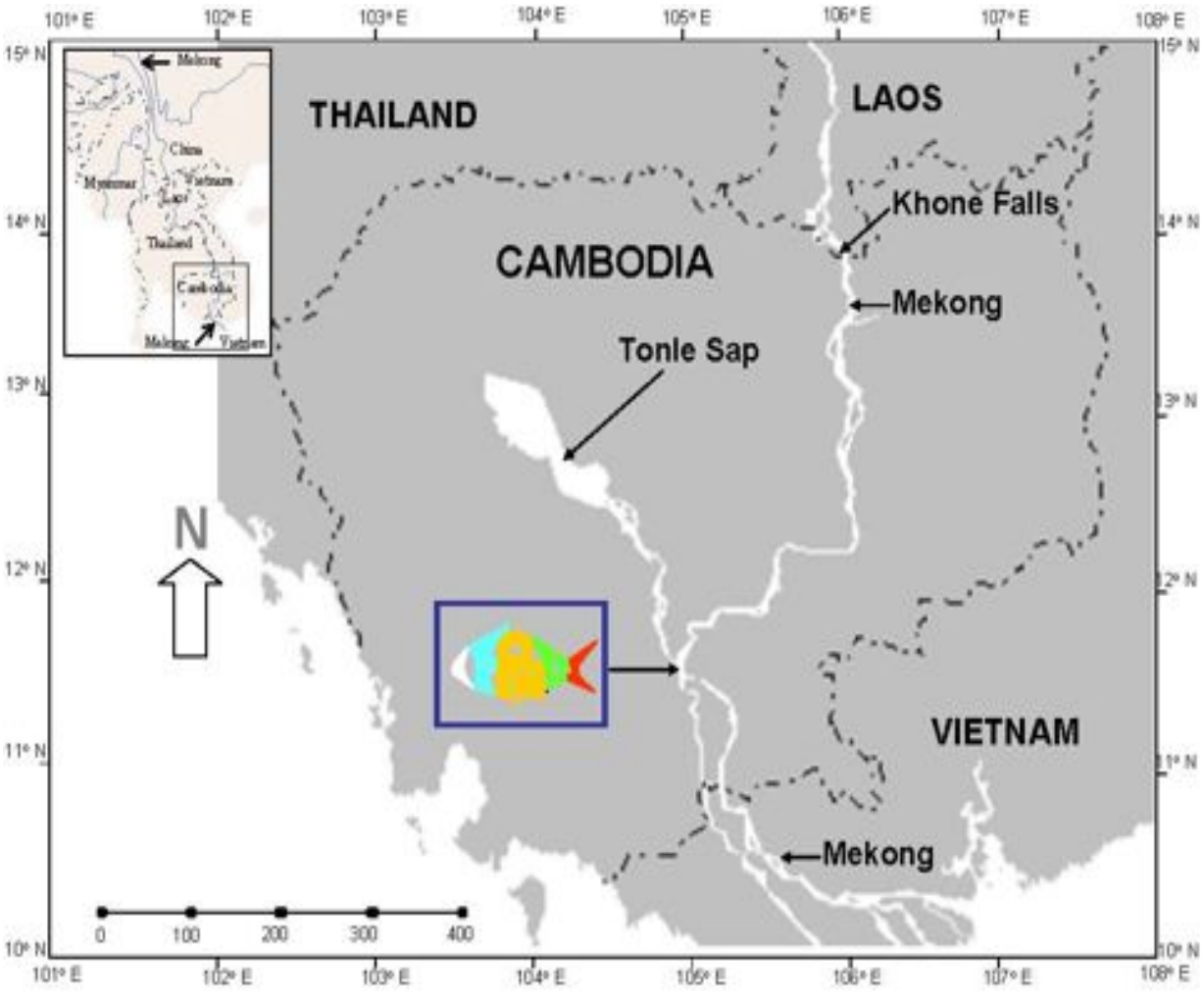
The site selected in **Cambodia** is based on the following specific criteria:

1. There is available existing physical infrastructure including laboratory facilities, communications, housing, transportation, roads, and access;
2. The Inland Fisheries Research and Development Institute (IFReDI), the only fisheries R&D institute in the country, is responsible for generating and communicating knowledge of inland fisheries resources in Cambodia. IFReDI can lead the Project and provide research collaboration to the AquaFish CRSP;
3. The project and project site have been supported in the past by the USAID Mission in Cambodia;
4. Cambodia is politically stable and has good working conditions for the HC and US participants;
5. There are adequate and safe working conditions for the HC and US participants;
6. The Project deals with only native, wild fish species permitted for research in the country. It specifically deals with snakehead fish;
7. All costs budgeted in the project proposal will cover the research needs of the project;
8. Cambodia is one of the largest fish eating countries in the region (based on official statistics, 30-40 kg/caput, and household surveys, 60-70 kg/caput), so fisheries and aquaculture production are crucial for all Cambodians in terms of food and household income. IFReDI has strong linkages with the research and extension network in all 24 provinces and cities in the country;
9. The language of communication is Khmer in the whole country, and the second one is English, which is mostly used by researchers, government and non-government officers, and private sector.

10. The vision of the Cambodia fisheries sector as described in the Fisheries Development Action Plan (2005 – 2008) (FDAP 2005-2008) is that "Ensuring the supply of fish and fishery products will keep pace with increasing demands to safeguard the nutritional standards, and the social and economic well-being of communities depending on fisheries for their livelihoods". The goal of the fisheries sector as described in the FDAP is to maximize the contribution of fisheries to the achievement of national development objectives, especially those related to improving rural livelihoods of the poor, enhancing food security and the sustainable development and equitable use of the fisheries resource base. One of the six fisheries sector priorities highlighted in the FDAP is to improve livelihood of poor rural people by enhancing the role of fish in food security, employment and income generation by ensuring the sustainable use of aquatic resources, and by increasing community and household production levels through rural aquaculture development as well as to reduce the pressures on natural fisheries resources.
11. An ecological significant site- the lower Mekong River basin representing one of the most fish productive basins in the world, ranked third after Amazon and Congo River basin
12. As stated in the original proposal, there is a strong possibility to leverage funds from other donors such as ACIAR and EU.

Water market on the Tonle Sap, where vendors come to buy and sell fish (Photo by Peg Herring)

INLAND FISHERIES RESEARCH AND DEVELOPMENT INSTITUTE (IFREDI)



Location map showing research site (IFReDI) in the Cambodia Mekong River Basin (After So, 2005).

Inland Fisheries Research and Development Institute (IFReDI) building located in Phnom Penh, Cambodia.

Aquatic biodiversity researches at IFReDI has also included work in the area of freshwater low-valued or small-sized wild fish diversity.

Inland Fisheries Research and Development Institute (IFReDI)

Site Status

Active Prime Site, Southeast Asia; 2002 to present.

General Location

Fisheries Administration, Phnom Penh, CAMBODIA

Description of Area/Region

Overall Description

Lies in the heart of the capital of Phnom Penh, the largest city in Cambodia.

Climate

Köppen classification **Aw**: *Humid tropical* group (A), *tropical wet-and-dry* type (w). Distinct dry and rainy seasons are observed.

Temperature

The temperatures are remarkably and uniformly warm throughout the year and subject to small variation due to elevation, season and maritime influences. Temperatures are high except during the early part of the north-eastern monsoon when occasional outbreaks of cool air from central Asia sweep over the land. Cool spells occur during December and January; while from the end of February to the break of the monsoon is hot and dry. These conditions last until the southwest monsoon commence in May. Mean minimum temperature is 22oC in the area. Monthly average highs in Phnom Penh range 30-35oC, and average lows range 22-24oC.

Precipitation

The rainfall is generally plentiful, but it is so unevenly and seasonally distributed and largely depends on geographic orientation. Annual average precipitation is 2,000-3,000 mm in low mountains of north-eastern region and 1,400-1,600 mm in south-western coasts. About 90% of the annual precipitation falls between May and October (i.e. the wet or rainy season). The average number of wet days varies from less than one day a month in December and January to more than twelve days a month in August and September. The monthly average precipitations range from 7.6 mm in January to 251.5 mm in October.

Humidity

The relative humidity of the atmosphere is highest in April at slightly more than 80% and lowest in March at just over 60%.

Seasonality

All of Cambodia has a clearly defined wet and dry season, with little temperature variation throughout the year. The rainy season is from May to October and the cool dry season is from November to February. The hot season is from March to May with the hottest month in April and the coolest in January.

Topography

The area is part of Cambodia's vast, nearly level central alluvial plain (the Mekong or Mekong Delta Plain, which extends through Vietnam to the South China Sea through several distributaries and through canals which have been constructed in Viet Nam to regulate flooding), and located at the confluence of the Mekong, Tonle Sap and Bassac rivers. These rivers provide potential freshwater and other resources.

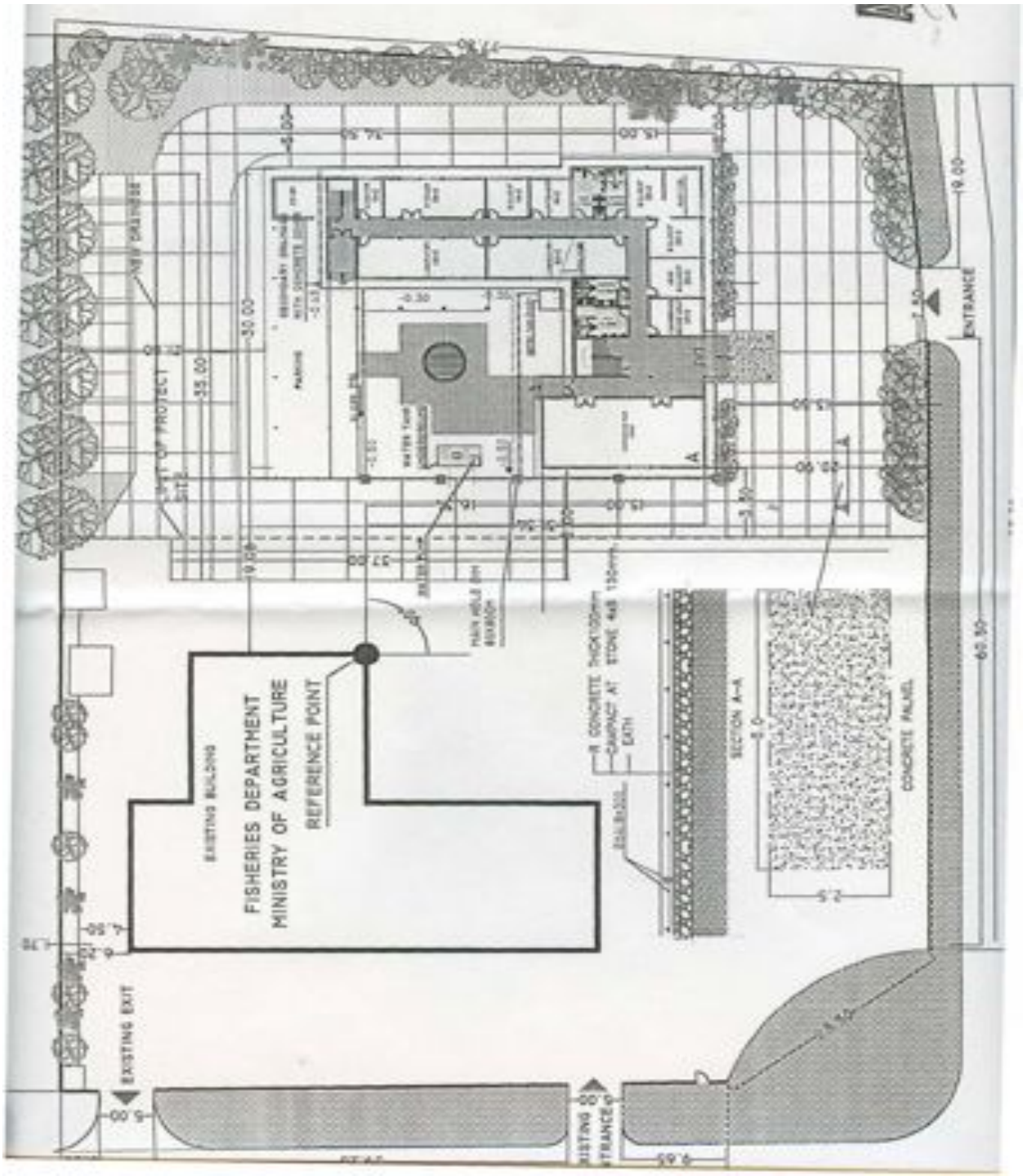
Geology/Soils

Influence of the Mesozoic sandstone and its weathering products is attenuated by Tertiary and Pleistocene igneous geology and by Pleistocene and Holocene sediments that mantle a

considerable proportion of the major rice growing parts of Cambodia. Recent and Pleistocene alluvial/ colluvial sediments that now form the parent material for most of the agricultural soils of Cambodia are substantially derived from the weathering and erosional products of the Mesozoic sandstone. However, low hills from felsic igneous intrusions particularly in south and south-east Cambodia have also supplied siliceous sediments for the recent and older alluvial/ colluvial terraces. In the north-east and west of Cambodia, basaltic lava flows of the Pleistocene cover significant areas of older alluvial terraces. Finally, the sediments deposited by the Mekong River along its flood plain and in the basin of the Tonle Sap means that much of central Cambodia is dominated by recent alluvial/lacustrine sediments derived in part from the Mekong River basin and in part from the immediate basin of the Tonle Sap.

Prahoc processing along the Tonle Sap River (Photo by Prum Somany)

Layout of Inland Fisheries Research and Development Institute (IFReDI)



Description of IFReDI

Map Coordinates	Elevation
11° 33′ 15″ N and 104° 55′ 21″ E	28 m

General

IFReDI occupies an area of approximately 0.5 ha located in the capital city of Phnom Penh. IFReDI, which is under the supervision of the Fisheries Administration, comprises six Divisions listed as follows.

Biological Division,
Laboratory Division,
Socioeconomic Division,
Technology and Information transfer Division,
Kandal Stung Fisheries Research Station, and
Administration Division

Presently the IFReDI has four senior researchers with Ph.D. degrees in biology, development communication and rural/community development from abroad (i.e. Belgium, Japan, Philippines and Vietnam). There are twelve staff members holding M.Sc. degrees in fisheries biology, aquaculture and aquatic resources management, natural resources management, watershed management, agricultural economics, development communication and rural planning and development from abroad (Australia, Malaysia, Philippines, Thailand and Vietnam) and national universities. There are also 24 staff member holding B.Sc. degrees in fisheries science, aquaculture and fisheries economics.

IFReDI staff have extensive experiences in fisheries biology and ecology, aquaculture development, fisheries policy development and planning, fisheries resources development, management and conservation, socio-economics and livelihoods, and participatory fisheries resources management.

IFReDI laboratory complex that houses instruments for measurement of the biological, physical, and chemical parameters of importance in fisheries and aquaculture.

Water Supply

Supply water for IFReDI laboratory comes from public/city water taps and ground water wells.

Soils

The soils at IFReDI are quite acidic, with average pH value of 4.9. They have sand contents averaging 40%, silt 35%, clay 25%, organic C 7.2 mg/kg and total N 0.7 g/kg.

Support Facilities at IFReDI

Laboratory and personnel at the Inland Fisheries Research and Development Institute (IFReDI) are available to the AquaFish CRSP Project. IFReDI has a library, including FAO, MRC, WorldFish Center, Fisheries Administration, and IFReDI research results literature. IFReDI is closely working with various regional and international organizations such as MRC, ADB, WorldFish Center, DANIDA, SIDA, FAO, IFM-Denmark, SEAFDEC, WCS, NACA, IUCN, ACIAR, UNEP, IWMI, JICA, WWF, CI, NEF-Japan, and IAMSLIC for research projects implementation collaboration and research results exchange. Recently IFReDI has singed the Memorandum of Agreement/Understanding with LARReC of Lao PDR, WorldFish Center; University of Sain Malaysia, Laboratory of Global Fisheries Science (University of Tokyo, Japan), Royal Veterinary and Agriculture University (Denmark), Royal University of Agriculture

(Cambodia), and Bangladesh Agriculture University (Bangladesh) to strengthen research collaboration.

In March 2006, the IFReDI research team received the award from the WorldFish Board of Trustees. This is very welcome recognition indeed from the WorldFish Board of Trustees for the extraordinary efforts of the IFReDI capacity building project team. This award is given to just one team from among all of the collaborative efforts the WorldFish Center engages in globally in more than 50 countries. The award is given on the basis of excellence in research and partnerships, and is meant to recognize achievements that make a strong contribution towards the RGC/FiA and WorldFish Center's mission of reducing poverty and hunger by improving fisheries and aquaculture.

Affiliations	
In-Country	US
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Current Contacts	
In-Country	US
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VIETNAM

Introduction

Site Selection

The research site selected in **Vietnam** in the Mekong River Delta (MKD) is based on the following criteria:

1. Aquatic resources are a major source of food and income as well as jobs for about half of the 18.2 million people living in the freshwater areas of the MKD in 2007. During the flooding period, about 70-80% of the households in the deep flooded areas participate in fishing activities. This figure is about 30-50% in the medium and shallow flooded areas;
2. The site in Vietnam is representative of the ecological zone of fisheries and other aquatic resources of the Lower MKD. The primary site could serve as the activating nucleus of a scientific network for information and technology transfer and exchange, depending on the fishery resources to be investigated;
3. The Central Government of Vietnam is willing to participate in the AquaFish CRSP and to make adequate commitments to support the research activities and assist the neighboring network countries (especially Cambodia, Lao PDR and Thailand);
4. Policies and plans of the Vietnamese Government at different levels are very supportive of fisheries research, extension, and production;
5. There is reasonable assurance of political and economic stability and ability to sustain a viable research program; and
6. The College of Aquaculture & Fisheries (CAF) of Cantho University (CTU) has basic institutional research capacity in the Mekong Delta of Vietnam to make collaborative research viable in areas related to the AquaFish CRSP activities.

The site selected in **Vietnam** is based on the following specific criteria:

1. There is available existing physical infrastructure including laboratory facilities, communications, housing, transportation, roads, and access;
2. The College of Aquaculture & Fisheries (CAF) is responsible for training and research on inland fisheries resources in the lower Mekong Delta of Vietnam. The College can lead the Project and provide research collaboration to AquaFish CRSP;
3. The project and project site have been supported by the USAID Mission in Vietnam;
4. Vietnam is politically stable.
5. There are adequate and safe working conditions for the HC and US participants;
6. The project deals with all activities related to capture and use of freshwater wild fish, and feeding of snakehead fish in the MKD of Vietnam;
7. All costs budgeted in the project proposal will cover the research needs of the project;
8. The lower Mekong River basin represents one of the most productive basins for fisheries in the world, ranked third after Amazon and Congo River basins in terms of aquatic biodiversity. In the fresh water bodies of the Delta, there are 145 species of freshwater fish (14 economic fish species) and 13 fresh water prawn species (4 economic species). The total volume of wild fish catch in fresh water bodies of the Delta is from 150,000-200,000 tones, depending on the level of annual floods, covering about 70% of the total capture production of inland wild fish of Vietnam. Aquaculture of MKD often contributes more than 60% of the total aquaculture production of the country. Vietnam is a fish-eating society (statistical data show that fish consumption per capita in 2001 was

19.4 kg, and the reports from household surveys show the figure of more than 30 60-70 kg/caput in the Mekong Delta);

9. The language of communication is Vietnamese in the whole country. English is the most common foreign language, which is mostly used by researchers, government and non-government officers, and private sector.
10. Fisheries, especially aquaculture, is given priority to develop from 2000 in the Mekong Delta of Vietnam. The Government also has the master plan for the development of the fishery sector to 2020, in which inland fisheries will contribute about 0.2 million tones among a total capture production of 2 million tones per year; and more than 2 million tones per year will be produced through aquaculture. In the Master Plan of the fisheries sector, the priorities are to improve livelihood of poor rural people by enhancing the role of fish in food security, employment and income generation by ensuring the sustainable use of aquatic resources, and by increasing community and household production levels through rural aquaculture development as well as to reduce the pressures on natural fisheries resources;
11. CAF of CTU has its own capacity and experience on training, research and extension activities, as well as a network for extension with all 13 provinces and cities in the Mekong Delta of Vietnam; and
12. As stated in the original proposal, there is a strong possibility to leverage funds from other donors such as ACIAR and EU.

The Cantho waterfront in Vietnam on the Lower Mekong River (Photo by Peg Herring)

CAN THO UNIVERSITY (CTU), COLLEGE OF AQUACULTURE AND FISHERIES (CAF)

Can Tho University (CTU) located in Cantho City, Vietnam

College of Aquaculture and Fisheries (CAF)

Laboratory Aquatic nutrition and wet-lab Aquatic nutrition research technology

Cantho University (CTU), College of Aquaculture and Fisheries (CAF)

Site Status
Active Prime Site, Southeast Asia, 1979 to present
General Location
Cantho University (CTU), Cantho City, Vietnam
Description of Area/Region
Overall Description
CAF and CTU are located in Cantho city, the center of the Mekong Delta of Vietnam.
Climate
Köppen classification* Aw*: Humid tropical group (A), tropical wet-and-dry type (w). Distinct dry and rainy seasons are observed.
Temperature
The temperatures are mitigated and warm year around and subject to small variation due to elevation, season and maritime influences. Average temperature is from 26 to 28ºC in the

Mekong River Delta. Lower temperature is from December and January; while it is hotter and dry from the end of February to the break of the monsoon. These conditions last until the southwest monsoon begins in May.

Precipitation

The rainfall is generally high but different by season, and unequally distributed depending on geographic orientation. Annual average precipitation is 1,600-1,800 mm in north-east part of the Delta and more than 2,000 mm in south-western coasts. About 90% of the annual rainfalls are between May and November (i.e. the wet or rainy season). Heavy rains are common in July and August The monthly average precipitations range from about 8 mm in January (dry season) to 250 mm in September (rainy season).

Humidity

The relative humidity of the atmosphere is highest at about 80-85% in September, and lowest in March at the level of about 60-65%.

Seasonality

The weather in the MKD of Vietnam is divided into 2 seasons. The rainy/wet season is from May to November while the dry season lasts from December to the next April. It is hotest in May and April, but coolest in December and January.

Topography

The MKD of Vietnam is a vast and low land area with the total natural area of about 4 million hectares spreads from Cambodia border to East Sea and the Gulf of Thailand. It is famous with 2 flood plains: Dong Thap Muoi and Long Xuyen Quadrangle. There are two main branches of the Mekong River, i.e., Hau and Tien rivers with a cross-network of natural and man-made canals which bring about 500 billion cubic meters of freshwater from upstream to the sea, yearly. In the wet season, water flow of the river in the wet season is about 40,00 m3/s, more than 20 times in comparison with that of dry season.

Geology/Soils

There are two major types of soils in the MKD of Vietnam. Alluvial soils cover 1.1 million ha or about 28%of the area and actual acid soils consist of 1.1 mil. ha (28%). Potential acid soils contribute about 0.5 mil. ha (13%) while saline soils share 0.8 mil. ha (21%), and hilly & peat soils occupy 0.4 mil. ha (10%), approximately.
Alluvial soils are mainly located along the main river branches (Hau and Tien rivers). Actual acid soils and potential acid soils are common in the flood plains. Hilly & peat soils are mainly observed in the areas along Cambodia border and the western coast. Saline soils are mostly located with mangroves in the eastern coast.

In the wet season, water flow of the river is about 40,00 m^3/s, more than 20 times in comparison with that of dry season. There are 9 provinces and cities with about 1.4-1.9 million ha and 9-10 million of people affected by annual floods.

Aquaculture has been encouraged in the delta from the beginning of the 1990s.
Aquaculture production from the Delta is about 60% of the total aquaculture production of Vietnam. Major species for freshwater aquaculture are Pangasius catfish, snakehead, giant freshwater prawn and some native fish species.

Description of the College of Aquaculture and Fisheries (CAF)

Map Coordinates	Elevation
10°1'52"N and 105°45'18"E	1 – 1.2 m

General

The college of Aquaculture and Fisheries (CAF) of Can Tho University (CTU, Website: http//www.ctu.edu.vn) was established in 1979. The main tasks of the College are to train high quality human resources at different degrees; to conduct research programs; and to transfer technologies for the development of the national aquaculture and fisheries sector, especially for the Southern part of Viet Nam. CAF has a strong team of staffs that is well trained from world-wide institutions, and an advanced laboratory system. CAF, therefore has made a long reputation about its activities and has been considered as one of leading aquaculture and fisheries institutions in the region.

The College of Aquaculture and Fisheries has trained thousands of engineers and hundreds masters for the region. Recently, CAF has diversified its academic and training programs in order to meet the increasing demands of society. Presently the CAF have 116 Staffs (3 Assoc. Professors, 18 PhD, 18 PhD students, 20 MSc, 19 MSc students).

CAF is offering different educational programs in the field of aquaculture and fisheries including 7 fields of bachelor degree, 1 field of master degree and two fields of doctoral degree. At the current time, the enrollments include 1,575 undergraduate and 100 post graduate students. The training programs and curricula of CAF are designed to meet the aquaculture and fisheries needs of the MKD region.

Research is one of the main and strong activities of College of Aquaculture and Fisheries (CAF). Research fields of CAF include:
-Aquatic taxonomy, biology, nutrition, physiology, genetic, eco-toxicology, ecology, biodiversity and resources;
-Developing technology for aquaculture systems and seed production;
-Fisheries economics, management, and sustainable development.

