Aquaculture Collaborative Research Support Program

Updated Site Descriptions

A Reference for Research Locations in the Aquaculture CRSP

Published 30 June 2008

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Funded by the United States Agency for International Development (USAID) under Grant No. LAG-G-00-96-90015-00 and by participating US and Host Country institutions.

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Acknowledgments

The Program Management Office of the Aquaculture CRSP gratefully acknowledges the contributions of Aquaculture CRSP researchers around the world.

CONTENTS

ASIA

Introduction

The Aquaculture Collaborative Research Support Program (ACRSP) represents an international community of researchers and institutions dedicated to the following goals:

- optimizing the efficiency of pond aquaculture systems,
- minimizing the negative environmental impacts of fish culture,
- exploring the socioeconomic intricacies associated with fish farming,
- disseminating scientific and technical information, and
- developing economical and culturally appropriate aquaculture strategies.

It is one of several agricultural CRSPs supported by the U.S. Agency for International Development under the authority of Title XII of the International Development and Food Assistance Act of 1975.

This on-line version of the site descriptions grew out of the printed publication of the PD/A CRSP site descriptions in 1999 and the *Pond Dynamics/Aquaculture Data Reports, Volume One, General Reference: Site Descriptions, Materials and Methods for the Global Experiment* designed as an introduction to the Data Reports series. Data Reports contain the results of the CRSP Global Experiment, a series of experiments conducted in an identical manner at sites in different parts of the world. The first edition (Egna et al., 1987) includes descriptions of each of the seven sites participating in the first three cycles of the Global Experiments, as well as descriptions of and methods for those cycles and procedures for pond management, fingerling production, and soil sampling and analysis.

The second edition (Bowman and Clair, 1996) builds on the first edition, adding information on new CRSP research sites (two additional sites in Thailand and one each in the Philippines, Honduras, and Egypt). Since the Data Report series includes only those data resulting from the first three cycles of the Global Experiment and because site-specific research to complement the global experiments has increased in importance, the second edition of the Site Descriptions does not contain procedural descriptions.

Since 1982, the ACRSP had conducted research in 13 countries. The site description booklet published in 1999 contains descriptions of many of the research sites, including those that participated in the first three cycles of the Global Experiment (Panama, Honduras, Rwanda, Thailand, the Philippines, and Indonesia), the results of which make up the CRSP Data Report series. Additional sites where CRSP research was conducted (including later global experiments as well as cross-cutting and regional research) are located in Egypt, Kenya, Peru, Mexico, Guatemala, and Nicaragua. Additional sites appear in this on-line edition. Data for sites which are no longer active CRSP research sites were accurate as of the time of last CRSP involvement.

Many of the field data collected in CRSP research are filed in the CRSP Central Database, which can be ordered on CD-ROM or accessed via the Web at <biosys.bre.orst.edu/crspDB/>. The results of PD/A CRSP research are published in scientific journals as well as in CRSP Data Reports, Research Reports, and annual Administrative and Technical Reports. Many of these reports can be accessed electronically a <www.orst.edu/dept/crsp/pubs/publications.html>. A complete list of CRSP publications and information can be requested from:

Publications
Aquaculture CRSP
Oregon State University
418 Snell Hall
Corvallis, OR 97331-1643 USA

References

Kris McElwee (compiler and editor), 1999. Pond Dynamics/Aquaculture Collaborative Research Support Program Site Descriptions. Pond Dynamics/Aquaculture CRSP Oregon State University, 400 Snell Hall, Corvallis, OR 97331-1614 USA. 83 pp.