Research projects are under different levels, scales, and funding sources including university level, provincial level, ministerial level, national level and international

Water Supply

Water for the operation of laboratories and experiments at CAF is from public water tabs.

Support Facilities at CAF

The aquatic nutrition laboratory has equipment for analysis of nutrition parameters (protein, lipid, mineral, fiber, Energy…). Two web- laboratories are used for nutrition research (100 tanks of 500 litters, 100 tanks of 100 litters….). CAF also has one small miller (200 kg/hours) for aquatic feed processing.

The laboratory of aquatic animal health and diseases has equipment for analysis parameters related to fish pathology (PCR, …).

CAF also has a hatchery and nursery site located about 2 ha from the main campus. This is good for experiments and training of students.

In addition, the central laboratory of Cantho University can help with other analysis for research activities.

Each lecturer and senior researcher has one computer. Two computer labs and a library of CAF also support the students. The central library of Cantho University is a good place to access reading material and the internet, including wireless service.

Affiliations	
In-Country	US
College of Aquaculture & Fisheries Cantho University 3/2 Street, Ninh Kieu District Cantho City, Vietnam	University of Connecticut – Avery Point Agricultural and Resource Economics/CT Sea Grant 1080 Shennecossett Road Groton Connecticut, USA
Current Contacts	
In-Country	US
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MEXICO

Introduction

At the end of the twentieth century, aquaculture has become a world wide alternative mechanism for food production in continental waters as much as in brackish and marine waters.

Mexico is very rich in natural resources, with a variety of natural regions; aquaculture is one of the promised industries for development in the country. The AquaFish project is focused on developing new indigenous marine and freshwater fish species into sustainable aquaculture and establishment of clean techniques on masculinization for Tilapia and native cichlids. Mexico produces more tilapia than any other country in the Americas, 94,279 t in 1996. Tilapia is cultured under extensive and intensive methods and is captured from reservoirs stocked with fingerlings. There are highly developed internal markets and few fish are exported. The government has begun a project to develop three tilapia parks. These parks will be research, education and demonstration sites as well as major production locations. As additional technology is applied, Mexico's tilapia production will expand.

Mexico's government has intense support into aquaculture research, extension and production. From 1990 the "Single Window" program was instituted, the intent of this program was to designate the Subsecretary of Fisheries as the sole contact point for applicants for aquaculture permits. Rather than applying to separate agencies and boards for reviews and permits, one office would handle the entire application and contact pertinent governmental bodies. This procedure has had limited success but it can still take years to complete the process. The bulk of regulations pertaining to aquaculture in Mexico are contained in the 1992 Fisheries Law (Ley de la Pesca Reglamento 1992). It allows for 100% foreign ownership of most aquaculture operations, extended many aquaculture leases from 20–50 years, and simplified transfer and renewal of leases. Also in 1992, a new Water Law was passed. This removed many of the restrictions on use of water for aquaculture, especially opening reservoirs and irrigation canals for cage culture of tilapia.

Tabasco State is the main site of the AquaFish project in Mexico. Tabasco is considered an important wetland ecoregion, containing about 30% of the freshwater resources of Mexico and has a lot of importance like nursery and reproduction areas for many relevant fish species. Facilities and places are located in strategic areas for diverse aquaculture activities focused on quality seed and broodstock and available production for rural and private farmers; facilities help to improve training activities for local farmers. UJAT (Universidad Juarez Autonoma de Tabasco), the State University, is the main research for this project. The University has plenty of support from the government and from private industries.

The four off-site research centers are part of an agreement with the Federal and State government; this agreement includes full support from facilities, staff and diverse resources.

The State of Tamaulipas is also a research site. In this State the fishing industry is well developed because of the state's location on the Gulf of Mexico. The primary catch includes

shrimp, crayfish, oysters, and crabs. Freshwater fish such as tilapia and catfish are also found in the state. There is also a thriving sport fishing industry serving tourists to the state. Oil is the primary mineral resource. The University of Tamaulipas is in charge of the research projects of AquaFish in Tamaulipas. State facilities, University Laboratories, students, and staff are part of the supported unit for conduct of the project.

UNIVERSIDAD JUAREZ AUTONOMA DE TABASCO

Aquaculture Laboratory

UJAT has 3 main areas; Reproduction, Sex Reverse Research, and Nutrition, of these species; Tilapia, Garfish and Native cichlids.

Universidad Juarez Autonoma De Tabasco
Aquaculture Laboratory

Site Status

Prime site

General Location

Aquaculture Laboratory, Universidad Juarez Autonoma de Tabasco, Villahermosa City, Centro Municipality, Tabasco, Mexico

Description of Area/Region

Overall Description

Aquaculture Laboratory is located at the northwestern extension of the Biological Science Division of the Universidad Juarez Autonoma de Tabasco, in the riverside of Carrizal River and at the entrance of the city of Villahermosa, the capital of the State.

Climate

The climate is damp and warm with high precipitation in the summer (Am).

Temperature

The average annual temperature is 27.0 °C; the lowest temperatures occur in December and January from 23 to 24 °C, and the highest temperatures occur from April to August having variations between 33 to 38 °C.

Precipitation

The annual total rainfall is 1,947 mm. The rainy season occurs from July to October and the dry season occurs from February to May.

Humidity

Villahermosa tends to be highly humid all year, over 50% humidity.

Topography

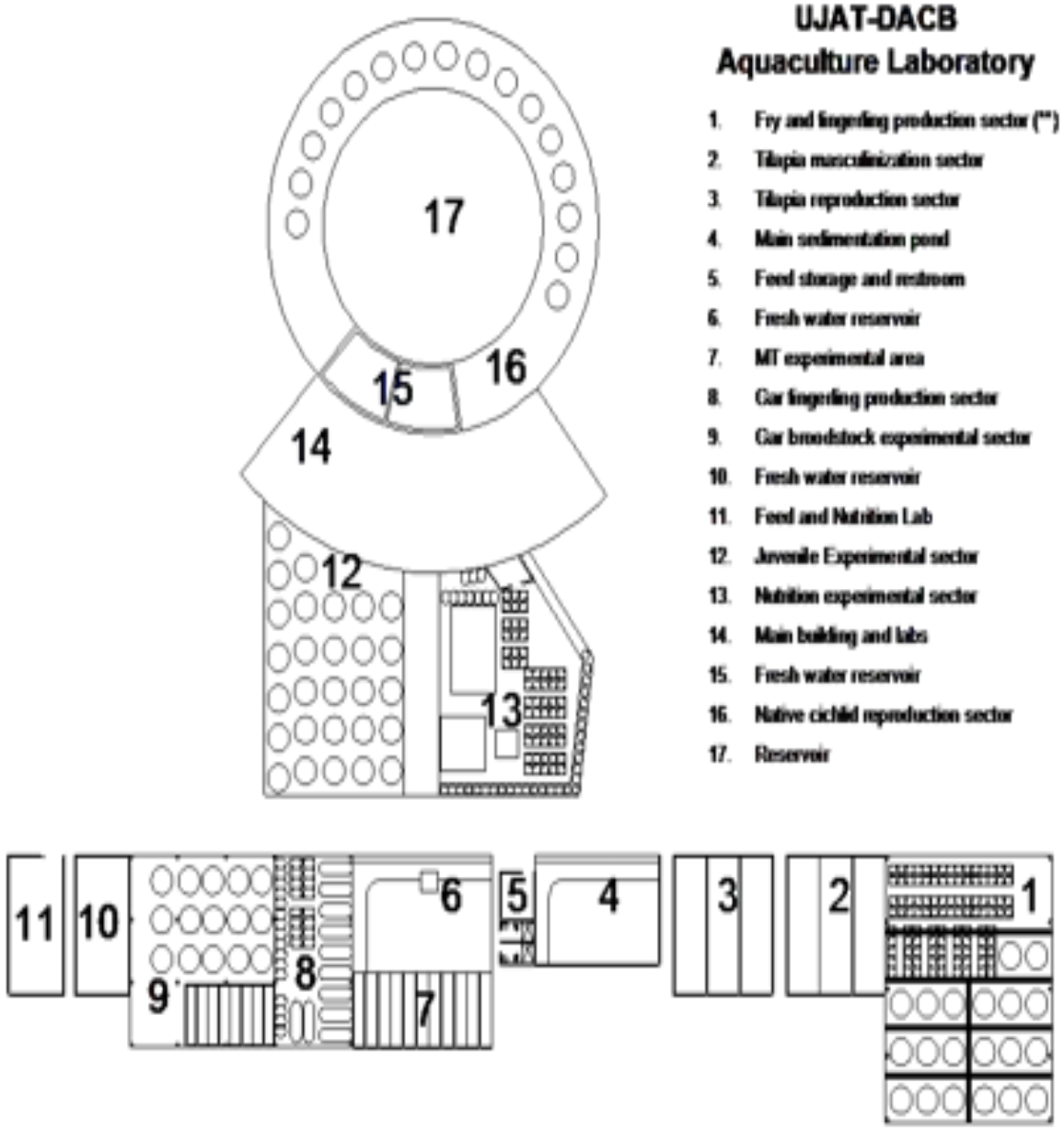
Vilahermosa city is a flat lowland area, with some elevations at the south part of the Municipality, with an average of 30m.

Geology/Soils

Villahermosa has gleysols eutric and fluvisols gleyic soils.

Enrique Hernandez, a graduate student at UJAT in Villahermosa inspects mesh fish cages. (Photoby Tiffany Woods)

Layout of UJAT



Description of UJAT, Aquaculture Laboratory

Map Coordinates	Elevation
17° 59’ N and 92° 56’ W	10 m above sea level.

General

The Aquaculture Laboratory is part of the Biological Science Division of the Universidad Juarez Autonoma de Tabasco, main University in the State. The Aquaculture Laboratory has: seven professors who teach undergraduate and graduate courses in the Biological Science Division; and, more than 35 students involved in research areas like: reproduction, physiology, endocrinology, nutrition, genetics, and histology of aquatic organisms. The Aquaculture Laboratory develops research projects with the Federal Government (Agriculture Agency,

Science and Technology Council, Natural Resources Agency and Education Secretary) and, State Government (Biosphere Reserves, SEDAFOP, PEMEX). In addition, the Laboratory develops projects for private aquaculture farmers acting as a projects service institution. UJAT has 3 main areas: Reproduction, Sex Reverse Research, and Nutrition, with species like; Tilapia, Garfish and Natives cichlids with a total of 64 plastic tanks, 24 concrete tanks, and 6 systems with a total of 240 plastic tanks of 100 L.

Water Supply

Water comes to the Aquaculture Lab through a pump system from the Carrizal River, through deep wells and through the city's water supply.

Soils

The Soil at the Aquaculture Laboratory is highly clayed with over 50% in its composition; also, the soil at this facility contains a high percentage of organic matter due to the proximity to the Carrizal River.

Support Facilities at Universidad Juarez Autonoma de Tabasco (UJAT)

The Aquaculture Laboratory has the following equipment: two laser printers, two color laser printers, two scanners, and 21 personal computers. These include: seven computers for the professors, three computers for the service extension area, eight Apple computers for the student area, donated by CRSP, and which have been supported by many of the undergraduate and graduate students for development of their research. In addition, there are three computers with specialized programs for the nutrition and genetic laboratories. All of these resources are connected to the main internet system of the Universidad Juarez Autonoma de Tabasco which also includes a voice system. Other support facilities include: multimedia room, library, and conference room that are part of the Biological Science Division.

Affiliations

In-Country	US
Aquaculture Laboratory Biological Science Division Universidad Juarez Autonoma de Tabasco Villahermosa, Tabasco, Mexico	Dr. Kevin Fitzsimmons Environmental Research Laboratory University of Arizona Tucson, Arizona, USA

Current Contacts

In-Country	US
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STATE GOVERNMENT HATCHERY AT TEAPA MUNICIPALITY

Teapa facility is rounded by medium high elevation mountains, which give excellent temperatures for aquaculture.

State Government Hatchery at Teapa Municipality

Site Status

Off station site

General Location

Teapa, Tabasco, Mexico

Description of Area/Region

Overall Description

The State Government Hatchery at Teapa is located south of Tabasco State, and approximately 62 km from the capital of the state. Teapa borders to the north with the municipalities of Centro y Jalapa; and in the south, east and west with the state of Chiapas. This hatchery was created to solve the demand of fry from rural aquaculture farmers.

Climate

In Teapa the climate is hot and humid with rain all year (Af).

Temperature

In Teapa, the average annual temperature is 26°C. The lowest temperatures occur from December to February between 21 to 23 °C, and the highest temperatures occur from June to July averaging 38°C.

Precipitation

The total annual rainfall in Teapa is 3,424 mm. The months with the most precipitation are from August to October with the driest months from March to May.

Humidity

Teapa tends to be highly humid all year, over 50% of humidity.

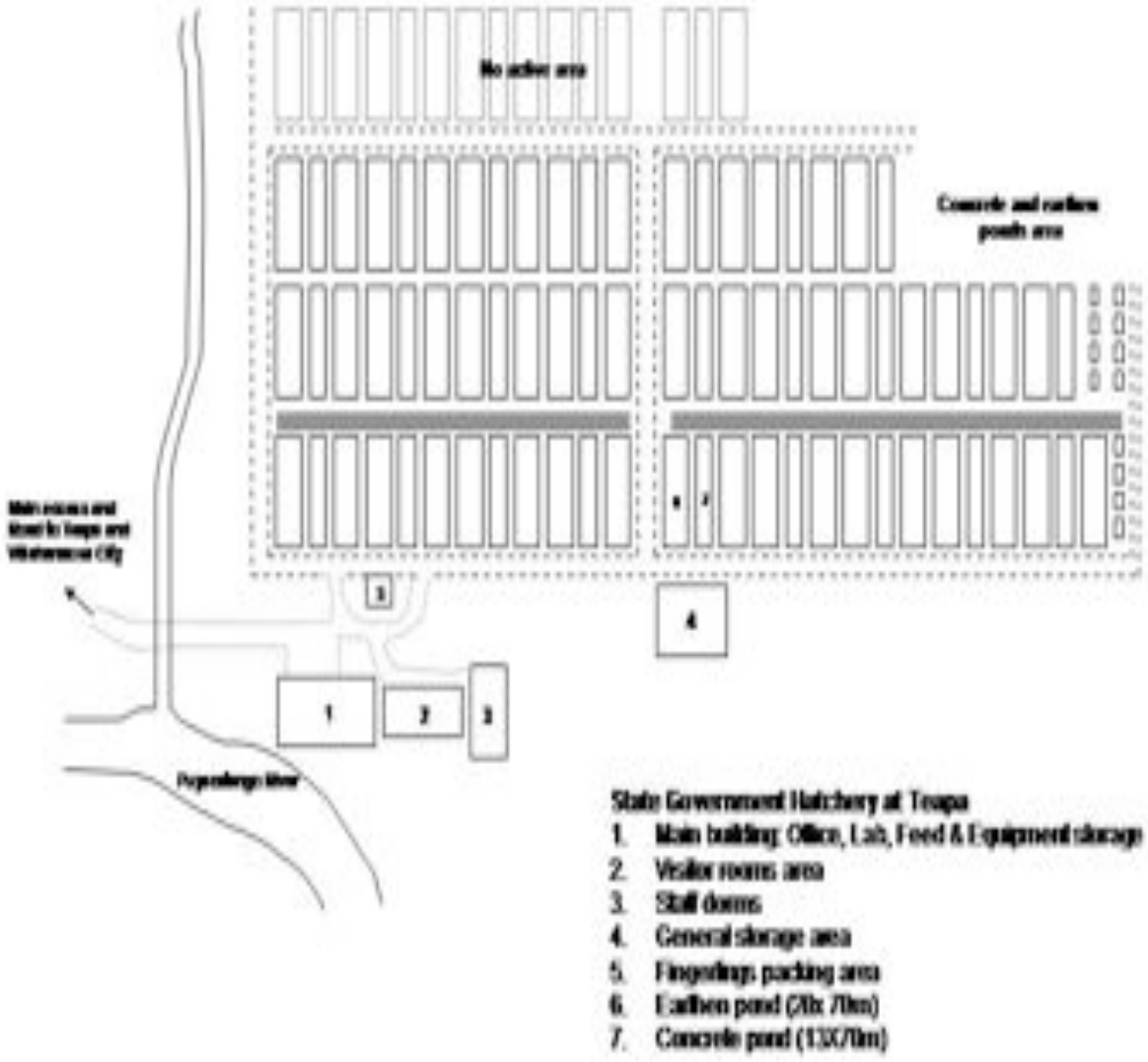
Topography

The Teapa facility is located in a low elevation mountain zone, with elevations like Cocona and Azufre Hills below 1000 m above sea level. Teapa is also surrounded by the Puyacatengo, Teapa and Pichucalco Rivers.

Geology/Soils

In Teapa, the region has some elevations and has variations in its soil composition; soils are gleysols eutric and fluvisols gleyic.

Layout of the State Government Hatchery at Teapa Municipality



Description of the State Government Hatchery at Teapa Municipality

Map Coordinates	Elevation
17° 33´44.83" North latitude, 92°57´11.54" west latitude	50m asl
General	
The State Government Hatchery at Teapa is the biggest aquaculture facility from the Government in Tabasco. It has 145 Ha in total extension with 24 earthen ponds and eight concrete ponds, with one office building, one storage building, dormitories, one water quality	

laboratory, and one biological laboratory. In this facility, two main CRSP projects have been developed: elimination of methyl- testosterone, and development of the Tabasco's Tilapia line. This facility produces around two million Tilapia fry every year, which are used for support rural aquaculture in Tabasco. The staff at The State Government Hatchery at Teapa includes one general manager, three technicians, 14 workers and one office assistant. This facility also served as a plant nursery and, at some seasons of the year, they grow chickens or pork to support rural productive projects in the State.

Water Supply

Water comes to The State Government Hatchery at Teapa through one water canal from the Teapa River.

Soils

Soils are gleysols eutric and fluvisols gleyic which are common for this part of the region.

Support Facilities at The State Government Hatchery at Teapa Municipality

The State Government Hatchery at Teapa Municipality has two main laboratories (biology and water quality), library, two lecture rooms with three personal computers, and dormitories. This facility holds field trips, field works and is used as an experimental unit for undergraduate and graduate students from the Aquaculture program and Biology program at the Universidad Juarez Autonoma de Tabasco. This facility supports rural Tilapia aquaculture in the State providing free fingerlings for rustic farmers as well as advisory in rural aquaculture by their technicians.

Affiliations

In-Country	US
Aquaculture Laboratory Biological Science Division Universidad Juarez Autonoma de Tabasco Villahermosa, Tabasco, Mexico	Dr. Kevin Fitzsimmons Environmental Research Laboratory University of Arizona Tucson, Arizona, USA

Current Contacts

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NATIONAL GOVERNMENT HATCHERY "PUERTO CEIBA" AT PARAISO

Puerto Ceiba facility has 22 earthen ponds with brackish water

National Government Hatchery "Puerto Ceiba" at Paraiso

Site Status

Off-station site

General Location

Puerto Ceiba, Paraiso, Tabasco, Mexico

Description of Area/Region

Overall Description

The National government hatchery is located in the coastal zone of Puerto Ceiba which is a region mainly dedicated to fisheries in the coastal municipality of Paraiso in the State of Tabasco. Puerto Ceiba is localized at 6km northeast of Paraiso the main city in the Municipality and at 68 km from the Capital of the State. Puerto Ceiba has a population of 2 726 habitants, this site belongs to the Mecoacan Lagoon system which is a very important coastal lagoon in this area, serving as a biosphere reserve for many endangered specie and as a migratory bird site.

Climate

The climate in Paraiso is (Am): humid- hot with a strong raining season during summer.

Temperature

The annual average is 27.1 °C at Paraiso; the lowest temperatures occur in December and January from 23 to 24 °C and the highest temperatures occur from April to August having variations between 30 to 33.5 °C.

Precipitation

The total annual rainfall in Puerto Ceiba is 1,895 mm.

Humidity

The humidity tends to be high, over 50%.

Seasonality

The raining season is from July to October and the dry season is from February to May.

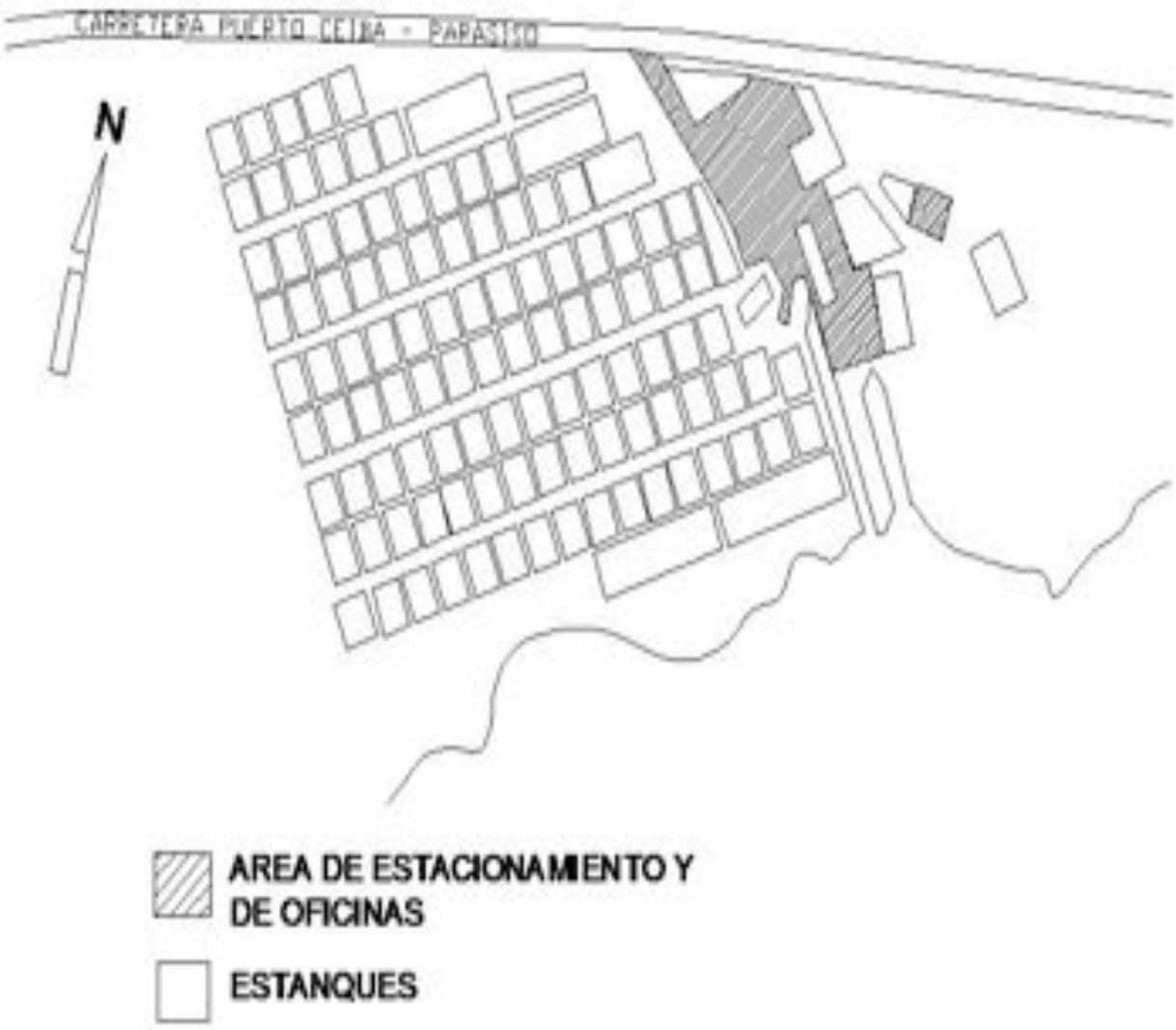
Topography

Puerto Ceiba is a wetland area with poor elevations, flat and with some decrease elevation to the sea. Puerto Ceiba facilities are near to Mecoacan coastal lagoon with an extensive mangrove forest.

Geology/Soils

The soil has diverse variety in its composition, the soil type are; gleysols, eutric and vertic, from palustrine and lacustrine origin.

Layout of National Government Hatchery "Puerto Ceiba" at Paraiso



Description of the National Government Hatchery "Puerto Ceiba"

Map Coordinates	Elevation
18° 25'21.73" North latitude, 93° 09'29.65" West latitude	10 m asl
General	

The National Government Hatchery "Puerto Ceiba" originally had 82 earthen ponds of 10 x 20 m but after a major hurricane damaged now there is only 22 earthen ponds, 1 office, 1 storage building, and 2 multi purpose buildings. In this facility the staff is composed by federal employees (1 general manager, 1 technician and 11 workers) who are dedicated to Tilapia aquaculture with traditional culture systems. Is good to mention that this facility was semi abandoned after the hurricane disasters, but after the develop of the CRSP project; shrimp-tilapia

polyculture, the facility was used again, and now is a very important site for aquaculture research, now diverse research projects are perform here through the collaboration of professors, undergraduate and graduated students from the Aquaculture and Biology program of the Universidad Juarez Autonoma de Tabasco.

Water Supply

Water supply is provided trough one main channel fro the Mecoacan lagoon for brackish water supply.

Soils

Mainly sandy loam, sandy clay

Support Facilities at National Government Hatchery "Puerto Ceiba"

After the hurricane affectations that this facility suffered was semi abandoned and all electronics equipment were lost, only the buildings and some earthen ponds were suitable for be used. With the CRSP project this site was used again, and was possible to rebuild the earthen ponds and the main channel, there are some others projects from different funding sources that are equipping this facility.

EXPERIMENTAL SEASONAL UNIT (ESU) OF UJAT AT JALAPITA

The ESU is localized in the coast line of Frontera municipality is a new developing unit

The ESU has three areas; broodstock area, phytoplankton production, and nursery with a total of 18 plastic tanks

Experimental Seasonal Unit (ESU) of UJAT at Jalapita

Site Status

New off station site

General Location

Jalapita, Centla, Tabasco, Mexico

Description of Area/Region

Overall Description

ESU of UJAT is an experimental unit from the Biological Science Division of the Universidad Juarez Autonoma de Tabasco, this unit was founded in 2006, under CRSP and federal funds with the purpose of perform aquaculture research of marine native species with high economical, cultural an social value. The facility is localized in Jalapita a small town of Centla municipality. This facility is located at 45 minutes from Villahermosa the Capital of the State. This facility includes four geomembrane tanks and 8 plastic tanks and 6 tanks for the phytoplankton production system all in marine water.

Climate

The climate in Jalapita is (Am): humid- hot with a strong raining season during summer.

Temperature

The annual average is 26.0 °C in Centla; the lowest temperature occur in December and January from 18 to 22.5 °C and the highest temperature occur from May to August having variations between 36 to 39 °C.

Precipitation

The total annual rainfall in Jalapita is 1,995 mm.

Humidity

The humidity tends to be high, over 60%.

Seasonality

The raining season is from July to October and the dry season is from February to May.

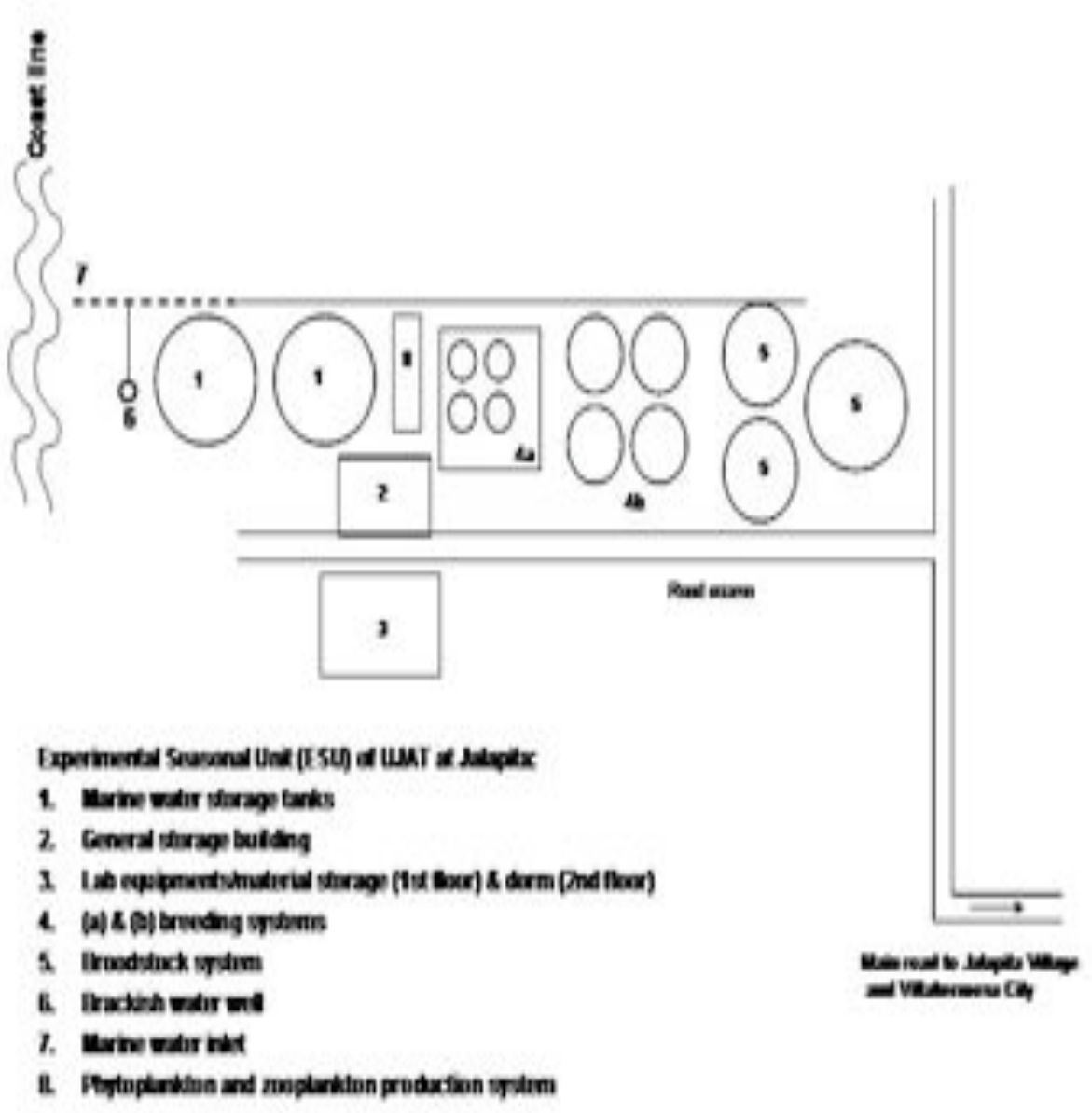
Topography

Jalapita form part of a wetland area without elevations. The experimental Unit of Jalapita is localized at the coastal line.

Geology/Soils

The soil in Jalapita is totally flat and have a variety in its composition, the soil type are; gleysols, eutric and vertic, from palustrine, marine and lacustrine origin.

Layout of the Experimental Seasonal Unit (ESU) of UJAT at Jalapita



Description of Experimental Seasonal Unit (ESU) of UJAT at Jalapita

Map Coordinates	Elevation
18° 24'24.987" North latitude, 93° 00'00.24" West latitude	ESU is localized at sea level
General	
ESU is a marine unit research of the Biological Science Division from the Universidad Juarez Autonoma de Tabasco, is a recent experimental unit dedicated to develop new aquaculture	

techniques using marine natives species of high value. This unit was created under the support of CRSP and the federal government due to the necessity of implement marine high value species to aquaculture. The unit has 18 plastic and geomembrane tanks in three different areas (broodstock, phytoplankton production and nursery). This facility has been well accepted for the local habitants of Jalapita, as they learned that aquaculture research can be the solution for many of their problems. This facility is the place of new research for the develop of aquaculture techniques of different marine species (Centropomus spp.) undergraduate and graduate students conduct research at this facility from the Biology program from UJAT.

Water Supply

Water comes to the ESU through a marine water system from a deep well.

Soils

Sandy clay and sandy loam

Support Facilities at the Experimental Seasonal Unit (ESU) of UJAT at Jalapita

In this unit works two full time workers from the same community, also collaborate 8 undergraduate and 4 graduate students as well as professors of the Biological Science Division of UJAT. This facility has three main marine water systems, 2 blowers, 2 pumps, and equipment for the measurement of water quality. Is good to mention that, this experimental unit was founded in 2006 under support of CRSP and the federal government. Currently there is the purpose of write a proposal for Fisheries and Aquaculture Council and continue with the research in this unit.

Affiliations

In-Country	US
Aquaculture Laboratory Biological Science Division Universidad Juarez Autonoma de Tabasco Villahermosa, Tabasco, Mexico	Dr. Kevin Fitzsimmons Environmental Research Laboratory University of Arizona Tucson, Arizona, USA

Current Contacts

In-Country	US
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UNIVERSIDAD AUTONOMA DE TAMAULIPAS, CIUDAD VICTORIA, TAMPS.

Aquaculture facility at Universidad de Tamaulipas

Close-up of new facility at Universidad de Tamaulipas

Interior of facility at Universidad de Tamaulipas

Universidad Autonoma de Tamaulipas, Ciudad Victoria, TAMPS.

Site Status

Active

General Location

Tamaulipas limits are US at north and Veracruz and San Luis Potosi at south; Nuevo Leon at west and the Golf of Mexico at orient.

Description of Area/Region

Overall Description

The land and crop irrigation is a common practice for disposal of aquaculture effluents in Mexico, the Environmental Protection Agency has recommended this practice and suggested as perfectly safe. However, examination of typical effluents and residual pathogens is recommended as might be present on leafy vegetables with fish farm effluents. The Tamaulipas State is situated northeast of Mexico in the border with USA and the cost of Gulf of Mexico and has plenty of potential for aquaculture; it has 420 km of littoral (8,763 km2 of shore) and 140 water basins of fresh water, that represents 3.3% of the water of the country. Government of Tamaulipas in collaboration with the Federal government (SAGARPA, SEMANAT) is committed with the aquaculture sustainable by supporting the PROGRAMA NACIONAL DE ACUACULTURA RURAL (PRONAR) helping the poor communities to develop sustainable small production projects. The government is committed to care that all the projects are sustainable in order to keep the environmental balance.

Climate

See Map 1 Below

Temperature

The climatology in the State is divided by the 3 geographic conditions: Latitude, influence of the Gulf of Mexico and altitude. The Cancer Tropic divides the State in 3 zones: the south with warm climate and humid, center and north less warm. The marine influence can be noted during the year, during the summer humid breeze provokes precipitation mostly n the center of the state. The altitude of the mountains determines the temperature from warm along the coast to temperate in the southeast. Also have influence from the neartic and neotropic regions and varies from 25° C to 28.2° C and can reach -10 ° C to 48° C. (See Map 2 Below)

Precipitation

The annual precipitation varies between 400 mm to 1600.3 mm.

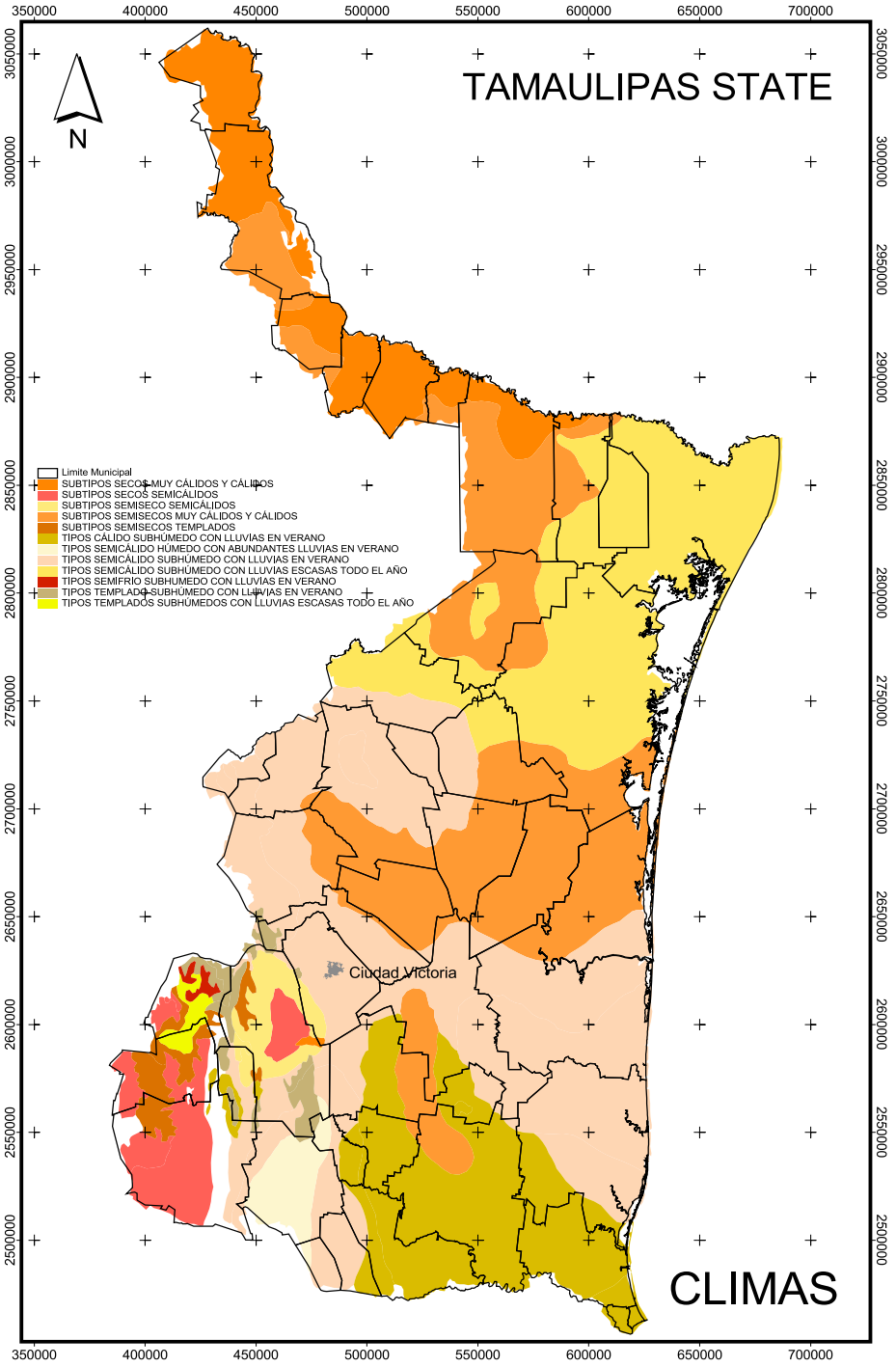
Topography

See Map 3 Below

Geology/Soils

The sedimentary rocks are prevalent with in the State, marine in origin rich on clay and carbonates. In the "Sierra Madre" the rocks contains mainly limestone and are the oldest in formation. Sandy clay and sandy loam.

Map 1


TAMAULIPAS STATE
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Limite Municipal
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SUBTIPOS SECOS SEMICÁLIDOS
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SUBTIPOS SEMISECOS TEMPLADOS
TIPOS CÁLIDO SUBHÚMEDO CON LLUVIAS EN VERANO
TIPOS SEMICÁLIDO HÚMEDO CON ABUNDANTES LLUVIAS EN VERANO
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TIPOS SEMIFRIO SUBHÚMEDO CON LLUVIAS EN VERANO
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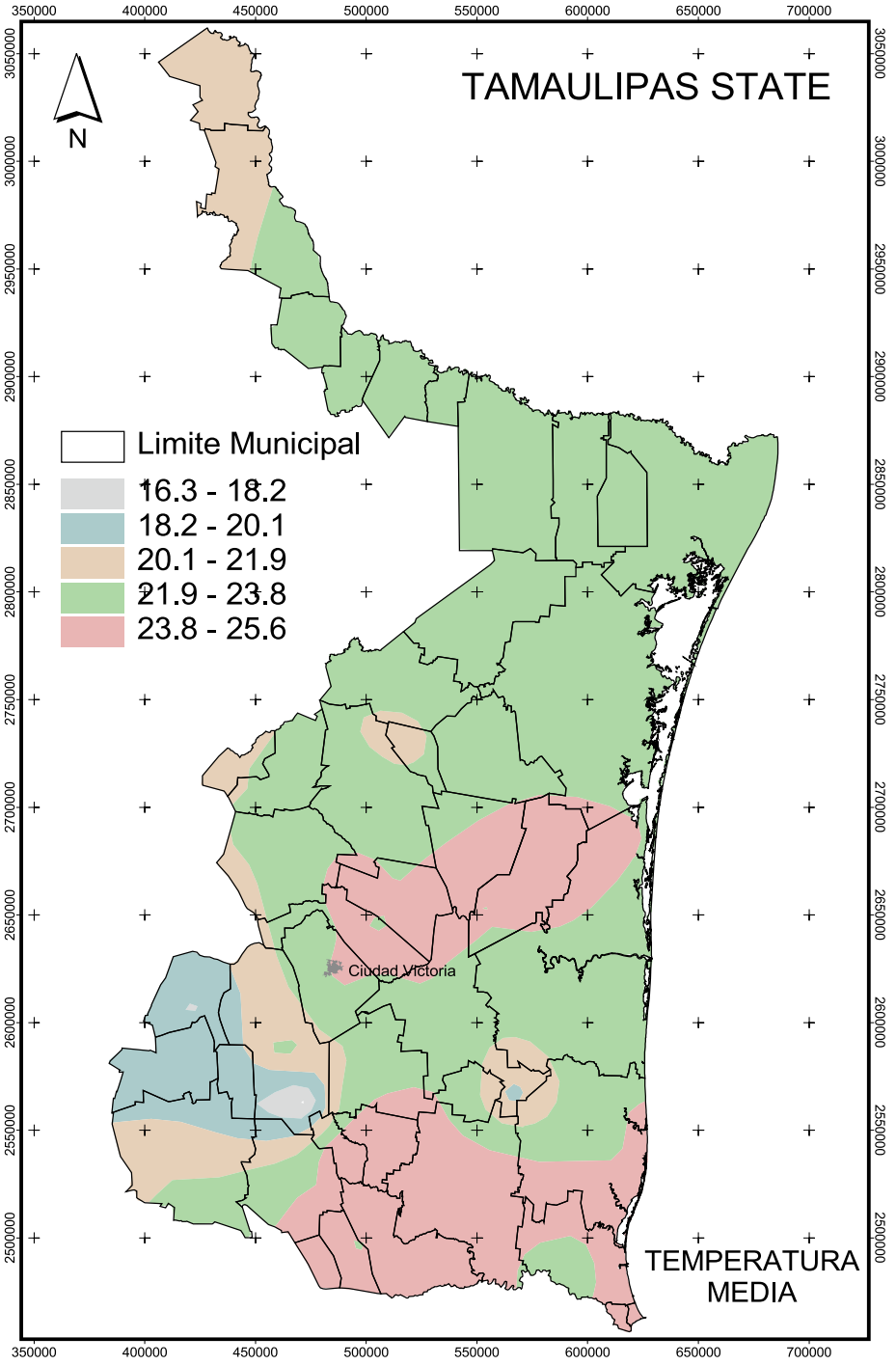
Map 2


TAMAULIPAS STATE
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Limite Municipal
16.3 - 18.2
18.2 - 20.1
20.1 - 21.9
21.9 - 23.8
23.8 - 25.6
Ciudad Victoria
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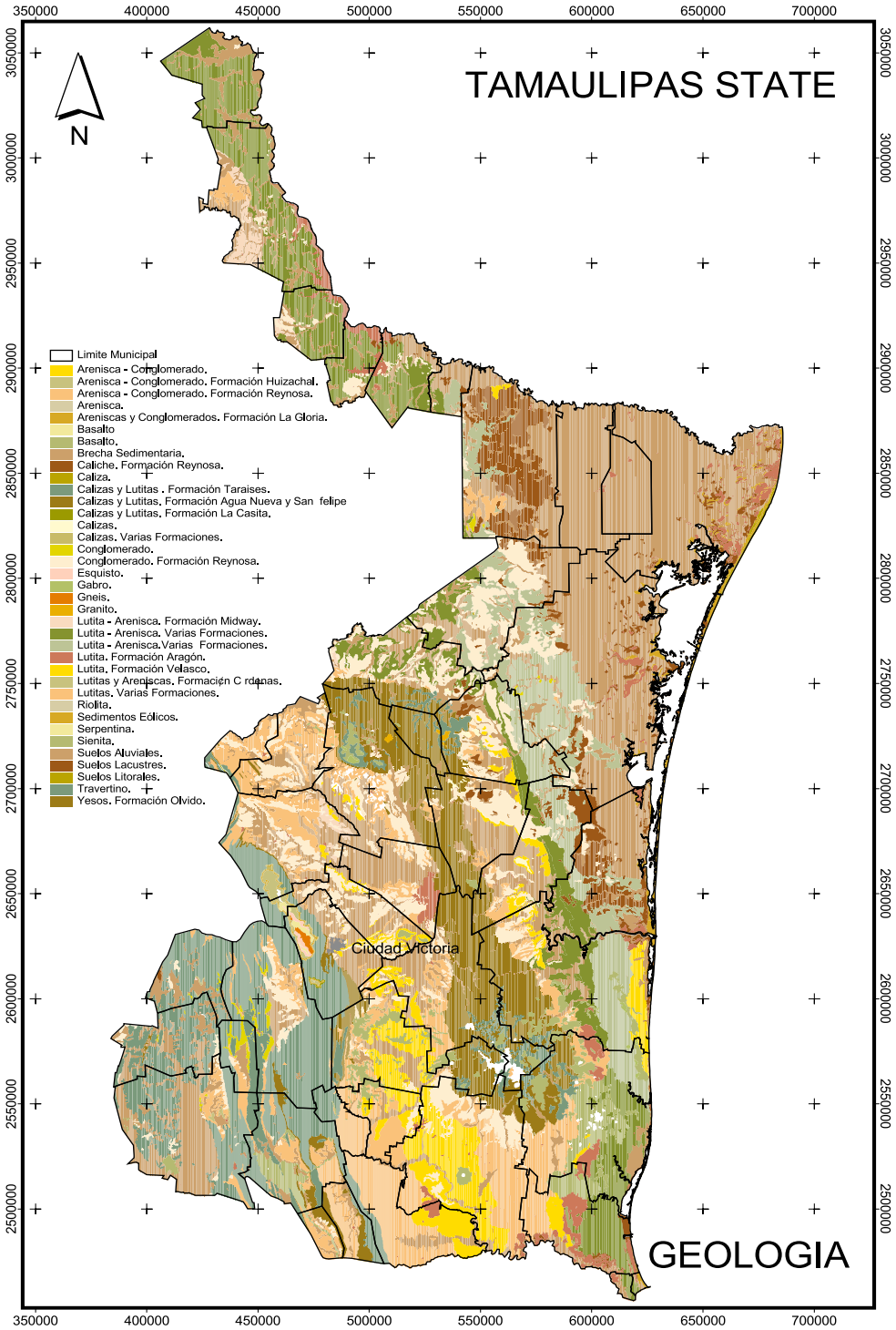
Map 3


TAMAULIPAS STATE
N
Limite Municipal
Arenisca - Conglomerado.
Arenisca - Conglomerado. Formación Huizachal.
Arenisca - Conglomerado. Formación Reynosa.
Arenisca.
Areniscas y Conglomerados. Formación La Gloria.
Basalto
Basalto.
Brecha Sedimentaria.
Caliche. Formación Reynosa.
Caliza.
Calizas y Lutitas . Formación Taraises.
Calizas y Lutitas. Formación Agua Nueva y San felipe
Calizas y Lutitas. Formación La Casita.
Calizas.
Calizas. Varias Formaciones.
Conglomerado.
Conglomerado. Formación Reynosa.
Esquisto.
Gabro.
Gneis.
Granito.
Lutita - Arenisca. Formación Midway.
Lutita - Arenisca. Varias Formaciones.
Lutita - Arenisca.Varias Formaciones.
Lutita. Formación Aragón.
Lutita. Formación Velasco.
Lutitas y Areniscas. Formación C rdenas.
Lutitas. Varias Formaciones.
Riolita.
Sedimentos Eólicos.
Serpentina.
Sienita.
Suelos Aluviales.
Suelos Lacustres.
Suelos Litorales.
Travertino.
Yesos. Formación Olvido.
Ciudad Victoria
GEOLOGIA
350000
400000
450000
500000
550000
600000
650000
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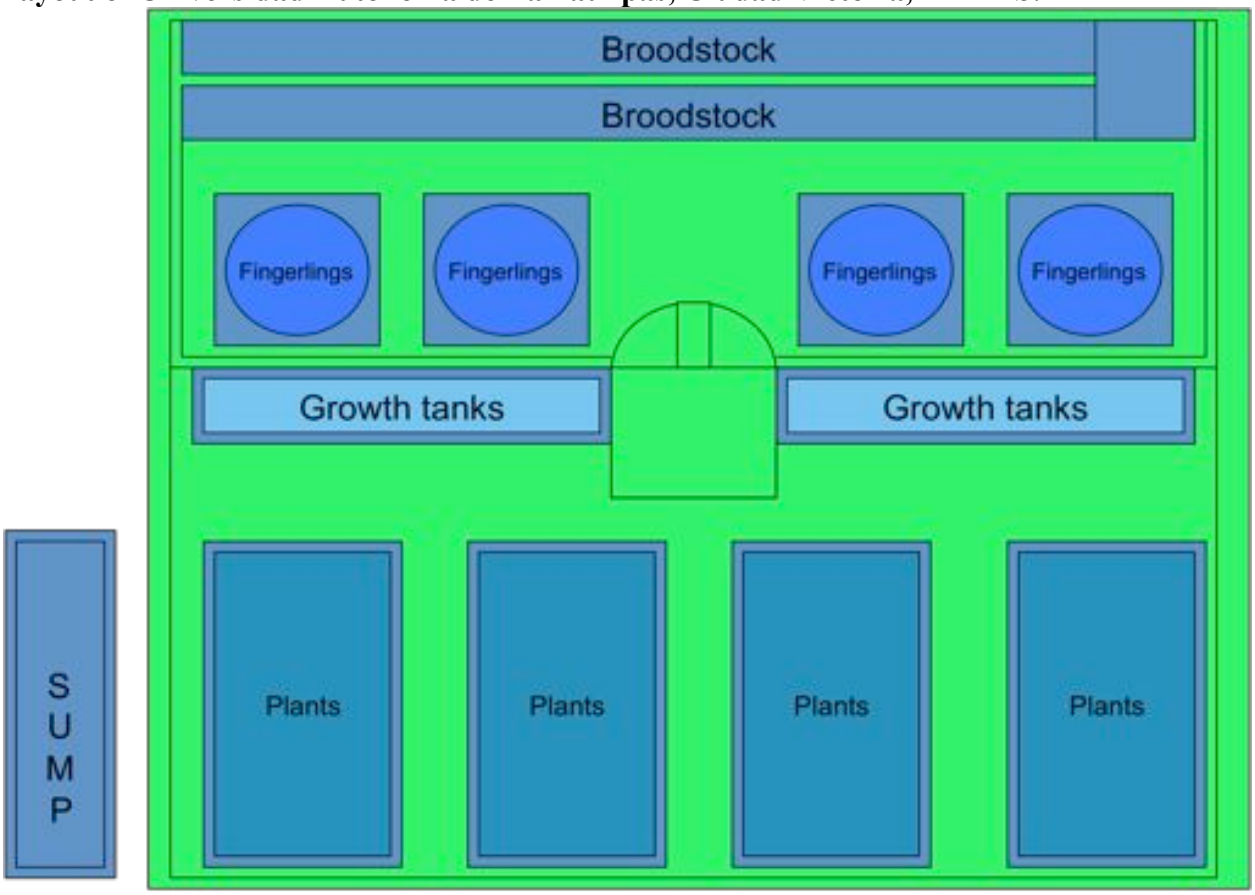
Layout of Universidad Autonoma de Tamaulipas, Ciudad Victoria, TAMPS.