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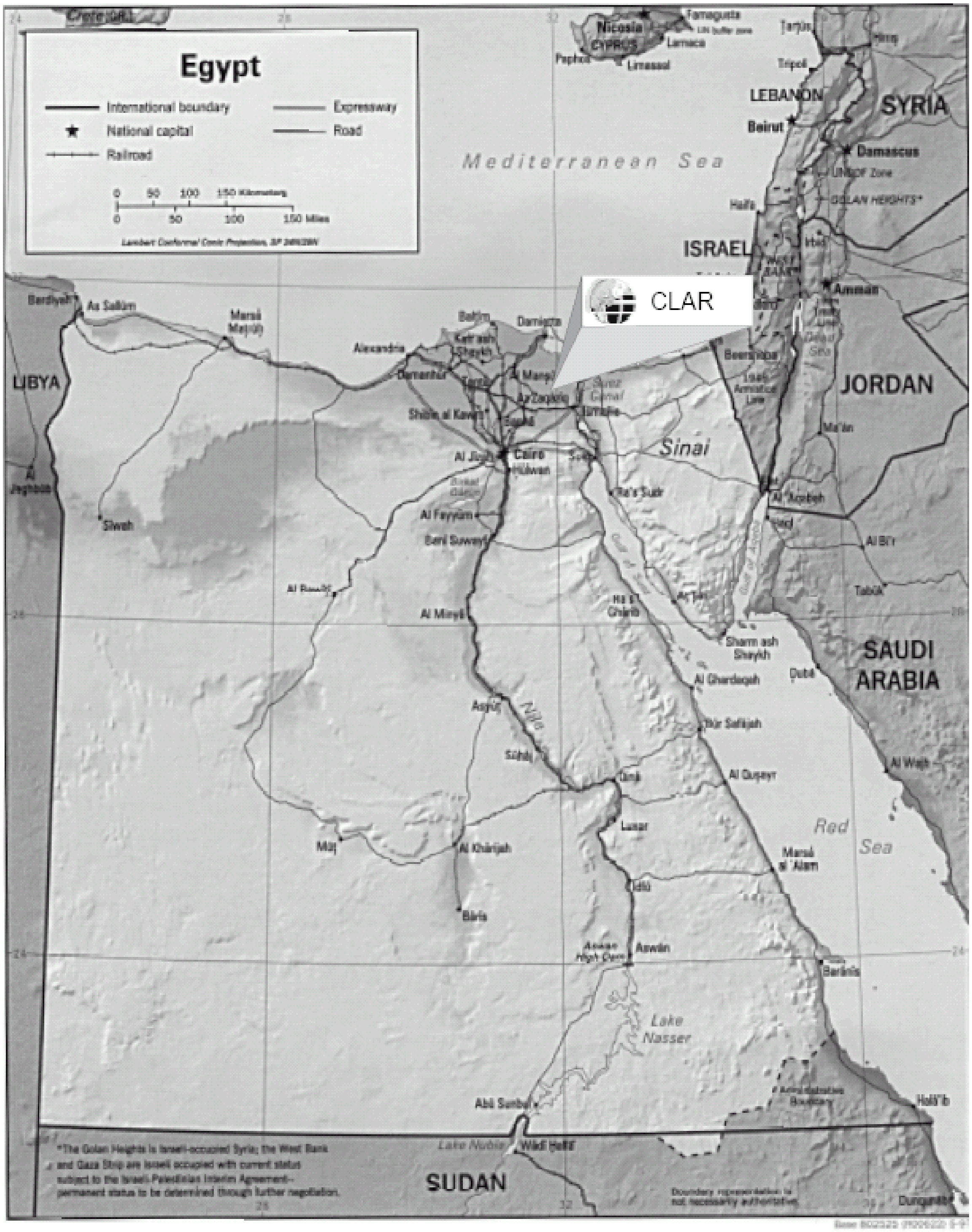
Egna, H.S., N. Brown, and M. Leslie (editors), 1987. Pond Dynamics/Aquaculture Collaborative Research Data Reports, Volume 1, General Reference: Site Descriptions, Materials and Methods for the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 84 pp.


Egypt
International boundary
National capital
Railroad
Expressway
Road
Mediterranean Sea
CLAR
CYPRUS
Nicosia
LEBANON
Beirut
SYRIA
Damascus
ISRAEL
Amman
JORDAN
SAUDI ARABIA
LIBYA
SUDAN
Sinai
Red Sea
Lake Nasser
Alexandria
Cairo
Siwah
Al Fayyum
Bani Suwayf
Al Minya
Asyut
Al Kharijah
Luxor
Aswan
Al Ghardaqah
Bur Safajah
Al Qusayr
Sharm ash Shaykh

Central Laboratory for Aquaculture Research (CLAR)
Abbassa

A central theme of CRSP-supported research at the Central Laboratory for Aquaculture Research (CLAR), Abbassa, Egypt, was the effort to control the encroachment of aquatic weeds such as *Azolla*, *Typha*, and *Phragmites* into pond areas.

CLAR lies in the heart of the Nile Delta, a vast fertile plain that stretches from Cairo north to the Mediterranean coast.

Abbassa
Central Laboratory for Aquaculture Research (CLAR)

Site Status: Former Prime Site*, 1992 to 1995
Location: Abbassa, Abou Hammad, Sharkia, Egypt
Caption/Description: The Central Laboratory for Aquaculture Research (CLAR) is located in Abbassa, Abou Hammad, Sharkia Governorate, approximately 70 km northeast of Cairo and 25 km east of the city of Zagazig. It is about 80 km inland from the Mediterranean Sea.

Description of Area/Region

Climate

Köppen-Trewartha classification* **BWh***: *Dry desert (arid)* group (BW); *hot tropical-subtropical* type (h).