Description of Universidad Autonoma de Tamaulipas, Ciudad Victoria, TAMPS.

Map Coordinates	Elevation
The state of Tamaulipas is situated between 22° 12` 31`` and 27° 40`52`` north latitude: and 97° 08`38`` and 100°08`51`` longitude west.	The "Tamaulipeco" territory and site elevation is 500 m above sea level and is conformed by hills in extended zones.

General

The University of Tamaulipas (UAT), responsible for the research project, the facilities of the educational center for social adaptation (CUAUTLI) is used for the aquaponic practices and the laboratory of the Veterinary College for the biology, microbiology and pathology analysis. Each laboratory has specialized equipment for research and trained staff. Having this collaboration between Federal and State government, State University and CRSP, we plan to successfully conclude this project on time and obtain useful results.

Water Supply

The most important rivers are "Bravo" (Rio Grande), "San Fernando", "Soto la Marina" y "El Guayalejo", all of them end at the Gulf. The rain is contained in water basins like "The Presa Falcon"and used to generate electricity that provides energy to several cities. Other important water basins are Guerrero Lake and Marte R. Gomez. The facility receives its water from a well and from municipal supply.

Soils

Sandy clay and sandy loam

Affiliations	
In-Country	US
Aquaculture Laboratory Veterinary Science College Universidad Autonoma de Tamaulipas Ciudad Victoria, Tamaulipas, Mexico	Dr. Kevin Fitzsimmons Environmental Research Laboratory University of Arizona Tucson, Arizona, USA
Current Contacts	
In-Country	US
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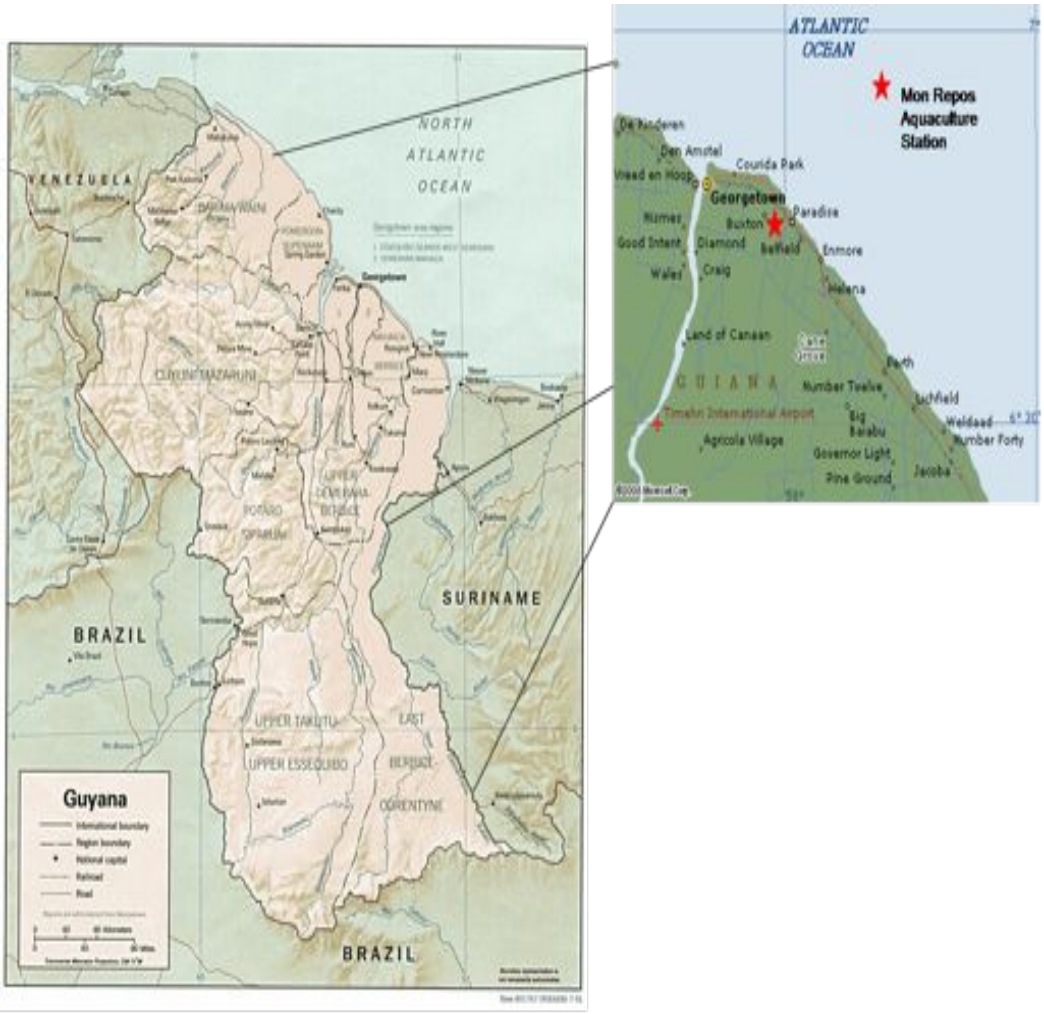
GUYANA

Introduction

By volume, Guyana has the tenth greatest water resources of all the nations of the world. Several large rivers low out through the country, they have a 400 km coastline and extensive coastal and inland wetlands. The Government of Guyana has determined that aquaculture should be a significant industry both for local consumption and export. To support this effort, the government has organized an aquaculture unit within the Department of Fisheries under the Ministry of Agriculture. The unit receives close supervision from the top levels of government. The Minister of Agriculture dedicated a new hatchery in July 2008 and reviews new project proposals.

The Mon Repos Aquaculture Center also named – Satyadeow Sawn Center, has been placed along the Agriculture Road neighboring the National Agricultural Research Station, the National Agriculture School, and several smaller private and government labs and certification offices. The Center is 2.5 km from the coast and is surrounded by agricultural lands, mostly planted to sugar cane. Extensive irrigation systems connect to the center.



MON REPOS AQUACULTURE CENTER, GUYANA

Photo circa 2006

Photo August 2008. Mon Repos Aquaculture Center is surrounded by very rich farmland; water source is abundant from irrigation canals

Mon Repos Aquaculture Center, Guyana

Site Status

The Mon Repos Aquaculture Center, also named – Satyadeow Sawn Aquaculture Center is located with the other Ministry of Agriculture facilities in the town of Mon Repos, 20 km to the east of Georgetown, Guyana.

General Location

Mon Repos, Agriculture Station Road, Demerara County, Guyana

Description of Area/Region

Overall Description

The center lies just 2.5 km south of the coastal highway running east from Georgetown toward Berbice. The site is also 3 km south of the seawall along the coast and about four meters above sea level.

Climate

Guyana has a tropical climate (Am) with almost uniformly high temperatures and humidity, and much rainfall.

Temperature

Temperatures in this facility are quite constant, with an average high of 32°C and an average low of 24°C in the hottest month (July), and an average range of 29°C to 23°C in February, the coolest month. The highest temperature ever recorded in the capital was 34°C and the lowest only 20°C.

Precipitation

The annual total rainfall is 1,500 mm.

Humidity

70 percent year-round

Seasonality

The rainy season occurs from April to September. Coastal areas have a second rainy season from November through January. Rain generally falls in heavy afternoon showers or thunderstorms

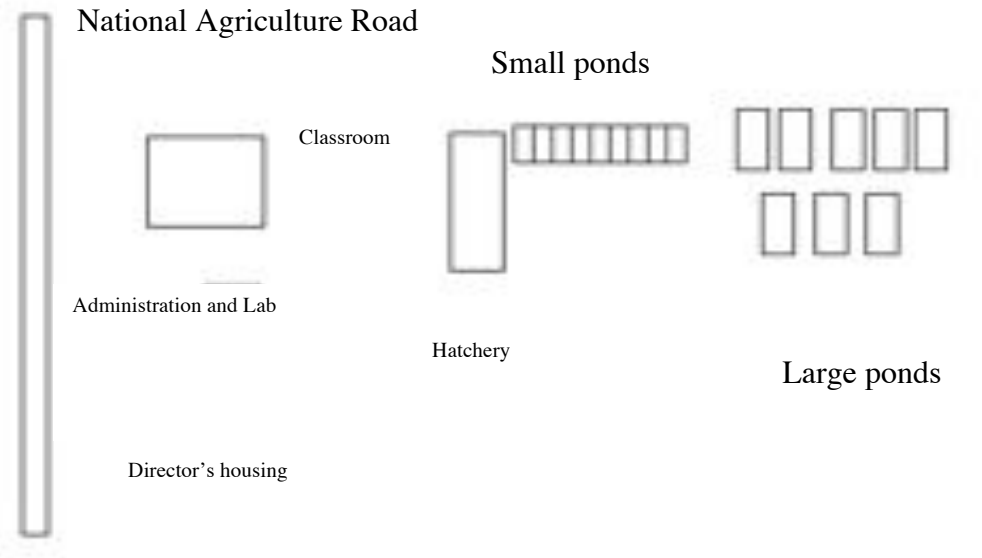
Topography

Guyana has three main natural regions: a low-lying coastal plain, extending for about 435 km (270 mi) and ranging from 16 to 64 km (10–40 mi) in width, much of which is below high-tide level and must be protected by sea walls and drainage canals; a region of heavily forested, rolling, hilly land, about 160 km (100 mi) in width, which contains most of the mineral wealth and comprises almost five-sixths of Guyana's land area; and in the south and west, a region of mountains and savannas. There are several large rivers, including the Essequibo, Demerara, and Berbice, but few are navigable for any distance above the plains because of rapids and falls

Geology/Soils

The Precambrian rocks (GSC) north of the Takutu Basin (TB) include folded metasedimentary rocks and metavolcanic rocks as well as coarse- and fine-grained sedimentary rocks with intercalations of volcanic rocks. Intrusive bodies occur within the folded strata.

Layout of Mon Repos Aquaculture Center



Description of Mon Repos Aquaculture Center

Map Coordinates	Elevation
6º 46' 07" N and 58º03' 53" W	Four meters above sea level.

General

The Mon Repos Aquaculture Station has access to 44 acres of land, but only 4 acres are being utilized at this time. The following water surface area is as follows:

- Concrete Ponds: Ten ponds, of 100 square meters each (23 x 46 ft.)
- Earthen Ponds: Eight ponds, of 140 square meters each (30 x 50 ft.)
- Spawning Tank: One tank, of 2 square meters (4 x 6 ft.)

The facility also has an Office/Training Building, a Storage area, and a staff residence. A new hatchery building was inaugurated in August 2008. The station has access to internet and telephone.

Water Supply

The water supply for the station comes from both a well and from irrigation canals. The groundwater is pumped from less than 5 meters.

Soils

The coastal soils are fertile but acidic. The fine-particle, grayish blue clays of the coastal plain are composed of alluvium from the Amazon deposited by the south equatorial ocean current and of much smaller amounts of alluvium from the country's rivers

Support Facilities at Mon Repos Aquaculture Center

The primary lab building contains offices with internet access and phone. The microscopy lab contains multiple compound microscopes and a dissecting scope. The water quality lab has equipment for basic aquaculture water quality tests including DO, pH, nitrates, nitrites, ammonia, phosphates and hardness and alkalinity.

The separate office/training building has a classroom with audio-visual equipment, a small kitchen area and seating for about 50 persons.

Affiliations	
In-Country	US
The station is directly administered by the Fisheries Department within the Ministry of Agriculture. The Station is flanked by the National Agricultural Research Institute, the Guyana School of Agriculture (associated with the University of Guyana), and several smaller labs and control boards.	Dr. Kevin Fitzsimmons Environmental Research Laboratory University of Arizona Tucson, Arizona, USA

Current Contacts	
In-Country	US
Ms. Pamila Ramotar Aquaculture Coordinator - Department of Fisheries Ministry of Agriculture Georgetown, Guyana Pamilasnuggles_54321@hotmail.com	Dr. Kevin Fitzsimmons Environmental Research Laboratory University of Arizona Tucson, Arizona, USA phone 520-626-3324 fax 520-573-0852

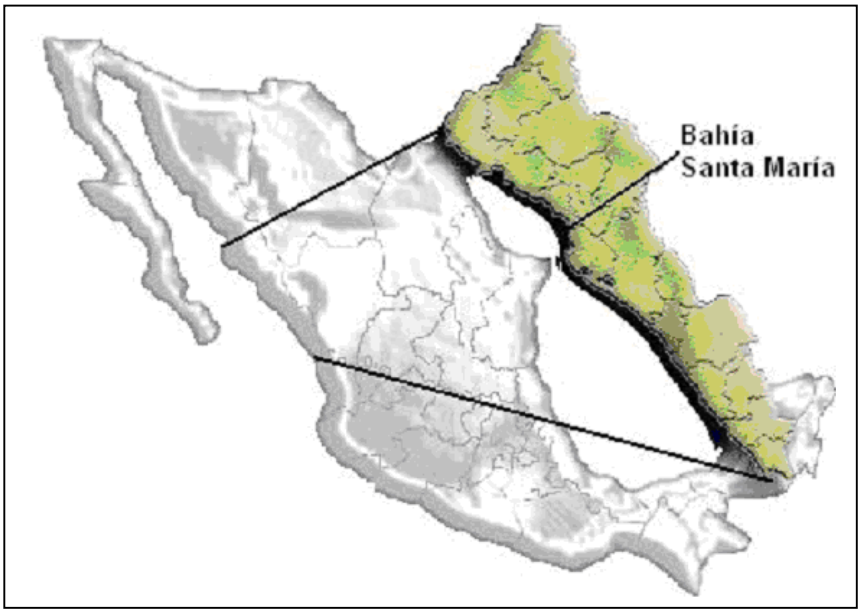
MEXICO

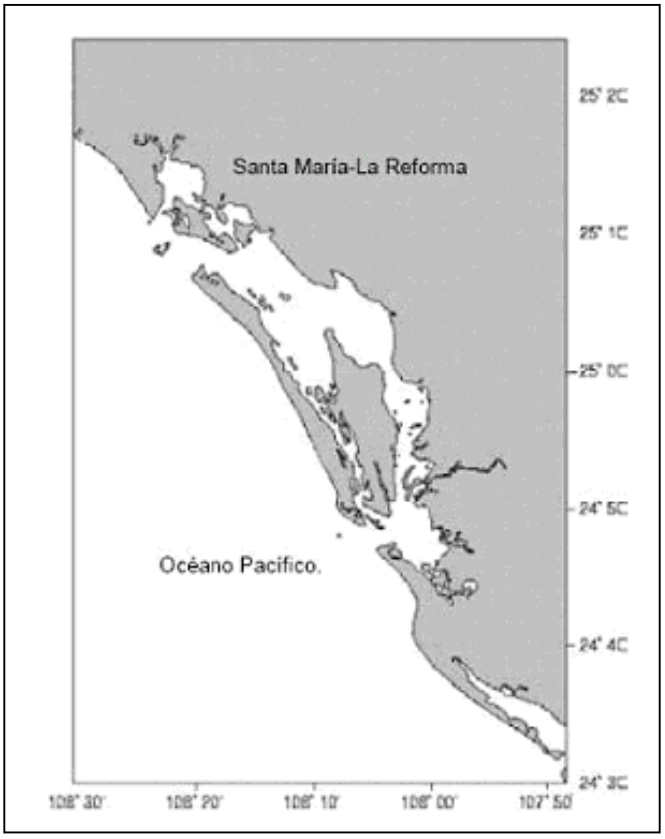
Introduction

The University of Hawaii, Hilo led AquaFish CRSP project has been working in Mexico since project inception to build capacity among aquaculture producers, processors, and vendors to improve seafood safety during all stages of production and marketing. Aquaculture production in the States of Sinaloa and Nayarit, Mexico, consists largely of shrimp, tilapia, and bivalve shellfish in coastal areas. Expanding bivalve and tilapia production have been prioritized by the Mexican National and Sinaloa State governments as a means of diversifying aquaculture, which is now dominated by shrimp culture. Research done under the former ACRSP in 2006 suggested that seafood safety and quality were problematic for nearly all aquaculture and seafood products at all stages of production and marketing. Large-scale shrimp culture was one exception, as shrimp is produced mainly for export and is thus subject to strict safety standards and inspections. Other products were mainly affected by the general lack of awareness of producers and vendors as to specific techniques to maintain hygienic standards, although most people are aware of the need to handle and select seafood carefully. The cultural preference of coastal residents in Mexico to consume seafood raw, pickled, or lightly cooked highlights the importance of food safety standards. Most Mexicans are keenly aware of the need for special attention to seafood safety. One issue is the increasing popularity of using freshwater fish for sushi and ceviche, which can spread the disease. As fish culture grows, prevention becomes more critical. The Center for Food and Development Research (CIAD) in Mazatlan has produced a series of best management practices manuals for shrimp, bivalves, catfish, and tilapia. Shellfish sanitation has been a key theme in the CRSP project since the beginning, and headway has been made in raising awareness of the need for, and components of, shellfish sanitation programs among a wide variety of stakeholders. Again, this is important due to the tradition of consuming bivalve shellfish raw and because of their susceptibility to post-harvest contamination.

Promotion of seafood and aquaculture products consumption is also important— the average Mexican consumes only about 12 kilograms of seafood per year, with most of this consumption is by coastal residents. Aquaculture can help provide some of the protein needs in areas, which still have food security issues, including many coastal areas. For example, a typical toddler would only need one ounce of fish or shellfish to meet his or her daily protein requirements.

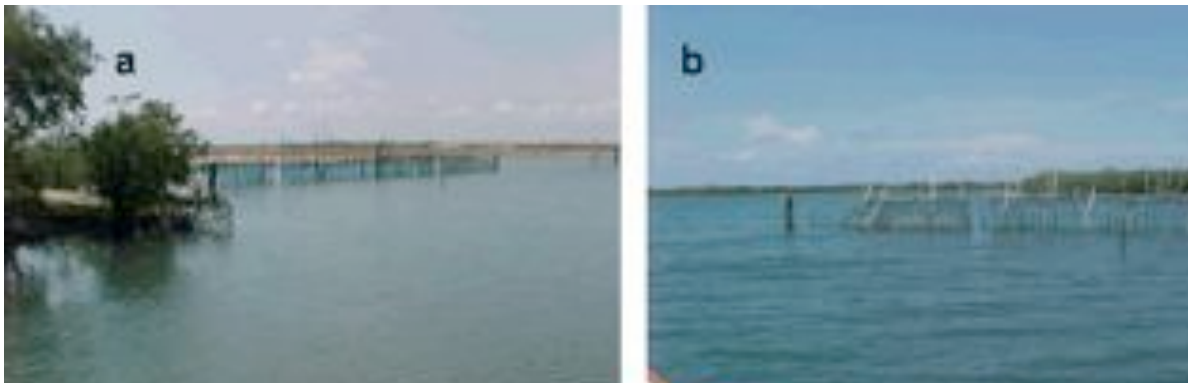
BAHIA SANTA MARIA, SINALOA, MEXICO





Bahia Santa Maria, Sinaloa, Mexico

Bird nesting area in Bahia Santa Maria-an important bird nesting and wintering area for north American birds.



Oyster culture sites

Bahia Santa Maria, Sinaloa, Mexico

Site Status

Active

General Location

Bahia Santa Maria, Sinaloa, Mexico

Description of Area/Region

Overall Description

Bahía Santa María is located in the north central region of the state of Sinaloa approx. 125 km southeast of Los Mochis and approx. 95 km northwest of Culiacan. The bay is an important oyster culture area and bird nesting area.

Climate

Climate is classified as Bw(h')w(e), or hot, dry and desert-like.

Temperature

There are distinct hot and cold seasons. Highest temperatures occur during May-June rising as high as 36°C. Lowest temperatures are around 12 °C in January and February.

Precipitation

Total rainfall averages 819 mm, 6% over national average

Humidity

Humidity tends to be high, ranging between 22% and 18%.

Seasonality

67% of precipitation falls between June and December. Region is subject to an average of 1.5 hurricanes per year.

Topography

Low elevation wetlands with poorly drained soils. Little permanent vegetation inland of mangrove areas.

Geology/Soils

Bahia Santa Maria is an estuary surrounded by extensive wetland areas. Predominant soil types found for the eastern, inland coast are Solonetz and Solonchak, characterized by the presence of salt in the upper layer. Clay content is variable, many sites in the area are adequate for pond construction provided they are located inland of the mangrove area.

Description of Bahia Santa Maria, Sinaloa, Mexico

Map Coordinates	Elevation
The northern extent of Bahia Santa Maria is at 25°09'43N and 108°21'52 W, with the southern most point at 24°46'42N and 108°03'03 W. The area encompasses 46,000 ha of water surface.	0

General

Bahia Santa Maria is an important estuary on the Pacific Coast in the State of Sinaloa, being one of the largest mangrove areas in Mexico. It is also a major fishing site for shrimp, fish and blue crabs, and a major shrimp farming area. CRSP work targeted this site as one study area for three case studies examining issues of human and environmental health related to aquaculture development. Some oyster culture and extensive shellfish collection occurs in the bay.

Water quality monitoring is being conducted as a prelude to classification of waters for shellfish sanitation purposes.

Water Supply

Ocean

Soils

Predominant soil types are Solonetz and Solonchak, characterized by the presence of salt in the upper layer.

Affiliations	
In-Country	US
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Current Contacts	
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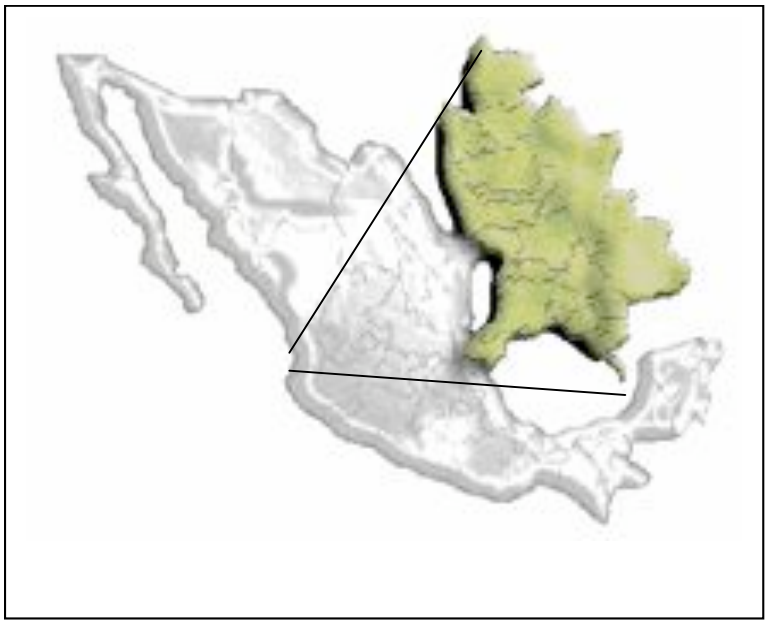
BOCA DE CAMICHIN, NAYARIT, MEXICO



Boca de Camichin, Nayarit, Mexico

Oyster farming community in Marismas Nacionales.

Oyster culture activities at Boca Camichin

Boca de Camichin, Nayarit, Mexico

Site Status

Active

General Location

Boca de Camichin, Nayarit, Mexico

Description of Area/Region

Overall Description

Boca de Camichín estuary lies at the mouth of San Pedro River in the municipality of Santiago Ixcuintla. The estuary is approx. 150 km north of Puerto Vallarta. Area has extensive marshes. Important oyster culture area.

Climate

Climate is hot and humid, or sub-humid.

Temperature

Highest temperatures occur during May-June rising as high as 29.4°C. Lowest temperatures are around 20.2 °C in January and February.

Precipitation

The region encompasses three climatic zones in which annual rain fall varies between 800 mm and over 1200 mm annually.

Humidity

Humdity ranges between a high of 24.22% during summer in the most humid areas to 15.27% in the least humid areas.

Seasonality

Highest rainfall occurs between July and September, with the driest times in March and April. Region is subject to an average of 2 hurricanes per year.

Topography

The area encompasses coastal planes, wetlands and mangrove swamps.

Geology/Soils

Boca de Camichin is the mouth of a narrow estuary formed by an outlet of the extensive wetland areas comprising the Marismas Nacionales (National Wetlands). Predominant soil types found for the eastern, inland area are Solonetz and Solonchak, characterized by the presence of salt in the upper layer. Clay content is variable, some sites in the area are adequate for pond construction provided they are located inland of the mangrove area and wetlands.

Description of Boca de Camichin, Nayarit, Mexico

Map Coordinates	Elevation
21°42"08 and 105°27'57 W	0

General

Marismas Nacionales is an extensive wetlands and mangrove areas located on the Pacific Coast of Mexico, in the state of Nayarit. Water surface area is 2000 km^2. This area contains 80% of mangrove areas on the Pacific Coast and 22% of all of Mexico's mangroves. It is designated as a Ramsar site and is under various protected areas management plans. CRSP work focuses on assisting inhabitants of poor coastal villages develop oyster culture, implement improved shellfish sanitation and monitor water quality. The oyster cultured is a native species, *Crassostrea corteziensis.* Some shrimp farming also occurs in the area.

Water Supply
Ocean
Soils
Boca de Camichín estuary lies at the mouth of San Pedro River in the municipality of Santiago Ixcuintla. The estuary is approx. 150 km north of Puerto Vallarta. Area has extensive marshes. Important oyster culture area.

Affiliations	
In-Country	US
Universidad Autonoma de Sinaloa Culiacán, Sinaloa, Mexico	Pacific Aquaculture and Coastal Resources Center University of Hawaii Hilo Hilo, HI 96720
Current Contacts	
In-Country	US
Eladio Gaxiola Universidad Autonoma de Sinaloa Culiacán, Mexico gacela@usa.uasnet.mx	Maria Haws Pacific Aquaculture and Coastal Resources Center University of Hawaii Hilo Hilo, HI 96720 haws@aol.com

Oyster cultivation in Boca de Camichín (Photo by Tiffany Woods)

NICARAGUA

Introduction

1. Site Selection Criteria

Research and extension for the Human Health and Aquaculture AquaFish CRSP project focuses on bivalve shellfish. There are over 200 species of bivalves on the Pacific Central American coast and this species groups represents an important fisheries and aquaculture resource. Bivalve shellfish (hereafter referred to as "shellfish") are also critically important to family food security as they often constitute an emergency food supply for the poorest-of-the-poor, particularly women and children. The use of shellfish as a fisheries resources is more predominant than aquaculture. Although several local shellfish species have been developed for aquaculture, there is at this time no commercial shellfish culture in Nicaragua. Bivalve fisheries management is, however, a critical issue. There are indications that bivalve populations are being overexploited, both by Nicaraguan residents and Honduran and Salvadorean fishers who enter Nicaragua and fish both legally and illegally. Black cockle species (*Anadara tuberculosa* and *A. similis*) are the most heavily extracted bivalve species and are widely consumed by coastal residents and are transported all over Nicaragua as well as to other Central American countries (illegally). Extraction volume may be as high as 4 million cockles annually. The CRSP-sponsored work focuses on resolving issues related to the cockle fishery in the estuary systems of Pacific Nicaragua, including water quality andshellfish sanitation.

The primary theme area of this work is "Human Health and Aquaculture" which pertains to shellfish culture as these organisms are particularly prone to contamination by human pathogens, toxins and heavy metals. Other species are included in certain investigations of this work as a result of the past ACRSP research which demonstrated that aquaculture sanitation was largely lacking for all aquaculture and fisheries species except for industrial shrimp production.

The Center for Aquatic Ecosystems Research (CIDEA), a part of the Central American University (UCA), has been working on bivalve culture and fisheries research and management issues for over ten years. The Nicaraguan government supports this work as evidenced by the Ministry for the Environment granting research permits and providing collaboration with associated efforts. CIDEA has all the infrastructure and services needed to support fisheries and aquaculture research and extension efforts.

Nicaragua is a relatively stable and peaceful country and is suitable to sustain a viable research program. No problems with personnel security have been encountered in over 10 years of prior work in this region.

2. Specific Selection Criteria

The Pacific Coast of Nicaragua is a particularly good location to conduct research-in part due to the high level of need and justification for this type of work, previously established during a prolonged assessment period under the USAID-sponsored SUCCESS project (Sustainable Coastal Communities and Ecosystems), but because it also possesses all the physical infrastructure, human resources and services required to execute the planned work. The level of institutional collaboration is high as evidenced by past successes with multi-institutional

collaborations and the current existence of 2 multi-stakeholder working groups which are involved in these efforts. USAID/Nicaragua has also expressed its support for this work. Because many of the same management issues associated with bivalve populations in Nicaragua are also found throughout Latin America, work conducted in Nicaragua on bivalve fisheries management and aquaculture will be applicable on a regional basis.

Nicaragua is a relatively peaceful and stable country. Although some political turmoil occurs, this rarely affects research efforts. In most cases researchers and visitors who exercise reasonable caution will not be affected. In over 10 years of work, none of the local researchers or visiting researchers has experienced problems. Economically, Nicaragua is a relatively low-cost environment for conducting research and extension.

The focus species for this work, the black cockles, are native to Nicaragua. Moreover, bivalve shellfish meet all CRSP criteria for "sustainable" aquaculture species since they do not require feed, have low requirements for technology and capital, provide ecosystems services and can directly benefit the most marginalized stakeholders.

Aquaculture is wide spread on the Nicaraguan coast, but the bulk of production and value are with shrimp mariculture. Shellfish aquaculture is seen as a way to diversify away from this capital-intensive and large-scale industry, providing opportunities for poor stakeholders and reducing potential environmental impacts. Inland aquaculture farms also produce tilapia on a relatively small scale with only one large commercial farm in the country. Aquaculture of species other than shrimp in Nicaragua is the least well developed in Central America. Extension services do exist but are limited-one goal of this work is to expand capacity for providing technical assistance to farmers since this is one of the limiting factors for aquaculture development. Hatcheries are few and cannot meet the demand for seed for most species, with the exception of a few shrimp hatcheries. There is still a reliance on imported seed of all types, another issue this work can partially address with development of spat collection methods and training in bivalve hatchery methods.

Nicaragua does have a USAID mission with no termination plan for the near future the official language of Nicaragua is Spanish. Leveraging and buy-in are available through coordination of efforts with other funders. For the current project, the team has targeted a number of fund-raising possibilities, both local and international. As mentioned above, the Nicaragua site has clear ecological and environmental importance as an example of a major national wetland site that makes a good model for sustainable development and natural resources management.

ASERRADORES ESTUARY, CHINANDEGA, NICARAGUA

Aserradores Estuary, Chinandega, Nicaragua

Site Status

Off-Station Site

General Location

The study site, the Aserradores Estuary, is located in the coastal department of Chinandega, which has a surface area of 4,929 km2.

Description of Area/Region

Overall Description

Chinandega is divided into thirteen
municipalities: Chinandega (department head), El Viejo, Corinto, Chichigalpa, Posoltega, El Realejo, Puerto Morazán, Villanueva, Somotillo, Santo Tomás del Norte, San Juan de Cinco Pinos, San Pedro del Norte y San Francisco de Cuajiniquilapa The municipality of El Viejo, to which Aserradores belongs, is located in the northwest end of the country, about 139 kilometers from Managua, the capital, and five kilometers from city of Chinandega. Its geographic position is 12°40¨ North and 87°10¨ West. El Viejo contains 1,308 km2 of land, which is 27% of the Chinandega department and 1% of the national territory. The municipality of El Viejo has more than one hundred and thirteen rural communities, one of which is Aserradores, located on the estuarine ecosystem of the same name.

The estuarine ecosystem of Aserradores extends from the Viejo River to the island El Grandillo, and has its southern borders with the departments of Corinto and Leon.

Climate

The Pacific region of Nicaragua is characterized by a tropical savannah climate. The Koppen classification is Aw.

Temperature

The mean annual average temperature is 27.1 °C, with some insignificant variation on the coldest months, December and January. April is the hottest month registering temperatures up to 35°C.

Precipitation

The annual rainfall average ranges from 750 to 2000 mm, with a noticeable dry season between November and April, and a rainy season between May and October. Most rainfall occurs in July, September and October.

Humidity

The relative humidity is 75% and great variation occurs, registering lower values in the dry season and maximum values in the rainy season. Evaporation reaches the greater values in March and April, registering 223 mm on average, and the lowest values in September and November with only 136 mm.

Seasonality

between May and October. Most rainfall occurs in July, September and October. Wind pattern is generally steady in the northwest-southwestern direction with low speeds between 2.7m/s y 1.8m/s, in all geographic directions. The area is subject to hurricanes, floods and tropical storms. Hurricane Mitch devastated this area in 1998 and impacts are still being felt.

Topography

The area around the estuary is flat with only a few feet of elevation. Elevation rises gently across the Department of Chinandega, punctuated by several volcanos. The hydrologic area of El Viejo is known as the Pacific hydrological plain due to being located in the geographic region of the same name. It is heavily utilized for irrigation to support this region's rich agriculture. The rivers in the area are characterized by their short length, many extending for less than 20 km, with low volume. The majority are ephemeral. Their waters are classified as being of low quality as they carry high quantities of sediments (clay, slime, sand) chemicals, untreated water, etc.

Geology/Soils

From a geomorphologic point of view Nicaragua is divided in five provinces. Three of these provinces have a direct influence on the site of the study.

1- Pacific Coastal Plain: This extends from the Cosigüina volcano in the north to the Rivas isthmus in the south. It has a width of 10 to 35 km with elevation ranging from 0 to 200 m in the north and 500 m in the south. In this sector are volcanic and sedimentaryrocks.

2- Nicaraguan Depression: This extends from the Costa Rican border in the southeast to the Gulf of Fonseca in the northwest. It has a width of 30 to 35 km and is formed by avalley with a very shallow slope

3- Volcanic Mountain Range of the Pacific: This extends for 300 km from the Cosiguina volcano in the north to the Maderas Negras Volcano in the south. It is the most important geomorphologic characteristic of the Pacific of Nicaragua. It is formed by a volcanic chain dating from the Quaternary period of the Pleistocene.

The north departments of the Pacific region of Nicaragua, Leon and Chinandega, have fertile soils of volcanic origin, derived from rock beds and transported by wind and water over relatively short distances. These grounds, in addition to being the most productive, are most susceptible to the erosion due to new accumulations of volcanic material. This northern part of the Pacific Coast, within which the estuarine complex of Aserradores is located, is composed of alluvial grounds, marshes, coastal beaches and volcanic rocks.

Description of Aserradores Estuary, Chinandega, Nicaragua

Map Coordinates	Elevation
Geographic coordinates of the location of the mouth of the estuary are X-0462897 Y-1394371. This community is relatively isolated and among the poorest on the Pacific Coast.	0

General

In general, the communities located in the coastal areas are socially and economically marginalized. Most are extremely poor and have limited access to basic services. Aserradores is a very young community. It is populated mostly by fishers who came from surrounding communities looking for better conditions to unload their catches. The population relocated after the tidal wave that severely affected the Pacific Coast in 1992.

Currently it has more than 600 inhabitants. The main economic activity is fishing (74%), followed by the extraction of the black cockle (*Anadara* sp.) and a few small businesses (shops

and bars). Neighboring the community is a relatively new, large marina which serves touring foreign yachts, but this activity has little influence in the economy of the local population.

Shellfish collection is an activity conducted by women and children between eight and fifteen years old. It is an activity that takes place depending on the success of the fishing. For example, if the fishing is good, then women and children do feel the need to extract shellfish. This activity is important however, in that it provides single women and mothers with a consistent supply of food and income, and serves the entire community as an emergency food supply.

The community of Aserradores falls within the category of extreme poverty; it only has electrical energy, a small clinic and a primary school. It does not have potable water, sewage system or ublic communication system. The community can be accessed by a dirt road in good weather. During rainy weather the community is inaccessible for long periods, which causes food shortages and other health problems. Public transport goes to the community once a day.

Shellfish sanitation has been relatively little studied in Central America, but given the poor sanitary conditions of the estuaries and poor post-harvest handling, this has become an issue of concern. Recently the Central American University has carried out studies on the microbiological contamination of water *(Echerichia coli, Salmonella spp y Vibrio parahaemolyticus)* over a period of twelve months in the three main extractionareas. Results indicated that a potential risk of contamination exists, due to the presence of *Vibrio parahaemolyticus* y *E. coli* in all the sites studied. *E. coli* levels are higher than the permissible level dictates by the USEPA 1976 for fishing and harvest of seafood.

The current CRSP investigation is focused on evaluating the microbiological quality of bivalve growing waters and tissues. Six sampling stations are located in the main zones of extraction of the mollusk *Anadara spp*. in the Aserradores estuary. These sites include four no-take zones that are being used as part of a community-based management effort to improve management of shellfish populations. Results will guide researchers and community members in determining which areas have water quality safe enough to permit the harvest of cockles. Additionally, no-take zone could be relocated to areas with high levels of contamination where collection would be contraindicated for reasons of human health, thus leaving safer areas available for community use.

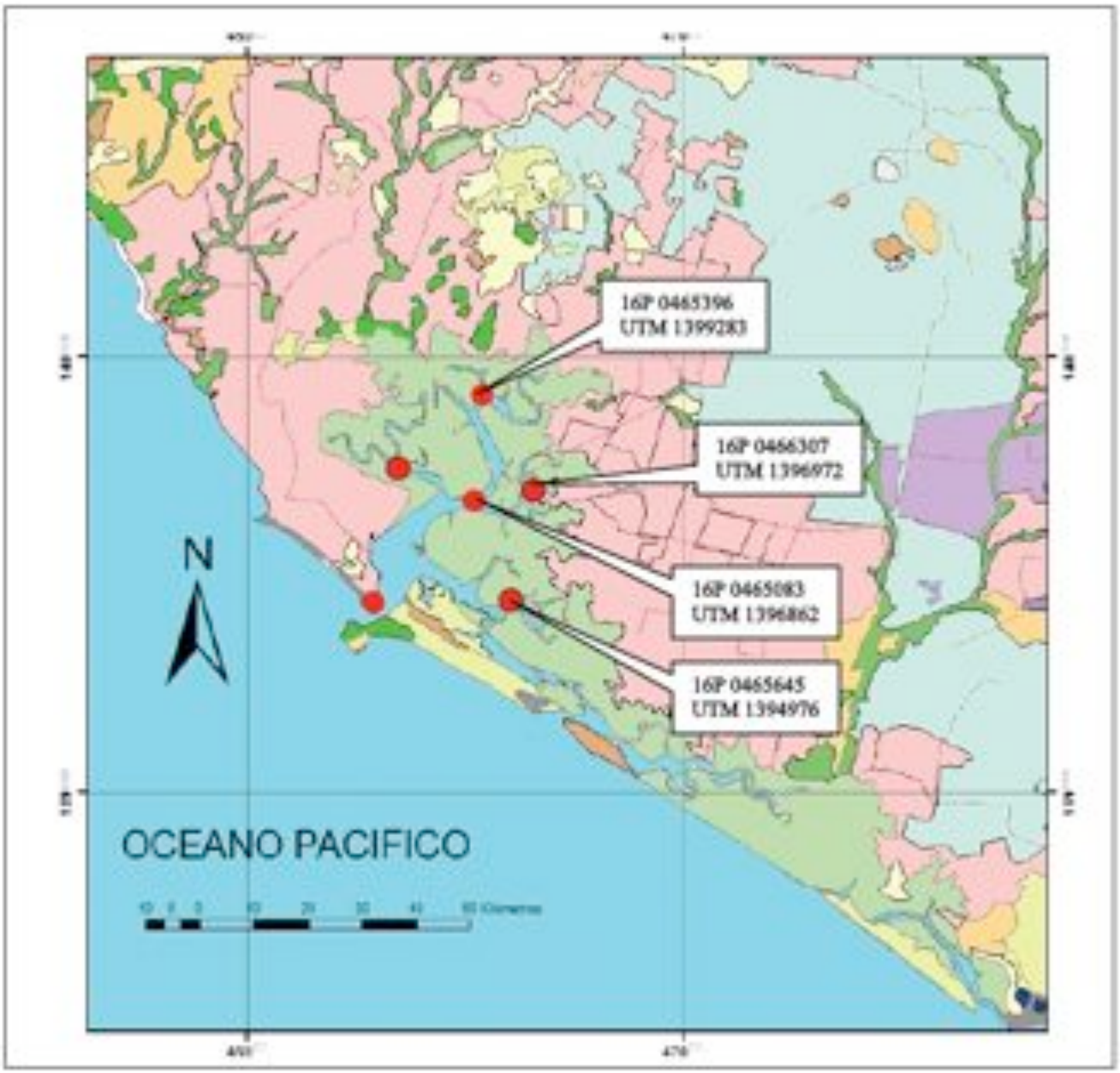
The Center for Aquatic Ecosystems Research (CIDEA) of Central American University (UCA) has it primary offices on its campus in the capital city of Managua. It also has laboratories for water quality, microbiology, aquatic pathology and algae. CIDEA has a demonstration and training center located in the department of Chinandega, which has offices, a classroom, brackish water ponds used to grow shrimp and housing. It also has a freshwater training and demonstration site currently used to keep tilapia located just outside Managua at La Polvosa.

Water Supply

The Municipality of El Viejo has wetlands and estuaries, divided into four sectors: Aserradores, the Padre Ramos estuary, the delta of the Real estuary and the wetlands of Cosiguina. There are few environmental studies of these estuaries, but generally they are characterized by water temperatures near 26°C and salinities that vary between 33.6 and 32.7 ppt. Freshwater to the

estuary is supplied by several small rivers and creeks. Water flow is highly variable depending on precipitation and is modified by the presence of several dams. Soils tend to have some clay content around the area estuary and are generally suitable for pond construction, as evidenced extensive shirmp pond areas. The CRSP work does not involve pond construction. Water quality parameters
are being monitored as part of the research.

Location of the water sampling stations in the Aserradores estuary, Municipality of El Viejo, Department of Chinandega (red dots indicate the sampling stations; stations with locations noted are the no-take cockle zones).



Affiliations	
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SOUTH AFRICA

Introduction

The research involves capturing runoff in ponds for multiple uses including aquaculture, irrigation, and community water supply. South Africa is a water scarce nation, and methods for improving the water supply are important to food production and human health. The particular site is representative of the Western Cape Region of South Africa with respect to geology, climatology, and agricultural activities. Work on water supply and aquaculture done at this site could serve to activate interest in integrating aquaculture into water supply schemes in the specific region, other regions in South Africa, and other African nations. Water conservation, improved use of water supplies, and greater food production are major objectives of the South African government. A major problem in South Africa is immigration of poor people from neighboring nations. It is in South Africans best interest to assist neighboring countries improve technology for water supply and food production, for improving conditions in those countries could lessen immigration into South Africa. University of Stellenbosch is a major university equivalent in capability and quality to universities in the United States. The institution already has a research project on integrating aquaculture into water storage reservoirs, and they are interested in participating in the AquaFish CRSP in order to enhance their capacity to conduct research in this area. There is a long history of governmental support for research and extension by both provincial and national governments in South Africa. There is particular focus of increasing water supply and enhancing food production. Moreover, South Africa is the most politically and economically stable nation on the African continent.

Numerous ponds used for capturing water for irrigation are available for use in the study, and University of Stellenbosch has a history of working with the pond owners. The University of Stellenbosch has adequate laboratory and field equipment for conducting the study. They also have vehicles available for local travel. More importantly, all of the ponds are easily accessible by road. The HC PI, Mr. Khalid Salie, has tremendous interest in collaboration with the AquaFish CRSP, and he previously was a collaborator in the Aquaculture CRSP. A mechanism for collaboration between University of Stellenbosch and Auburn University was established during the Aquaculture CRSP activities. The goals of the USAID mission in South Africa are compatible with the objectives of the AquaFish CRSP.

As already mentioned, South Africa is a politically stable country. The Western Cape Region does not experience a great degree of social unrest, and it is safe for both HC and US participants to travel in the study area. The cost of travel in the region is similar to that of other parts of South Africa. There are rural fish farms, and the University of Stellenbosch has an extension program. The HC participants speak English well, and nearly all educated people in the Western Cape Region have a basic understanding of English. Afrikaans is commonly spoken, but English is a widely used second language. Experience from the Aquaculture CRSP suggests that there will be no difficulties related to shipping, customs, or other regulations related to logistics. There are environmental issues related to possible negative environmental impacts of water supply schemes and aquaculture. The University of Stellenbosch already has included environmental protection as a component of their aquaculture research. There also is an environmental component of the proposed AquaFish CRSP effort in South Africa.

STELLENBOSCH UNIVERSITY

Site Status

Active

General Location

Stellenbosch is located about 50 kilometres east of Cape Town and is situated on the banks of the *Eersterivier* ("First River"). In the region around Stellenbosch, many dams have been built to provide water for irrigation, and in recent years trout have been produced in cages in some of these reservoirs.

Description of Area/Region

Overall Description

Stellenbosch region soils developed from a variety of geological materials. The oldest rocks are sedimentary formations of the Malmesbury Group consisting of shales, schists, and greywacke (Theron et al. 1992). The Malmesbury sediments folded into chains of small mountains and were intruded by granite. The landscape eventually subsided and was covered by sands and shales. Erosion of the sands and shales exposed the remnants of the Table Mountain Group and low granite hills and in front of these formations the coastal plain of the Western Cape developed (Theron et al. 1992).

Farms for this study are on the slopes between the mountains and granite hills (Stellenbosch, Helderberg, Simonsberg, and Drakenstein Ranges) and the coastal plain. Soils on these slopes tend to be highly weathered, sandy, and acidic (pH 5-5.5), and they contain considerable quantities of stone (Conradie et al. 2002). Soils are of the Tukulu, Vilafontes, Avalon, Oakleaf, Glenrosa, Hutton, and Westleigh types.

Climate in the Western Cape region is classified as mild Mediterranean with mean monthly temperatures between 13°C in September and 22ºC in February (Conradie et al. 2002), and rainfall measures up to about 1,000 mm/yr (Walkingholidays.co.za). The natural vegetation is known as fynbos that consists of fine-leafed, thick, shrub-like plants, but much of this vegetation has been replaced with alien species – eucalyptus, acacias, pine, oaks, populars, fruit trees, pasture grasses, vineyards, and exotic weeds. Because of high water use by alien plants compared to native, fynbos vegetation (Dye and Versfeld 2007), the South African government has initiated programs to remove alien species from areas not devoted to agriculture and forestry and re-establish fynbos vegetation on these tracts.

The ponds under the heading cages were sites for cage culture of rainbow trout. The estimated production of trout in 2010 was 6,000 kg in Mountain Vineyards, 12,000 kg in Patryskloof, and 18,000 kg in Blue Gum. Trout fingerlings were stocked in April and fed three times daily with a 38% crude protein content, pelleted feed at about 3% of estimated body weight per day. Marketable-sized trout were harvested between October and December.

Climate
Mild Mediterranean climate
Temperature
Mean monthly temperatures range between 13ºC in September and 22ºC in February. The region is the coldest during July when the mercury drops to 6.6°C on average during the night.
Precipitation
Rainfall measures up to about 1,000 mm/yr (Walkingholidays.co.za)
Seasonality
Summers are dry and warm to hot, with some February and March days rising to over 30°C. Winters are cool, rainy and sometimes quite windy, with daytime temperatures averaging 16°C. Snow is usually seen a couple times in winter on the surrounding mountains. Spring and autumn are shoulder seasons and daytime temperatures hover in the 20°C's.
Topography
well-drained, hilly terrain

Map Coordinates	Elevation
33°55′12″S 18°51′36″E	136m
General	
Stellenbosch University is recognized as one of the four top research universities in South Africa. It has one of the country's highest proportions of postgraduate students of which almost ten percent are international students. The University has grown into the internationally recognized institution of excellence it is today with more than 24 000 students, 800 lecturers and some 50 research and service bodies.	

Water Supply

Numerous ponds used for capturing water for irrigation are available for use in the study, and University of Stellenbosch has a history of working with the pond owners.

Soils

The soils are dark alluvial to clay soils.

Soils on these slopes tend to be highly weathered, sandy, and acidic (pH 5-5.5), and they contain considerable quantities of stone (Conradie et al. 2002). Soils are of the Tukulu, Vilafontes, Avalon, Oakleaf, Glenrosa, Hutton, and Westleigh types.

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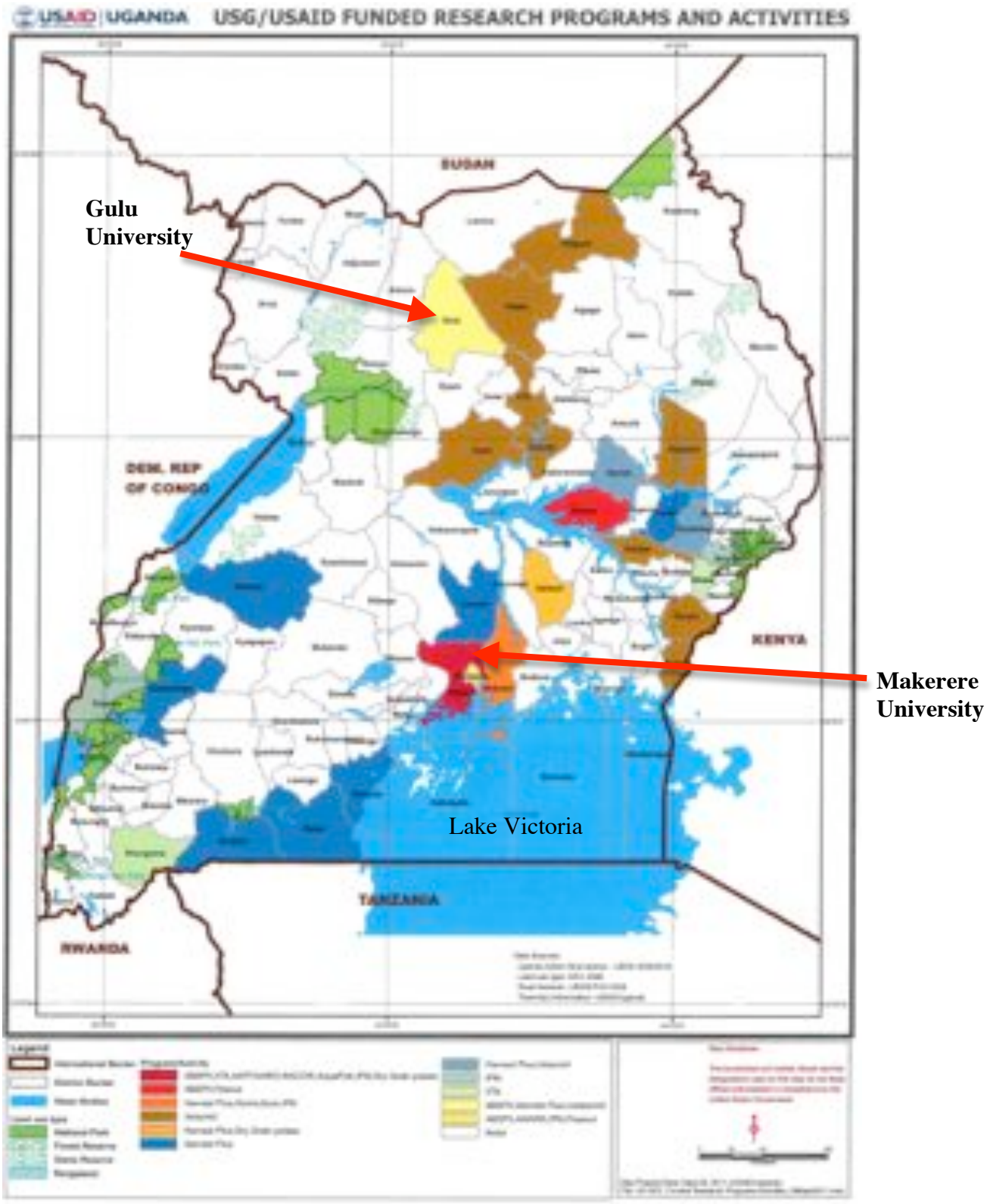
UGANDA

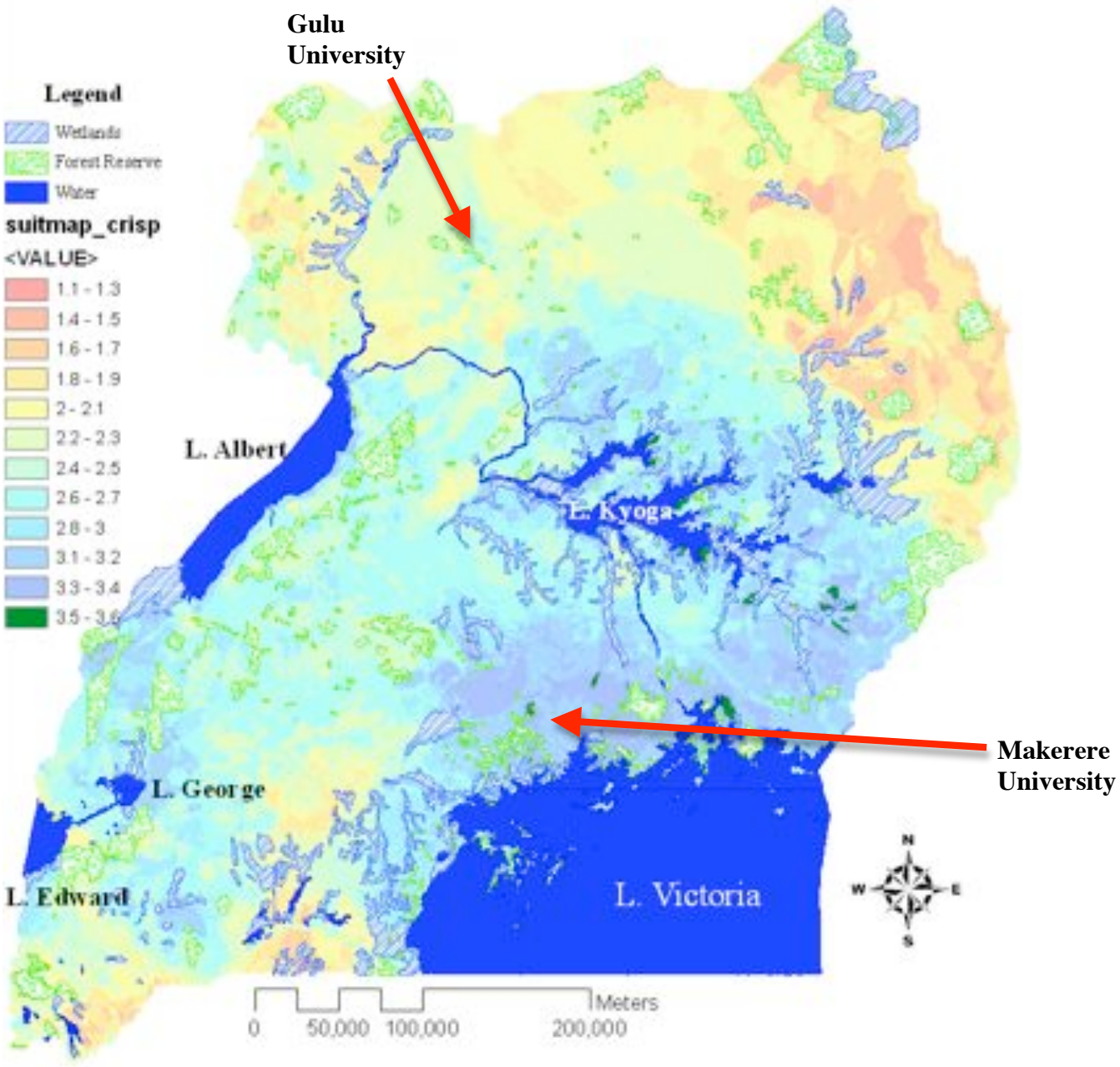
Introduction

Uganda was selected as a project site for several reasons. Existing physical infrastructure – including ponds (or land with suitable soils for ponds), laboratory facilities, communications, housing, transportation, roads, and access. Climate and topography suggest the possibility of diverse locations being suitable for capturing runoff and creating a sustainable water supply for fish and other purposes. We know of some operators who are agreeable to us documenting their successful operations. This will become the platform for defining how other areas can plan water collection structures. Institutional collaboration. The letters of intent from local HCPIs document this requirement. USAID Mission or local office goals and objectives must be compatible with AquaFish CRSP operations and objectives. The project will be conducted, keeping USAID local offices fully informed. Country political stability is not a serious issue at present. Safety, health considerations – adequate working conditions for the HC and US participants are a consideration and hazards are understood as investigators have prior experience in southern Africa. Economic considerations – operational costs, travel, and other costs are not inordinate compared to other countries in the region. Aquaculture is in a growth mode in Uganda, and research in the area is viewed as very appropriate and needed. English is spoken, thus communication should not be an issue. HCPIs will be responsible for communication with indigenous personnel. National strategies for aquaculture development. Host Country policies and strategies may affect research conduct and extension of results. This is an open question. Uganda does have USAID program eligibility without a planned termination in the near future. Investigators knowledgeable of the region suggest a high likelihood of finding local funds for constructing a model pond. Environmental/ecological significance – site represents an important environment and is useful within the AquaFish CRSP global perspective. Uganda meets these criteria. Shipping/ customs/clearance obstacles – evaluate potential constraints for shipping project supplies, or soil samples. Samples will be investigated in country and will not be shipped overseas. Potential for establishing a stable, long-term presence – prefer situations where the AquaFish CRSP can enter as a significant part of a site operation rather than a peripheral position with low priority to site operators. Makerere University desires to establish more of a presence in the water and food sustainability communities, areas, disciplines having committed to helping faculty achieves PhDs in the water resources area. Potential for improving food security and the environment in targeted areas is huge.

The fishery and other topographical, climate and soils resources to be investigated are major sources of food and income. The primary country site is representative of the ecological zone, or geographic region of the commodity, fisheries, soils, climate and topography; the primary country site could serve as the activating nucleus of a scientific network for pond design technology transfer and exchange. There exists in the country the basic institutional research capacity needed to make collaborative research viable at Makerere and other government stations. Government policies are more and more supportive of research, extension, and production. Uganda has a reasonable assurance of political and economic stability and ability to sustain a viable research program.


USAID | UGANDA
USG/USAID FUNDED RESEARCH PROGRAMS AND ACTIVITIES
Gulu University
Makerere University
SUDAN
DEM. REP OF CONGO
KENYA
Lake Victoria
TANZANIA
RWANDA

Tilapia and Clarias farming suitability map generated by "crisp" method.



MAKERERE UNIVERSITY

Site Status

Active

General Location

Makerere University is located on Makerere Hill, which is one of the many hills on which Kampala, the Capital City of Uganda, is built. The main Campus is about 5 km to the North of the City Centre covering an area of 300 acres.

Description of Area/Region

Overall Description

Kampala is the largest city and capital of Uganda.

Temperature

Kampala features a tropical wet and dry climate, however due to city's higher altitudes; average temperatures are noticeably cooler than what is typically seen in other cities with this type of climate. Kampala seldom gets very hot during the course of the year, it's warmest month being January.

Precipitation

Kampala features two distinct wet seasons. There is a lengthy rainy season from August through December and another shorter rainy season that begins in February and lasts through June. However, the shorter rainy season sees substantially heavier rainfall per month, with the month of April typically seeing the heaviest amount of precipitation at an average of around 175 mm of rain.

Topography

Uganda is mostly plateau with rim of mountains

Map Coordinates	Elevation
Latitude: 0° 19' 60 N, Longitude: 32° 34' 60 E	1,190 m (3,904 ft)

General

Makerere University (MAK), Uganda's largest and second oldest institution of higher learning, was first established as a technical school in 1922. In 1963 it became the University of East Africa, offering courses leading to general degrees from the University of London. It became an independent national university in 1970 when the University of East Africa was split into three independent universities: University of Nairobi (Kenya), University of Dar es Salaam (Tanzania) and Makerere University. Today, Makerere University is one of the oldest and most prestigious Universities in Africa with 22 faculties, institutes and schools offering programmes for about 30,000 undergraduates and 3,000 postgraduates.

Water Supply

Well-watered country with many lakes and rivers: ie. Lake Victoria and River Nile

A 60 m × 80 m pond has been constructed at a selected site for demonstration purposes and for future educational purposes and information dissemination. The site is close to Makerere University. (Photos of pond construction site, neighboring wetlands, and agricultural activities.)

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GULU UNIVERSITY

Site Status

Active

General Location

Gulu University is located in Laroo division in Gulu municipality, Located 380 kilometres north of Kampala. The campus is about 4km northeast of Gulu town. It is housed in the premises of the former Gulu District Farm Institute although more structures have been put up.

Description of Area/Region

Overall Description

Gulu is the largest city in Uganda's Northern Region

Climate

Tropical; generally rainy with two dry seasons (December to February, June to August); semiarid in northeast

Precipitation

There is a lengthy rainy season from August through December and another shorter rainy season that begins in February and lasts through June. However, the shorter rainy season sees substantially heavier rainfall per month, with the month of April typically seeing the heaviest amount of precipitation at an average of around 175 mm of rain.

Seasonality

Tropical; generally rainy with two dry seasons (December to February, June to August); semiarid in northeast

Topography

Uganda is mostly plateau with rim of mountains

Map Coordinates	Elevation
2˚46'48N 32˚18'00E	Approximately 1100 m

General

Gulu University is a public University located in northern Uganda, 300 km from Kampala City. Setup in 2002, it is a government initiative targeting science teacher education, medicine, agriculture and environmental sciences, technology, business management, rural transformation and peace and conflict management studies. It is currently made up of three faculties; Business and Development Studies, Science Education, and Medicine.

Two additional faculties of Agriculture and Technology are to be introduced in 2005 and 2006 respectively. The University has a total of 166 staff of which 40 are administrative, 56 support and 70 academic staff, with a total student enrolment of about 1007. The University has four different campuses i.e. Gulu main campus, Lacor Hospital, Gulu Independent Hospital and Gulu Hospital.

This region of the country has been devastated with 20 years of war and with the return of peace; fish farming is one of the activities that have been embraced by the local populace.

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GHANA

Introduction

Ghana is located in West Africa and is bordered on the north by Burkina Faso; on the east by the Cote D'Ivoire and on the west by the Republic of Togo (Figure 1). The southern boundary is covered by the Gulf of Guinea, which provides a rich marine fishery for West Africa in general.

Ghana has moved significantly over the past two decades towards a fairly stable democracy, with 3 to 4 major political parties. There is however the traditional system, where every village and town has its chief and a council of elders. The 22 million inhabitants speak about 60 different languages but the major ones are Akan, Ga, Ewe, Dagbani, Fante and Hausa. English is the official language and is widely spoken throughout the country. Travel through Ghana is fairly easy because of good access roads across the country. Intercity travel is easy by private commercial transportation as well as a governmental owned transport company. Intra city travel is easy with numerous taxis and private commercial mini buses or small trucks.

Ghana has a range of diseases endemic to a sub-Saharan country, with common diseases such as malaria, cholera, typhoid, chicken pox, and measles. Ghana has some modern medical services provided by various governmental and non-governmental institutions such as Christian missions (private nonprofit agencies), and a relatively small number of private for profit practitioners.

Ghana promotes international commerce and trade and has a relatively simple tariff structure, comprising a low rate of 0-5% for primary products, capital goods, and some basic consumer goods, 10% for raw materials and intermediate inputs, as well as some consumer goods, and 25% for final consumer goods. However, there are a number of programs under which imports can be exempted from import duties and manufacturers can apply for permission to import raw materials and intermediate inputs at concessionary duty rates. Project supplies to institutions from abroad, if accompanied by the appropriate documentation, may be exempted from customs tax /duties or a very minimal handling fee may be charged.

Fisheries aquaculture represents a significant alternative livelihood activity in Ghana and remains a formidable alternative employment for the rural poor. The contribution of fisheries aquaculture to the fish requirements of Ghana is fairly restricted; meanwhile harvest from capture fisheries is on the decline. Ghana's fish imports amounts to about US$200 million per annum, an amount that can be reallocated to other sectors of the economy such as the aquaculture industry to supplement fish requirements in the country. Ghana has recognized the importance of aquaculture to help offset the nation's deficit of about 400,000 metric tons of the country's fish requirements. Consequently, the government is aggressively pursuing an aquaculture development policy to make fish farming a profitable business venture and not as a hobby. The government is adopting strategies to address constraints such as quality fish seed and feed, inadequate extension services and support, and marketing. The government has increased staff levels and provided training to improve expertise and skills to assist fish farmers with extension services.

Small-scale farming dominates the industry producing various species of tilapia such as *Oreochromis niloticus*, Tilapia zillii, *Sarotherodon galilaeus* and *Hemichromis fasciatus*, *Heterotis niloticus* and the catfishes (*Clarias gariepinus* and *Heterobranchus bidorsalis*). The government is also actively supporting an FAO project in the Volta Basin to develop fast-growing tilapia specie, the Genetically Improved Farmed Tilapia (GIFT) that would make fish farming commercially and economically attractive. GIFT takes about four to six months to mature for harvesting. Recent studies in Ghana by the Aquaculture Collaborative Research Support Program (ACRSP) have generated information and data on the economic profitability of fish farming, particularly, Tilapia *Oreochromis niloticus*, and catfish *Clarias gariepinus*; and preliminary studies demonstrate that it is a profitable farm enterprise. In recent times, cage farming is becoming attractive and a considerable number of cage farming is proliferating in the Volta Lake, the largest man-made lake in the world. About 1% of the Volta Lake in Ghana has been earmarked by Government for the production of fish under cage culture systems; indicating governments commitment to enhance aquaculture production in Ghana.

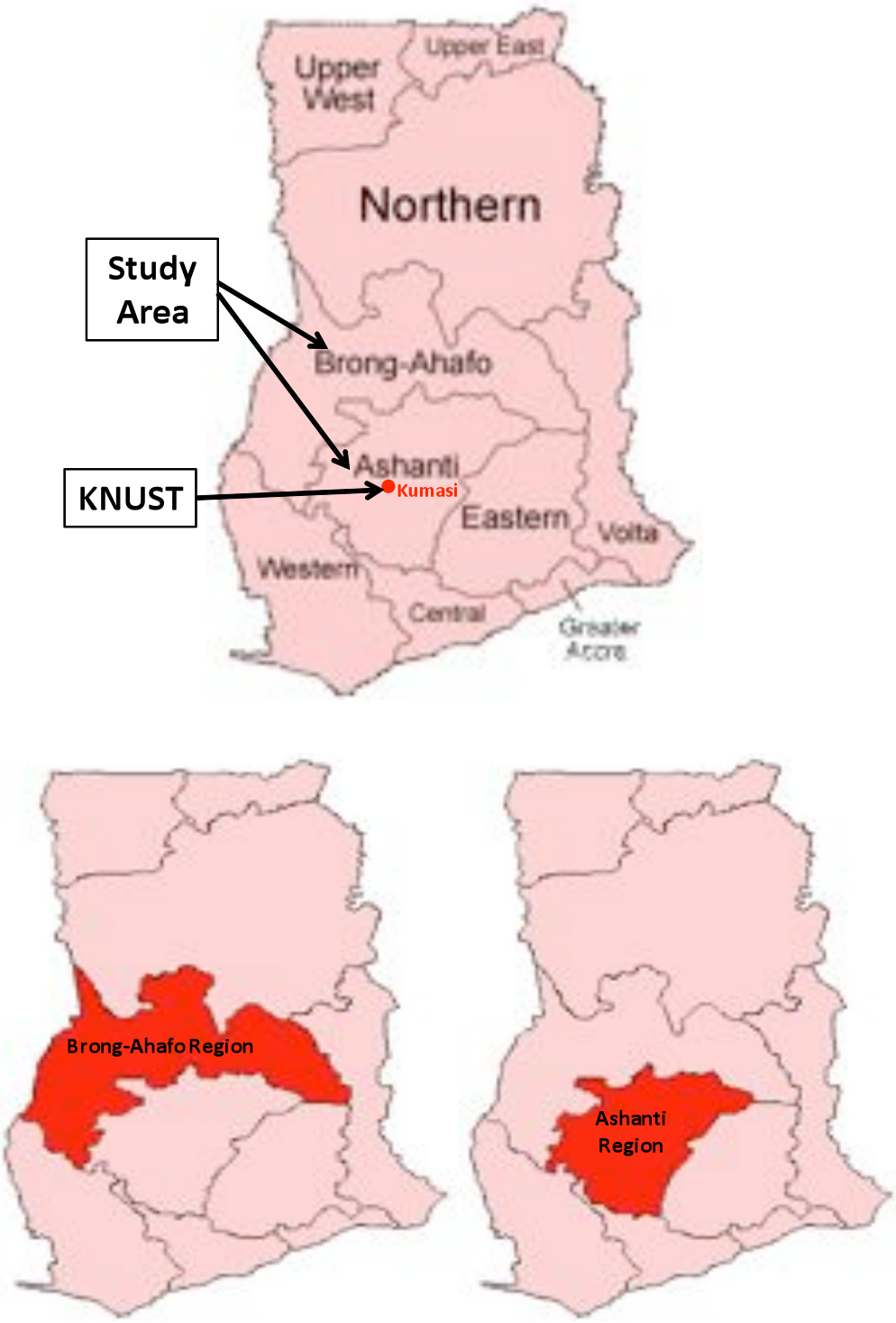
The Ministry of Fisheries (MOF) is the lead agency with administrative control of aquaculture responsible for planning and development in the aquaculture sub-sector. The MOF does not offer credit facilities to fish farmers but promotes the formation of fish farmers associations (FFAs). MOF support the growth of the FFAs by providing each FFA a D6 bulldozer on 7-year credit for the construction of ponds. Because Ghana is governed by a democratically elected government and the political climate is very stable, socioeconomic and political conditions are conducive for investment in aquaculture in the country. The political climate has attracted a number of financial institutions mainly banks from across the globe to invest in Ghana. This has made it possible for borrowing and leveraging of funds for various agricultural activities. It is expected that aquaculture will continue to develop and provide the required data and information to financial institutions so that the sector could benefit from support from banks and lending institutions. An Aquaculture Strategic Framework for the country has recently been fully documented and disseminated to relevant stakeholders.

The FFAs are responsible for lobbying on behalf of fish farmers, organizing purchase of inputs such as seeds and credit, and arranging markets for farmers' harvests. The Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) is responsible for aquaculture research in Ghana. The WRI is the major aquaculture research institution in the country, although the universities - Renewable Natural Resources Institute at Kwame Nkrumah University of Science and Technology (KNUST), Department of Fisheries and Oceanography at University of Ghana (UG), and the Department of Fisheries and Aquatic Sciences at University of Cape Coast (UCC) also conduct some aquaculture research. These three universities and one agricultural college offer training in aquaculture as well. Some limited but informal collaboration exist between the KNUST and the Ministry of Fisheries and it is hoped that these links will be further strengthened as research and extension capacities are developed further.

Ghana is endowed with abundant renewable natural resources. The country is well drained by many large rivers, streams and lakes, which makes it a potential location for aquaculture production either in artificial waters in natural lakes and rivers. Although fish constitute 60% of the total animal protein intake in Ghana majority of these resources are of marine origin.

Unfortunately, the increasing human population now means that the marine fishery is no longer able to sustain the growing demand for fish and fish products. Aquaculture production is carried out in rural Ghana and in some semi-urban communities in Ashanti and Brong-Ahafo regions of the country. There is a considerable number of rural fish farmers who are actively involved in fish farming in the rural areas and whose livelihood depends on it. Some of the major farms in Ghana are Kumah Farms, Tropo Farms, Crystal Lake Farms, Aqua Farms and several others that are actively involved in promoting aquaculture in Ghana.

Earthen fish ponds in Ghana are mainly located close to wetlands, rivers or in close proximity of some other water bodies. They may also be spring-fed. Associated with the production of fish in ponds is the discharge of fish farm effluents, which frequently pollute receiving waters. Receiving waters may be nearby streams, rivers, surface waters or even underground waters. The discharges impact negatively on the aquatic biota including the benthic macro-invertebrate fauna and affect the ecological integrity of such waters. They may also increase the organic loading to such waters. In rural areas, such receiving waters sometimes serve as sources of drinking water and may be used for domestic purposes such as washing of clothes. So far, little or no studies have been conducted on the effects of fish farm effluents on the Ghanaian environment; particularly on receiving waters. The study by CRSP on "Fish farm effluents and impacts on receiving Waters" will generate information and data on the impacts of farm effluents on receiving waters and environment. It will also document the extent of pollution of such discharges and contaminations to surface waters. This knowledge will provide a solid basis for appropriate interventions or strategies to be embarked upon for sustainable fish production and environmental management.



Map of Ghana showing the Brong-Ahafo and Ashanti Regions

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST)

Department of Fisheries & Watershed Management, Institute of Renewable Natural Resources, KNUST, Kumasi.

Kwame Nkrumah University of Science and Technology (KNUST)

Site Status

2004 to Present: Active

General Location

KNUST Department of Fisheries and Watershed Management Aquaculture Facility is about 13km east of Kumasi, in the Ashanti Region. KNUST is located in the transitional forest zone and has an elevation which ranges between 250 – 300 meters above sea level.

Description of Area/Region

Overall Description

KNUST is within the Kumasi metropolis, which falls within the wet sub-equatorial type.

KNUST has the laboratory space and limited facilities for analysis of water quality of effluents from fish farms. Laboratories that complement those of the Faculty of Renewable Natural Resources include those of Water Quality Labs at the Departments of Civil Engineering, Chemistry, Biochemistry and Applied BioSciences. It is expected that the Aquafish CRSP project will result in some modest additions of equipment to the existing ones to facilitate the effluent analysis during the project. For instance, we have recently received a hand-held GPS unit, which will enhance pond referencing as we start water sampling of fish pond discharges

receiving waters at various locations of the country.

Where necessary the Ghana Water Company, Kumasi, at some cost, has allowed KNUST to access its water quality laboratories for mutual benefit. KNUST has its own fish ponds that are primarily used for teaching and research for both undergraduate and graduate students.

KNUST in Kumasi is strategically located in Ghana as far as fish farming is concerned. Kumasi is a strategic market centre with the largest open market in West Africa and a central hub for Ghana. Workshops will be held at KNUST campus and in other strategic locations in the country where policy makers and implementers, local government agencies, NGOs, district authorities, fish farmers and relevant stakeholders will be invited to attend. This will enhance a sense of ownership of the project, cooperation and sustainability of the action after the project has ended.

Climate

tropical monsoon.

Temperature

The average minimum temperature is about 21.5ºC and a maximum average temperature of 30.7ºC.

Precipitation

The rainfall pattern is bi-modal. The major rainy season is between March and July and the minor season is between September and October. Annual rainfall values in these regions range between 1,200 mm to 2,000 mm with considerable variation and distribution with seasons. The months between November and February are usually dry.

Humidity

The average humidity is between about 84.16% and 60% depending on the time of the day.

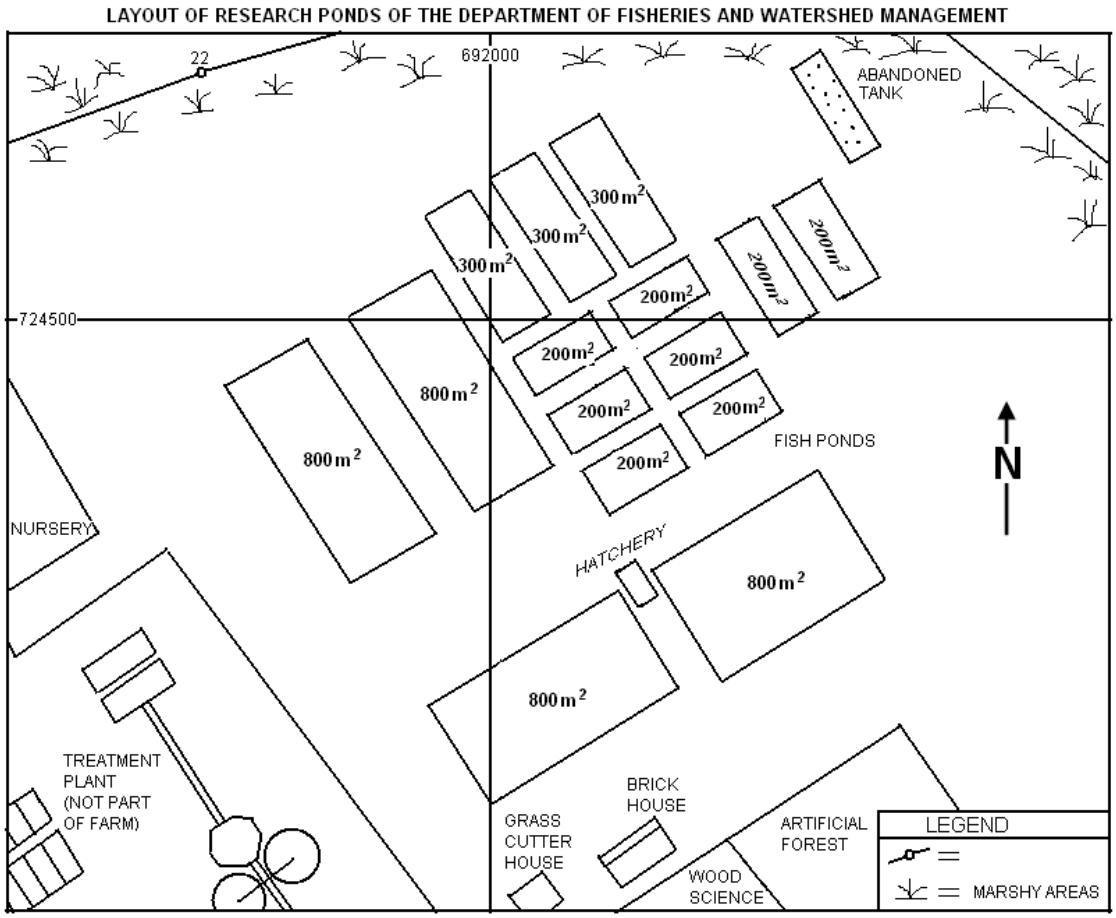
Seasonality

The major rainy season is between March and July, and the minor season between September and October. The months between November and February are usually dry due to the dry northeast trade winds, which blow from the Sahara desert.

Geology/Soils

Kumasi falls within the moist semi-deciduous South-East Ecological Zone with rich soils that are ideal for agriculture.

Layout of Kwame Nkrumah University of Science and Technology (KNUST)



Description of Kwame Nkrumah University of Science and Technology (KNUST)

Map Coordinates	Elevation
06°41'5.67"N 01°34′13.87″W	Mostly < 150 m across regions. Kumasi Airport: 287 m (8 miles west of KNUST Aquaculture Facility).

General

Farmer training and workshops have been conducted in collaboration with the Ministry of Fisheries in Kumasi using facilities of both institutions at the Pilot Aquaculture Training Centre, Kumasi and at the Department of Fisheries and Watershed Management, KNUST (Figure 2).

The aquaculture teaching and research ponds are a major component of the farm complex of the Faculty of Renewable Natural Resources. There are fifteen (15) earthen ponds of varying sizes, all of which are spring-fed (Figure 3). The ponds lie near a river, the River Wiwi, which traverses the university campus from the south end. Three are of the ponds have a total surface area of 300m^2, eight have a surface area of 200m^2 ponds, and four have a surface area of 800m^2 ponds. The average pH values of the pond waters range from 6.5-7.5, whilst water temperatures

range from 25.3^0C- 26.5^0C. There is also a wet laboratory, a store room, a small hatchery and a site for a duck pen.

Current work and research at the fish farm include: Tilapia and catfish fingerling production, and fish feed and nutrition experiments to find local suitable, cost effective feed for fish production to reduce overdependence on imported feed. Most of the feeds are farm-based and this represents a setback to a viable aquaculture production. Research is needed to identify local feeds and formulate them. Most commercial feeds are imported from Brazil or Israel but the sustainability of this has been questioned by many. Efforts are being made to produce extruded feed for the aquaculture industry and the government is backing this fully.

Recently the site received experts in aquaculture from USA, Honduras, Brazil, Kenya, Philippines and China to share experiences on cichlid culture, particularly Tilapia. The team included Dr. Hillary Egnah, Director of the HCPI Exchange Programme and Dr. R. Bowman, Coordinator for the project. The team held a meeting with the USAID officials in Accra, Ghana and formally presented the activities of AquaFish CRSP in Ghana and introduced the Host Country, PI. Dr. Steve Amisah. The team including the host country PI had earlier visited South Africa under the same programme.

KNUST collaborates with many international agencies and universities in the UK, USA, Canada, Netherlands, Israel, Germany, South Africa and several other African universities. It has affiliations with some new university colleges in Ghana but that is to provide some oversight as they try to develop their own curricular and set standards that meet international requirements. There are several formal and informal linkages with various institutions such as the Council for Scientific and Industrial Research (CSIR) and these frequently offer limited training facilities for both undergraduate and graduate students.

Water Supply

Water supply is from two surface water treatment plants; Owabi and Barekese headworks located 10km and 16km respectively from Kumasi. The supplies of water from these headworks serve Kumasi metropolis as well as surrounding communities outside the metropolis. The area has a 13,800m^3 storage reservoir located at Suame, and 1,900m^3 capacity reservoir located at KNUST.

Soils

The Kumasi Metropolitan area is dominated by the Middle Precambrian Rock, which is utilized in the construction industry. There are a few small-scale mining activities and the proliferation of stone Quarrying and Sand Winning Industries. The major soil type is the Forest Ochrosol, which is a very rich type used for the production of agricultural commodities such as vegetables, plantain, corn, and cassava etc.

Affiliations

In-Country	US
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BRONG-AHAFO AND ASHANTI REGIONS

Site Status

Active

General Location

The Brong-Ahafo region shares boundaries with the Northern Region to the north, the Ashanti and Western Regions to the south, the Volta Region to the east, the Eastern Region to the southeast and La Cote d'Ivoire to the west. It has 19 administrative districts, with Sunyani as the regional capital. The region lies in the forest zone and is a major cocoa and timber producing area. The northern part of the region lies in the savannah zone and is a major grain- and tuber-producing region.

The Ashanti Region is centrally located in the middle belt of Ghana and shares boundaries with Brong-Ahafo in the north, Eastern region in the east, Central region in the south and Western region in the South west. The region occupies 10.2% of the total land area of Ghana. More than half of the region lies within the wet, semi-equatorial forest zone.

Climate

The climatic conditions in the study regions; i.e. Brong-Ahafo and Ashanti regions are virtually the same.

Temperature

temperatures ranging between 20ºC and 37ºC and these vary with day and season

Precipitation

The regions are marked with fairly high incidence of solar radiation. The rainfall pattern is bi-modal. Annual rainfall values in these regions range between 1,200mm to 2,000mm with considerable variation and distribution with seasons.

Humidity

Morning Relative Humidity (RH) values are usually at their highest during the wet seasons and mean monthly figures range between 87-91% during 0900 hours decreasing to 62-78% at 1500 hours. The lowest RH values are usually between 83% and 87% in the morning and between 48% and 67% in the afternoon in the dry season.

Seasonality

The major rainy season is between March and July and the minor season between September and October. The months between November and February are usually dry due to the dry northeast trade winds which blow from the Sahara desert.

Topography

The regions' topography ranges from low lying, gently undulating regions to distinctly hilly and mountainous regions as well as some rocky surfaces. Brong-Ahafo region lies between 150-640m above sea level, while Ashanti region is 150-300m above sea level.

Geology/Soils

The two regions lie between the moist semi-deciduous forest belts of Ghana, with the northern part of the Brong-Ahafo Region having a transition into the Savanna. Parts of the Brong-Ahafo region lie in the Tropical High Forest zone. The zones are characterized by plant species of the *Celtis-Triplochiton* association with the *Antiaris-Chlorophora* association of plant species in areas around the Forest reserves in the Brong-Ahafo Region. There are a few primary forests which are reserved, secondary forests, thickets, and swamp vegetation.

Description of Brong-Ahafo and Ashanti Regions

Map Coordinates	Elevation
Brong-Ahafo Region coordinates: 7° 45' 0" N, 1° 30' 0" W Ashanti Region coordinates: 6° 45' 0" N, 1° 30' 0" W	The Brong-Ahafo region is about 150 meters in the southern and eastern parts to an average height of 640 meters above sea level in the northern parts while the Ashanti region is situated between 150 and 300 meters above sea level.

General

The bulk of fish farming activities in Ghana is concentrated in the Ashanti and Brong-Ahafo regions. Tilapia and catfish are the main cultured fishes in ponds. Aquaculture is now recognized by the Ghana government as a priority area for sustainable development.

Water Supply

Both regions are well drained by several major rivers, the Anum, Pra, Offin, and Afram rivers. Lake Bosumtwi lies 28km south-east of Kumasi in the Ashanti region. The northern parts of the region are dominated by the Black Volta River and Volta lake. The Brong-Ahafo region also has other prominent rivers such as the Tain, Bia, and Tano rivers. These rivers and their numerous tributaries cover many areas of the Brong-Ahafo region. There are other smaller rivers and streams which serve as sources of drinking water for residents of some localities in the two regions.

Soils

The soils of the area are acrisols and ochrosols with some nitisols, alisols, leptosols, gleysols and fluvisols. The texture of the soils varies according to the nature of the parent material. Some soils in the region are medium-texture, non-gravelly, moderately deep to very deep and well drained. On the other hand some have well drained soils overlying hard rock or bauxite pan. Clayey areas are dominant, presenting potential opportunities for earthen pond construction for successful aquaculture.

Affiliations

In-Country	US
Water Research Institute (WRI) Council for Scientific and Industrial Research (CSIR) P.O. Box 38, Achimota, Ghana Tel: (233 21) 775351-2, 77953-5, 775511, 761031 Fax: (233 21) 777170, 761030 E-mail: wri@ghana.com Ministry of Fisheries P.O. Box 3820 Kumasi Tel: (233-51) 29896	Dept. of Agricultural Economics Purdue University 403 W. State St., Krannert Building W. Lafayette, IN 47907-2056 USA Illinois-Indiana Sea Grant College Program Purdue University 195 Marsteller St., FNR Building, W. Lafayette, IN 47907-2033 USA

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KENYA

Introduction

The Republic of Kenya lies astride the equator on the Eastern seaboard of Africa (Figure 1). It covers an area of approximately 582,600 km^2 of which 133 km^2 is water. Kenya has played a leading role in the quest for peace and stability in the turbulent East African region, because of her stability and general neutrality. However, the 2007 election led to violence that later resulted in a coalition government that has incorporated all the major parties. Land use in Kenya is described in terms of ecological zones (I-VI), which are derived from a combination of climate, soil, topography and vegetation type. Most land is either of high, medium or low agricultural potential, depending on the ecological zone. Agricultural land use falls into two categories: either high-to-medium or low potential according to the amount of rain received and rates of evapo-transpiration.

The high-to-medium potential arable areas are 26% of total humid to sub-humid areas that receive 750-1400 mm of rainfall. The low potential areas (74% of the total) are marginal agricultural lands where rainfall is unreliable and is often less than 750 mm. In the absence of irrigation or water conservation, they are suited only to livestock raising. The high-to-medium agricultural potential areas supports 80% of the total human population (~33 million in 2007) while the remaining 20% live in the low potential areas (arid and semi-arid zones). The Capital city is Nairobi while official languages are English and Kiswahili.

The government of Kenya development policy has always focused on alleviating poverty through increased food production and minimizing environment degradation. Consequently, a major priority development need of the government has been trying to introduce low-cost aquaculture, which will increase available protein to local communities. Mixed-sex Nile tilapia culture represents over 75% of fish produced through aquaculture. Polyculture of Nile tilapia and catfish produce about 15% of the national aquaculture production. Until year 2000, aquaculture in Kenya had stagnated at an annual production of around 1,000 tonnes. Since 1999, however, through consistent efforts in on-farm research and training, Kenya's aquaculture production has risen and is currently at about 3,500 tonnes. The focus is now on encouraging the development of private, commercial large-scale aquaculture, which is likely to increase Kenya's production to about 12,000 tonnes in the next three years. This development follows the efforts of the Department of Fisheries with development partners such as ACRSP to promote aquaculture as one of the means to eradicate poverty and hunger. During the preparation of the Poverty Reduction Strategy Paper in 2000, the Government identified aquaculture development as a core activity for funding through the current Medium Term Expenditure Framework Budgeting System. The period from 2000 until now has been marked by aggressive research, training and private sector involvement in aquaculture. Production in real terms has doubled and is set to grow by over 1,000 percent (ten times) in the next three years. The prevailing conditions combine good prices and high demand, which are likely to boost fish production from aquaculture.

Since independence, Kenya has enjoyed rare blessings of economic growth and political stability, which make her a showcase in Africa. Indeed, it is this political stability, despite changes in its political system and crises in neighboring countries, that has been Kenya’s main

economic asset. This had been particularly true since the re-emergence of multiparty democracy and the accompanying increase in freedom (including freedom of speech, the press, and assembly).

However, the December 2007 elections were marred by serious irregularities, and set off a wave of violence throughout the country. The post-election violence triggered political unrest and heavily affected the economy. Following the February 2008 signing of a power-sharing agreement between President Kibaki and the opposition, a new coalition cabinet was sworn in April 2008, headed by Prime Minister Odinga. With the creation of the coalition government, the Kenyan Government has now focused its attention on achieving its ambitious reform agenda, aimed at avoiding a repeat of early 2008's post-election political and tribal violence. The government also plans to draft a new constitution by April 2009, specifically to address land rights issues and to restructure the government by strengthening institutions to create a more effective system of checks and balances.

Despite the post-election crisis, Nairobi continues to be the primary communication and financial hub of East Africa. It enjoys the region's best transportation linkages, communications infrastructure, and trained personnel, although these advantages are less prominent than in past years. A wide range of foreign firms maintains regional branches or representative offices in the city. The economy is expected to benefit significantly from reduced internet access prices and improved capacity.

A malaria risk exists all year round, but more around Kisumu and Mombasa and the lower coastal areas than in Nairobi and on the high central plateau. Immunization against yellow fever, polio and typhoid are usually recommended. A yellow fever certificate is required by anyone arriving from an infected area. Other risks include cholera and diarrhea. Protection against bites from, mosquitoes and tsetse flies is the best prevention against malaria and dengue fever, as well as other insect-borne diseases, including Rift Valley fever and sleeping sickness. AIDS is a serious problem in Kenya and the necessary precautions should be taken.

Water is of variable quality and visitors are advised to drink bottled water. Cholera outbreaks occur frequently, and travelers should take care not to drink contaminated water and eating food prepared by unlicensed roadside vendors. There are good medical facilities in Nairobi and Mombasa but health insurance is essential.

Nile Tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) are the principal aquaculture species in Kenya and the region and are well adapted to local conditions. Other Species include the air-breathing lungfish (*Protopterus ethiopicus*), *Labeo victorianus* and other endemic fish species.

Tilapia species form about 90 percent of farmed fish in Kenya. Polyculture of the Nile tilapia (*Oreochromis niloticus*) with the African catfish (*Clarias gariepinus*) is often practiced to control the prolific breeding of the former and increase production per unit area. Aquaculture takes many different forms ranging from the small hand-dug 'kitchen ponds', to fairly large earth ponds of 1 000 m2. Dams and other impoundments of stored water are often stocked with fish and

harvested periodically. Aquaculture practices include the intensive, semi-intensive and extensive systems. The semi-intensive systems form the bulk of aquaculture production in Kenya, contributing more than 70 percent of the total production from aquaculture. Intensive systems are few, while hyper-intensive systems are being set up and are projected to contribute as much as 90 percent of all farmed fish in Kenya by both volume and value.

Although there are many features of the Lake Victoria Basin, which are of interest to biologists, it is the fish that receive the most attention. The cichlids (including the Nile tilapia) in particular have had a remarkable burst of speciation in response to the environmental changes that have taken place in the basin and on Lake Victoria. One of the main events of importance to the Lake ecosystem in the past thirty years was the introduction of new species such as the Nile perch into the Lake. It is also important to note that the size of the fishery exploded from 1978 on, perhaps, a factor of five or more resulting from this introduction. Physical interferences, environmental degradation and change in land use have reduced fish catches, Aquaculture would therefore be a logical step in restoration of populations of selected and threatened species, improve fish supply to local riparian communities, return of delicacies to consumer markets and improved livelihood to fish traders and fish farmers.

Fish farmers could diversity their fish production to serve as baitfish for Lake Victoria, avail basic human food for local and distance markets. The demand for catfish fingerlings is projected to grow further as the aquaculture potential of the Lake Victoria Basin is deemed enormous considering its water resources the geographic characteristics of the basin, demographic trends, fish eating culture and declines in Lake Victoria capture fisheries productivity. The domestic market for Nile tilapia is quite promising. Prices are high in major cities and other parts of the country. The major towns surrounding the aquaculture production centers constitute assured markets.

The government strategy advocates a paradigm shift in the roles of government and the private sector in aquaculture. This finds expression in all major policy documents of the government of Kenya, such as the PRSP (Poverty Reduction Strategy Paper, 2001), KRDS (Kenya Rural Development Strategy), ERS - W&E (Economic Recovery Strategy for Wealth and Employment Creation, 2003) and SRA (Strategy for Revitalizing Agriculture). Some of the measures that the Government is planning in order to support aquaculture in both public and private sector initiatives are:

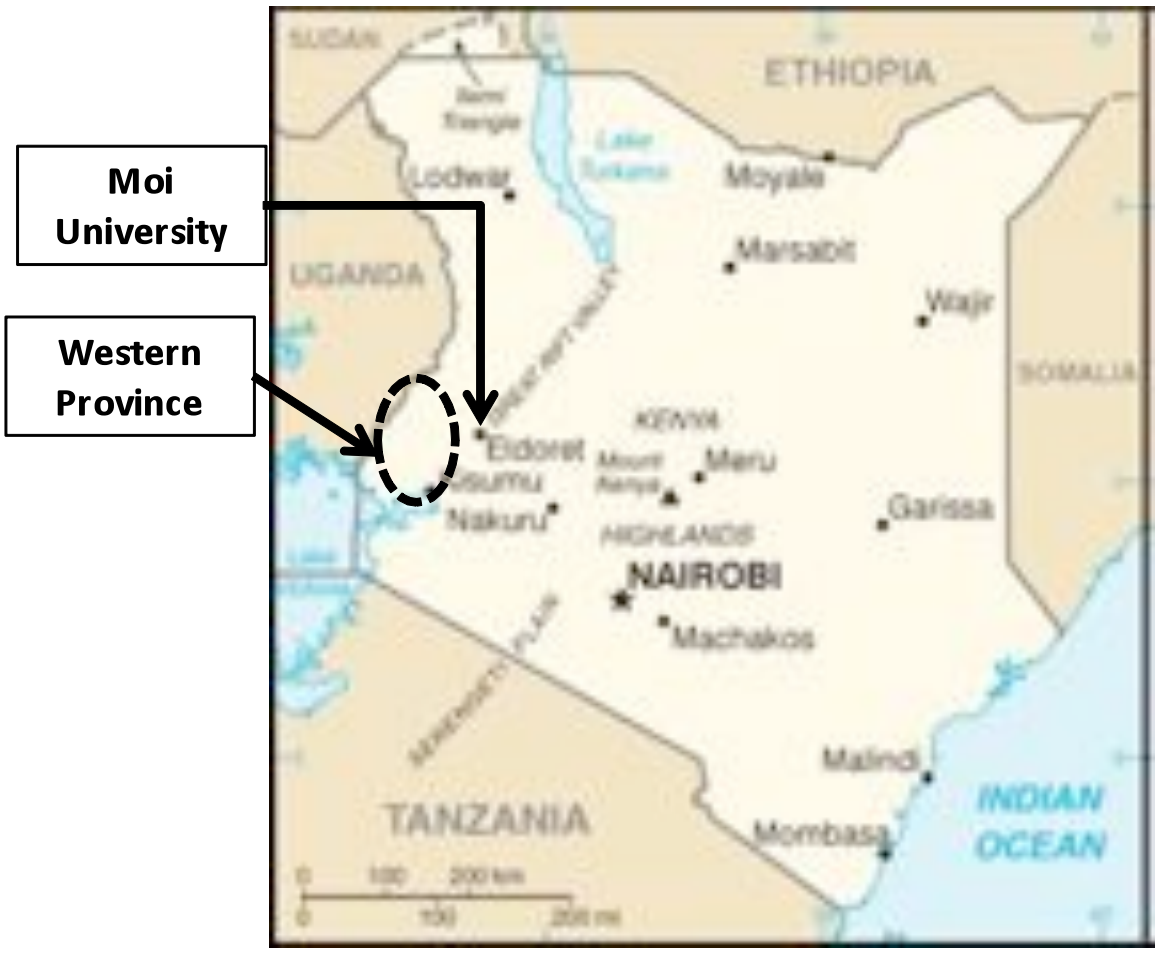
- Providing basic infrastructure for aquaculture development e.g. roads, electricity to fish farming areas, water, schools, hospitals and telecommunication and radio network systems
- Creating a legal framework and policies for aquaculture development
- Framing and implementing policies for commercialization and privatization of activities in the aquaculture sub sector
- Encouraging research and development for aquaculture
- Developing monitoring and evaluation systems
- Providing land for aquaculture development
- Involving the communities and other stakeholders in the process of policy formulation and implementation

- Encourage the private sector in order to drive aquaculture growth.
- Creating private-public partnerships in service provision through dialogue and joint programmes

Aquaculture development among rural households with limited resources remains a challenge. The rural poor face many constraints to entry into aquaculture farming and subsequent adoption of improved technologies and management practices. Among others, availability of startup capital, operational resources, and reasonable prices are important in order to adopt, operate and sustain improved fish farming practices and produce quality fish. Most developing projects are more concerned with increased production of fish. Producing more fish does not necessarily imply profitability of the fish farming business. Economic analysis is an important management tool necessary for business planning, seeking financial assistance from formal institutions and identifying economically sustainable enterprises.

The major Government Aquaculture Research Institutions are:

- Sagana Fish Farm at Sagana, Kirinyaga District, Central Province.
- Kiganjo Trout Farm, Nyeri District, Central Province.
- Moi University, Department of Fisheries and Aquatic Sciences, Eldoret, Uasin Gishu District, Rift Valley Province (Figure 1)
- Kenya Marine and Fisheries Research Institute, Mombasa District, Coast Province.



MOI UNIVERSITY AQUACULTURE RESEARCH FACILITY

Site Status

Moi University, Eldoret - Active
1999 to present – Primary site for Training and Survey work

General Location

The Moi University Aquaculture research facility is located 12 km outside of Eldoret Town. The Fish Farm has an area of approximately 10 ha, of which 5 ha is in ponds (Figure 2). There are 47 fishponds of various sizes, ranging from 100$m^2$to 0.2 ha in size. Site facilities comprises of a hatchery, quarantine unit and fishponds alongside supporting laboratories, workshop and offices. Electricity, telephone service, and clean water are provided. One Land Rover and a Toyota double cabin are available to support farm activities.

Description of Area/Region

Overall Description

Ponds are dug in black cotton soils formed from volcanic rocks on a gently sloping plateau approximately 10 km North of Eldoret Town. The black cotton soils indicate that the soils have formed under restricted drainage conditions, which are the result of low rainfall and the presence of level to moderate slopes. Considerable attention was given to both design and future operation of the fish farm. The Farm is situated on a plateau at the edge of the eastern wing of the Rift Valley and over looking Mount Elgon and, resulting in cool high altitude climate. The ponds are located on a gently rolling topography tapering into a wetland well vegetated by papyrus reeds.

Climate

cool high altitude climate

Temperature

Highest temperatures occur in March and the lowest in July with temperatures ranging from 13 to 19ºC in the cool season and from 17 to 25ºC in the warm season.

Precipitation

Rainfalls Average 1223 mm, Rains are unimodal and fall from March to September. The “long rains” fall from March through May with a single-month peak of 500 mm or more in April.

Humidity

Humidity in the highland region surrounding, the campus ranges from around 40% to 90% in the afternoon during, the dry season to 50-60% in the rainy season.

Seasonality

Average 1223 mm, Rains are unimodal and fall from March to September. The “long rains” fall from March through May with a single-month peak of 500 mm or more in April. There is a distinct cool season between June and August, when rainfall is at a minimum. Even though there is little rain, the skies tend to be overcast much of the day during this period. A rainy period known as the “short rains” occurs between October and December.

Topography

The Farm is situated on a plateau at the edge of the eastern wing of the Rift Valley and over looking Mount Elgon and, resulting in cool high altitude climate. The ponds are located on a gently rolling topography tapering into a wetland well vegetated by papyrus reeds.

Layout of Moi University Aquaculture Research Facility

Aerial photograph of Moi University Aquaculture production and research facility

Description of Moi University Aquaculture Research Facility

Map Coordinates	Elevation
The facility lies along the Eldoret-Ziwa-Kitale road between longitudes 34° 50' east and 0°03' and 0°55' north.	University Aquaculture research facility is 2180 meters above the sea level along

General

Researchers at the Moi University Fish Farm developed a technique for the induced spawning of the African catfish (*Clarias gariepinus*) using pituitary hormone. Subsequently, mature catfish previously raised from fingerlings were successfully spawned. The significance of this successful trial is that Moi University fish farm is now in a position to develop quality catfish fry for fish farmers. One recipient farmer has reared about 10,000 catfish fingerlings over a period of three months in a small 8 m x 12 m pond and these were then sold to become baitfish for the Nile

perch longline fishery of Lake Victoria. The return on this type of investment is well above returns from any other type of farming within reach of people in the region.

The Department of Fisheries has developed reasonable laboratory facility with basic equipment for ecology, fisheries, physiology, and water quality and fish post-harvest technology. Apart from laboratory-based facilities, the location of the department in Western Kenya affords it numerous opportunities for field research particularly on aquatic sciences. All the rivers that drain into Lake Victoria have their source from this region, making these catchments one of the most important ones in East Africa. This region is endowed with numerous natural freshwater and saline lakes with unique flora and fauna. These include Lakes Victoria, Nakuru, Bogoria, Baringo, Turkana, and Naivasha. The largest wetland habitats are also found in the region not forgetting Kakamega Forest, the only surviving tropical rainforest in the region.

The department has a small library with current and past issues of books, Journals donated from various persons, and institutions including; a donation of more than 1200 issues from ACRSP, Oregon State University. All these titles have been sent to Chepkoilel Campus Library. In April 2008, Aquafish CRSP Director purchased additional titles to help rebuild the department's library after some books were destroyed during the post election violence that occurred in January/ February 2008.

Chepkoilel Fish Farm is operated by the Department of Fisheries and Aquatic Sciences in the School of Natural Resource Management. Students from the University and several other institutions conduct field studies at the farm. Supplies of fertilizers, chicken feed, and feed ingredients such as rice bran are generally readily available, at least in Eldoret town and its environ.

Moi University offers MSc and a PhD degree in Fisheries with an Aquaculture option. A diploma in Aquaculture can be obtained from the Kenya Wildlife Training Institute at Naivasha. Other short courses in aquaculture are offered by the Department of Fisheries and Aquatic Sciences at Moi University. The Moi University Fish Farm was designed to fulfill a number of roles:

- To be a practical facility in support of fisheries students studying aquaculture;
- To act as a demonstration unit to promote the potential of freshwater fish farming to community leaders, government officials, extension workers and entrepreneurs (– this to be achieved through practical training courses, visits, 'open days' and the dissemination of information);
- To serve as a Regional Centre of Excellence for research into appropriate aquaculture methods and for the development and assessment of equipment, feeds, husbandry practices, etc., including economic evaluations of production methods;
- To function as a supplier of juvenile fish to farmers in the region to both generate local revenue and assist fish farming development;
- To provide applied research opportunities for faculty members and visiting scientists.

In order to satisfy the range of purposes outlined above, considerable attention was given to both the design and future operation of the fish farm. The main facilities include a hatchery, quarantine unit and fish ponds alongside supporting facilities of a seminar room, laboratories, workshop and

offices. To keep the risk of problems from fish diseases and parasites to a minimum, water supply to the ponds is from a 1.2 ha spring-fed reservoir. The ponds themselves were designed in accordance with FAO recommendations and have the following important features:

- Filled by gravity inflow to avoid the need for pumps;
- Fully drainable with adjustable plumbing work to enable effluent to be discharged from any chosen depth within the pond;
- Sloping sides to enhance natural productivity;
- Fertile surface soil, set aside during pond construction, used to cover the bed of the ponds;
- Effluents are intercepted by *C. papyrus* swamp prior to entering the exit stream.

Several sizes of ponds were constructed to hold Tilapia and Catfish fingerlings. In addition, there are holding facilities set aside for propagation of ornamental fish species such as Gold fish.

Soils

Soils are igneous in origin and underlain by tertiary volcanic rocks (phenolites) characterized by low natural fertility. The soils in this region are acidic with soil pH ranging from 5.5 to 6.4. They are red friable over petroplinthite and are classified as rhodic ferralsols. Clay content averages 30% and the soils have a high water holding capacity. The area is characterized by brown loamy soil—soil structures are mostly granular indicating low water seepage due to small soil pores.

Support Facility of Moi University Aquaculture Research Facility

Six districts in Western Kenya

Location of the six districts in western Kenya where the study will be done

General Location

Western Province, lying at 0^0 30' N and 34^0 35' E, has diverse physical feature, from the hills of the northern Bungoma district (which has now been split to three districts) to the plains bordering Lake Victoria in Busia District.

Description of Location
The climate is mainly tropical, with variation in altitude, hot and wet all the year round and ideal temperatures (ranging from 24 to 32^{0}C) for culture of Nile tilapia and African catfish. The six districts are Busia, Bungoma, Kakamega, Mumias (split from Kakamega), Vihiga and Emuhaya (split from Vihiga) as shown in the map.

Site Description
Bungoma coordinates: 0° 34' 0" N, 34° 34' 0" E
Busia coordinates: 0° 27' 0' N, 34° 5' 0" E
Kakamega: coordinates: 0° 17' 0" N, 34° 45' 0" E
Elevation = 1523m

Lake Victoria in the area produces about 170,000 metric tons of fish each year, with thousands of lakeshore residents employed in fishing and fish processing. Harvesting of Nile Perch (*Lates niloticus*), has generated about $US 100 million of foreign exchange in the past and there are about 10,000 people now employed at commercial fish processing facilities in the Kenyan towns of Kisumu, Homa Bay and Migori. The sustainability of the fishery is now threatened by, over fishing, pollution and uncertainty resulting in ecological instability. Fish traders and small-scale farmers in the Lake Victoria area will participate in this study. They will include Small-scale fish farmers in the six districts mentioned and fish traders in landing beaches neighbouring the six districts such as Port Victoria, Usenge and Uhanya.

Affiliations	
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TANZANIA

Introduction

Tanzania used to be ruled by only one party, the Chama Cha Mapinduzi (CCM) but the one party state ended in 1992 when amendments were made to the constitution and a number of laws were enacted to permit and regulate the formation and operations of more political parties. Tanzania enjoys a good political environment. The country is generally safe for both local people and visitors and there are no terrorist groups which are known to reside in the country. More information on history, culture, political parties, governance, etc. can be obtained at the national website (http://www.tanznia.go.tz). The country currently has twelve registered political parties, in addition to the ruling party (CCM).

Tanzania has more than 126 tribes and each ethnic group has its own language. Swahili is the official national language and is used for official business as well as inter-ethnic communications. However, English is taught in schools and is used for some official businesses and is used as a medium of instruction in the universities. Transportation network in Tanzania is satisfactory, mainly road transport, and rail. The quality of the road network is limited with paved highways confined to the north-eastern, central-eastern, and south-western regions of the country, including Morogoro, the AquaFish project site. Intercity travel is by private commercial transportation, mainly mini buses and trucks. Intra city travel occurs with taxis and private commercial mini buses, the "matatu."

The major health problems in Tanzania are communicable diseases, particularly HIV AIDS and obstetric complications while malaria is the leading parasitic disease. Other major parasitic diseases include hookworms, bilharzia, trypanosomiasis and intestinal worms. Tanzania has some modern medical services provided by various governmental and non-governmental institutions such as Christian missions (private nonprofit agencies), and a relatively small number of private for profit practitioners.

The Tanzania government adopted its first market-oriented national trade policy in February 2003 and implemented trade reforms resulting in substantial reduction in its average tariff protection. Tanzania is a member of the Southern African Development Community (SADC), the East African Community (EAC), the Cross Border Initiative, and is considering reentering the Common Market for Eastern and Southern Africa (COMESA) from which it withdrew in 2000.

Aquaculture in Tanzania is dominated by small-scale freshwater fish farming. Farming practices include both extensive and semi-intensive fish farming but majority are extensive small fish ponds integrated with other agricultural activities such as crop and animal production. Fish production activities are found mainly in Ruvuma, Iringa, Mbeya and Kilimanjaro (Figure 1). Several species are cultured, but mainly dominated by tilapia (*Oreochromis niloticus)*. Other species with potential for use in aquaculture include the milkfish (*Chanos chanos*), the flathead grey mullet (*Mugil cephalus*), the North African catfish (*Clarias gariepinus*), and shellfish such as shrimp, molluscs, crabs, oysters and mussels. Various species of seaweed is farmed in

Tanzania, mainly in coastal areas along the coastline from Tanga in the north to Mtwara in the south, and in the islands of Mafia and Zanzibar.

The Fisheries Division is the governmental agency responsible for the formulation, implementation, and enforcement of aquaculture policy and legislation. The Division conducts numerous workshops to create awareness in the communities on sustainable aquaculture, and provides low interest loans and a three-year tax-free period for investors in commercial aquaculture through the National Investment Center (NIC). Several institutions are involved in fisheries research, education and training. The Tanzania Fisheries Research Institute (TAFIMA) has overall responsibility for all the research on fisheries; the Faculty of Aquatic Sciences and Technology (FAST) at the University of Dar Es Salaam and the Sokoine University of Agriculture (SUA) are both responsible for carrying out research and training on fisheries. Other government Fisheries Centres and Institutes are involved in training as well.

In Tanzania the fisheries sector contributes about 10% of the national GDP. Fisheries sector provides food, income and employment for many people in Tanzania. It is estimated that the country's fish and fisheries products provide about 40 % of animal protein supply. The supply of fish comes from two main sources; fisheries based on the natural water bodies and from fish farming. The major areas of fishing are the shores of Lake Tanganyika, Victoria and Nyasa where about 360,000 full time and occasional fishermen are engaged in fishing or fishery related activities.

Although production from aquaculture accounts for only a small proportion of total fish produced at the national level, it provides vital animal protein to the population residing in areas which are located far away from the major fishery resources or where transport of fish is either difficult or too expensive. In some regions where protein intake per capita is low and where protein malnutrition prevails, the socio-economic benefit from aquaculture is high. Fish farming in Tanzania is done in dams, ponds and tanks by commercial farmers, smallholder farmers and institutions, mostly using Tilapia species. The species widely cultured are *Oreochromis niloticus*, *Oreochromis leucostictus* and *Oreochromis uroleptis*. Fish farmers obtain fingerlings from government fry centres and fisheries institutes.

For the past three decades, the government of Tanzania has recognized that the fisheries resources have been overexploited by local communities and other users. In realization of this, the government developed a policy and strategies for the fisheries sector in 1997. The policy emphasizes the need for change in attitude towards fisheries resource exploitation practices as well as the necessity to manage the resources sustainably, conserve and develop the fisheries resources for good and prosperity of all. The main goal of the national fisheries policy is to promote conservation, development and sustainable management of the fisheries resources for the benefit of present and future generations. The policy recognizes the potential for increasing fish production through aquaculture to complement the capture fisheries. The policy has set management principles and guidelines for the development of aquaculture in order to ensure sustainability of aquaculture production in the country.

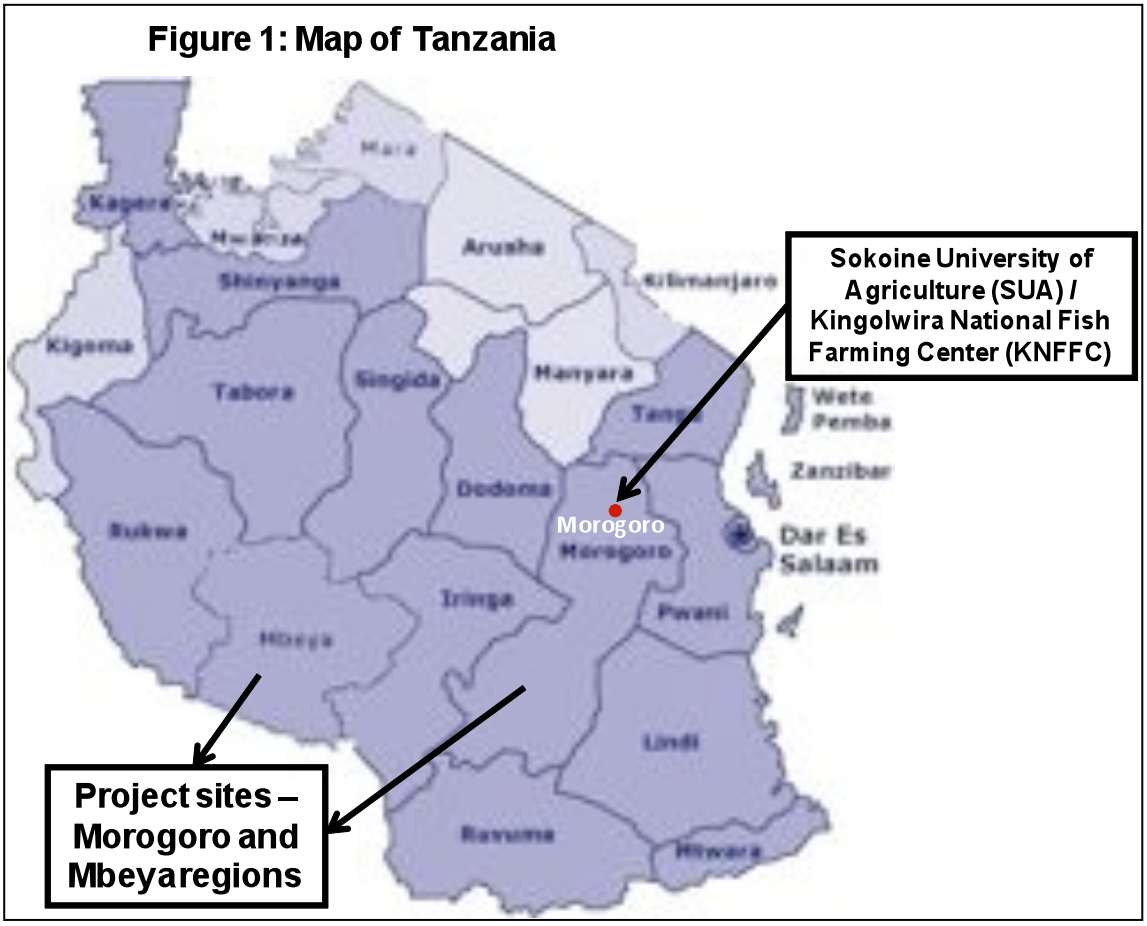
The objectives of the policy for aquaculture development are (i) to promote small scale, semi-intensive aquaculture systems with simple technologies and low capital investment, (ii) to promote the sound utilization of the ecological capacity of water based areas as a means to promote diversification of income sources and diet, and (iii) to promote effective farm and fish health management practices favouring hygienic measures and vaccines. To achieve these objectives, the policy enumerates the following strategies:-

1. Initiate the establishment of code of conduct for aquaculture to provide guideline to address issues such as site selection, construction, suitable species, introduction of exotic species, water abstraction, spread of disease and effluent control.
2. Establish effective procedures specific to aquaculture to undertake appropriate environmental assessment and monitoring with the aim of minimizing adverse ecological changes and related economic and social consequences resulting from water extraction, land use, discharge of effluent, use of drugs and chemicals and other aquaculture activities.
3. Promote research to identify better performing species for aquaculture development.
4. Promote extension of viable aquaculture technologies appropriate for small scale and/or semi-intensive level.
5. Encourage the private sector, non-governmental organizations to participate in aquaculture development.
6. Promote the utilization of small water bodies, dams and reservoirs for aquaculture.
7. Promote the integration of aquaculture into other farming production systems among the rural communities.
8. Establish, maintain and develop an appropriate legal and administrative framework which facilitates the development of sustainable aquaculture.
9. Ensure safe, effective and minimal use of therapeutants, hormones and drugs, antibiotics and other disease control chemicals.
10. Ensure the food safety of aquaculture products and promote efforts which maintain product quality and improve their value through particular care before and during harvesting and on site processing and in storage and transport of the product.

The selected protein sources to be utilized in this project do not conflict with human food security interests, as is the case with fishmeal. Recent livestock disease outbreaks have raised doubts on the wisdom of feeding animal derived-protein feed ingredients to non-carnivorous species such as fish. The use of plant-based protein sources in fish rations also appears to assure environmental sustainability of the natural fishery resources than the use of fish meal. Critics of aquaculture have suggested that fish diet rich in fishmeal and fish oil obtained from wild fisheries come mainly from small pelagic fish making aquaculture inherently unsustainable.

SOKOINE UNIVERSITY OF AGRICULTURE: AQUACULTURE RESEARCH FACILITY

Figure 1: Map of Tanzania



Sokoine University of Agriculture Aquaculture Research Facility

Sokoine University of Agriculture Aquaculture Research Facility

Site Status

Active: 2003-present- Primary site for Nutrition Study

General Location

Sokoine University of Agriculture is situated 3 km from the centre of Morogoro Municipality, which is about 200 km west of Dar es Salaam. The University is located between 6º– 7ºS and 37º – 38ºE.

Description of Area/Region

Overall Description

The University main campus, where aquaculture facilities are located, lies on the slopes of the Uluguru Mountains at an altitude of about 500 – 600 m above sea level. The dominant natural vegetation is that of Hyperrhenia spp and Sporobolus spp dotted with Miombo and Acacia bushes. However, the vegetation has been modified by established pastures and the dominant species are *Chloris gayana*, *Brachiaria* spp and *Pennisetum purpureum*.

Temperature

The area experiences day temperatures ranging between 20º – 27ºC in the coolest months (April – August) and 30º– 35ºC during the hottest months (October – January).

Precipitation

The area receives an average annual rainfall of between 600 – 1000 mm

Seasonality

The area has bimodal rainfall, the short rains falls between November and December, followed by a short dry spell between January and February. The main rainy season is from March to May. The period between June and October is a dry season.

Geology/Soils

The soils around the University main campus are mainly oxisols with scattered patches of sandy-loams with pH ranging between 5.5 and 6.0.

Description of Sokoine University of Agriculture Aquaculture Research Facility

Map Coordinates	Elevation
The University is located between 6° – 7°S and 37° – 38°E.	500 – 600 m above sea level

General

The aquaculture section is under the Department of Animal Science and Production. The Department maintains 20 concrete cylindrical tanks with diameter of 3 m and 10 earthen ponds with the size of 20 m x 15 m (Figure 2). The Department also has an animal nutrition laboratory for analysis of feed samples. The laboratory has a capacity of carrying out proximate analysis, NDF and ADF determination, determination of mineral anti-nutritional contents of various feed stuff. In terms of human resource, there are two persons with Ph.D and three persons with M.Sc. in aquaculture, respectively. Among those with M.Sc., two of them are currently undertaking Ph.D studies. The Department is in the process of recruiting two additional staff for aquaculture. There are many staff members in various fields of Animal Science (e.g. Animal nutrition, Animal breeding and genetics) in the Department who assists the aquaculture section.

Soils

The soils around the University main campus are mainly oxisols with scattered patches of sandy-loams with pH ranging between 5.5 and 6.0.

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MOROGORO AND MBEYA REGIONS

General Location

Freshwater aquaculture is concentrated in six regions in Tanzania: Arusha, Kilimanjaro, Morogoro, Iringa, Mbeya and Ruvuma. Morogoro and Mbeya has the most fish farming activities. The Morogoro Region is one of the 20 Regions in Tanzania Mainland. The Region lies between latitude 5° 58" and 10° 0" to the South of the Equator and longitude 35° 25" and 35° 30" to the East. It is bordered by seven other Regions. Arusha and Tanga regions to the North, the Coast Region to the East, Dodoma and Iringa to the West, and Ruvuma and Lindi to the South.

Description of Area/Region

Overall Description

The annual rainfall ranges from 600mm in low lands to 1200mm in the highland plateau. However, there are areas which experience exceptional droughts with less than 600mm of rainfall. These areas are in Gairo and Mamboya divisions in the North of Kilosa District and Ngerengere Division in the East of Morogoro Rural District. The climate of Mbeya Region is

greatly influenced by physiology and altitude. The climate is generally tropical with marked seasonal and attitudinal temperatures and high rainfall variations causing dry and rainy seasons. The region enjoys abundant and reliable rainfall. Annual rainfall varies between 650mm. in Usangu Plains and Chunya to 2600mm. on the Northern shores of Lake Nyasa in Kyela District and highlands of Rungwe and the Southern parts of Ileje District. The rains normally start in October until May with dry and cold spell between June and September. The crop growing season in most parts of the region begins in November and continues to May.

In most arable areas, soils are commonly of moderate fertility, coarse or medium textured and varying from sandy loams, alluvial solids to cracking rocks. Although a large area of the regions is cultivated, large tracks of land are still covered with natural vegetation such as "Miombo" (*Broschystegion,Julbernardia*) woodland. Areas with rains between 800-1200 mm per annum favour the growth of Miombo woodland, while areas with less rain especially in the North of the region support the growth of wooded grassland and bush lands of dense thickets of acacias and thorny trees. Areas with higher rainfall support forests, often evergreen and bamboo trickers except at the highest elevations, where afro-alpine grasslands occur

Climate

The climate is generally tropical with marked seasonal and attitudinal temperatures and high rainfall variations causing dry and rainy seasons.

Temperature

The average annual temperature varies between 18ºC on the mountains to 30ºC in river valleys. In most parts of the region, the average temperatures are almost uniform at 25ºC. In general the hot season is from July to September. Temperatures in Mbeya range between 16ºC in the highlands and 25ºC in the lowlands areas.

Precipitation

The annual rainfall ranges from 600mm in low lands to 1200mm in the highland plateau. However, there are areas which experience exceptional droughts with less than 600mm of rainfall.

Geology/Soils

In most arable areas, soils are commonly of moderate fertility, coarse or medium textured and varying from sandy loams, alluvial solids to cracking rocks. Although a large area of the regions is cultivated, large tracks of land are still covered with natural vegetation such as "Miombo" (*Broschystegion,Julbernardia*) woodland.

Description of the Morogoro and Mbeya Regions

Map Coordinates	Elevation
The Region lies between latitude 5º 58" and 10º 0" to the South of the Equator and longitude 35º 25" and 35º 30" to the East.	475 metres above sea level with high peaks of 2981 metres above sea level

General

The regions lie at an altitude of 475 metres above sea level with high peaks of 2981 metres above sea level at Rungwe higher attitudes. The major topographic features of Mbeya region are the low elevation of the Western Rift Zone that covers Lake Rukwa and Nyasa; and the Eastern Rift Zone that covers the Usangu Plains and the neighbouring parts of the Ruaha Trough. The lowlands within the Rift Valley lie between 500m and 1400 m above sea level. Of the regional

surface areas, 61,868 km^2 is dry land, about 57,000 km^2 arable land; and 1.757 km^2 is covered with water.

Support Facilities in Tanzania

Mikindu Village: Mikindu is a village in the mountainous areas of the Morogoro Region. Aquaculture is practiced extensively in this area with many fish ponds located near homes. Most farmers utilize animal and vegetable by-products to feed fish, which can reach over 200 grams in six months. Fish farmers in the area have organized themselves into fish farmers groups, which allow accessibility to the farmers to obtain high participation in national extension programs.

A section of fish farmers in Mikindu village receiving instructions from Aquaculture CRSP project personnel.

Kingolwira National Fish Farming Center (KNFFC), Morogoro

Workshops and farmer training programs are conducted at Sokoine University of Agriculture (SUA) and the Kingolwira National Fish Farming Center (KNFFC), Morogoro. KNFFC started in 1989 with funding from UNDP-FAO and the United Republic of Tanzania government. The center has reliable water supply, office building, a vehicle and two motorcycles, and twelve (12) ponds. The center also has eighteen (18) four meters diameter round concrete tanks at the hatchery/nursery section (Figure 4). There are also twelve (12) rectangular 1 X 0.5 meters concrete tanks. The center operates integrated fish farming with animal husbandry whereby poultry pens, and pig and goat building are constructed adjacent to the earthen ponds. The center also has ten (10) earthen ponds that are off site at about 14 kilometers from KNFFC.


Kingolwira National Fish Farming Center Aquaculture Research Facility

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