Temperatures	Precipitation
In the coastal areas temperatures range from approximately 14 to 37°C, while in the desert areas the range is greater, with lows around 6 (as low as 0°C in winter) and highs reaching 46°C. Prevailing northerly winds throughout the year moderate potential extremes of temperature. Average air temperatures around Cairo range from about 13 to 30°C, while those at Abbassa range from 4 to 40°C, with pond water temperatures ranging from 9 to 34°C.	Rainfall is low throughout the country, but increases somewhat towards the north, nearer the Mediterranean, where it averages about 200 mm annually. In Cairo the average annual rainfall is between 25 and 29 mm, while at Abbassa (part way between Cairo and the Mediterranean) annual rainfall averages between 25 and 50 mm. Rainfall may occur only once in several years in many of Egypt's desert areas.
Humidity	**Seasonality**
Very dry climate, with slightly greater humidity along the Mediterranean.	Nearly constantly dry, with a hot season from May to September, and a cool season from November to March.

Topography

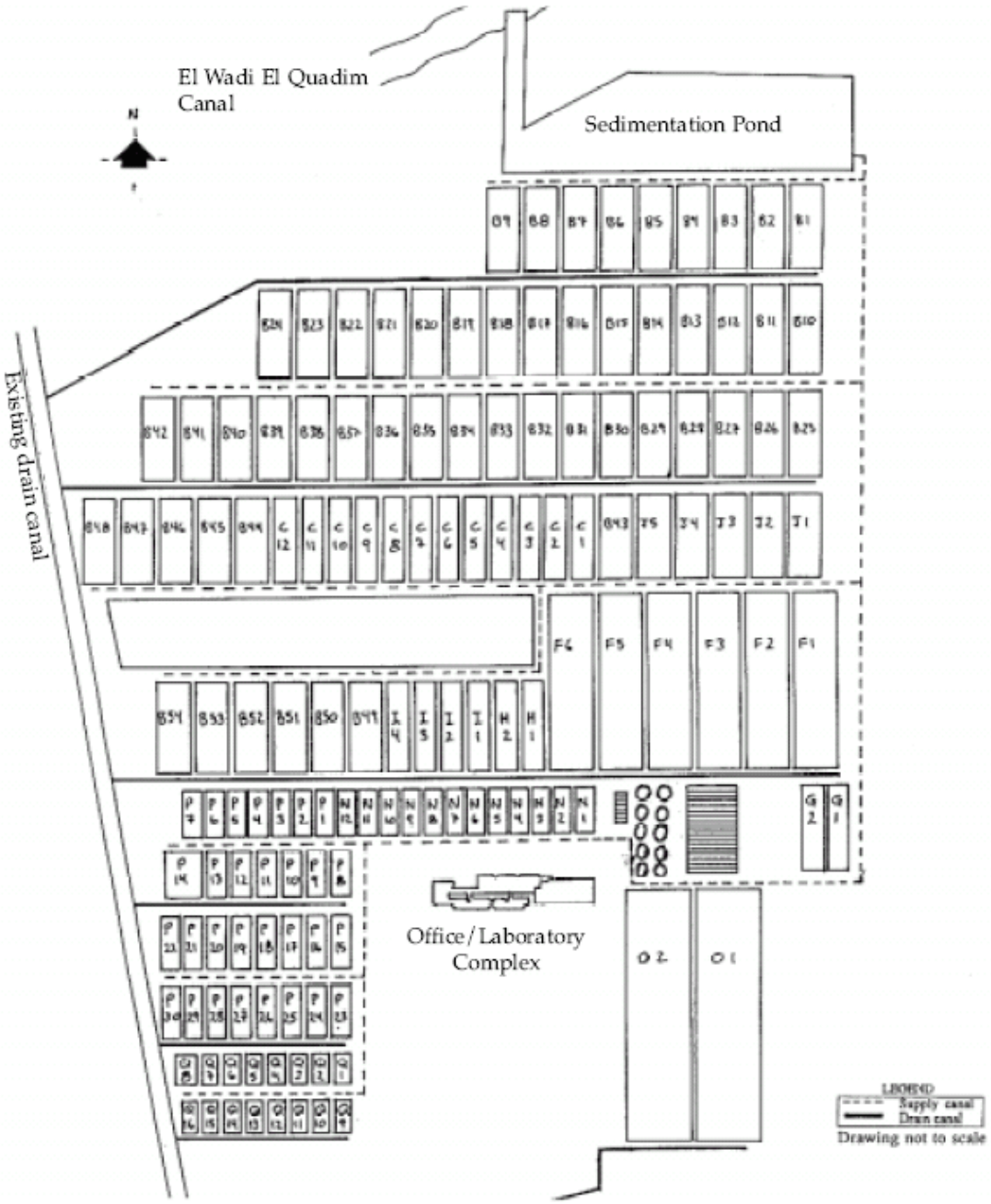
CLAR is north of Cairo in "Lower Egypt," the relatively flat, fan-shaped delta of the Nile River after it leaves the narrow, cliff-lined valley to which it is confined farther south. The delta, formed by the deposition of silt by the Nile, Rashid, and Dumyat rivers, is the most fertile region in Egypt; its perimeter lines nearly 250 km of the coastline of the Mediterranean Sea. Other than along the Nile valley south of Cairo, little vegetation is found outside the Nile delta. Elevations throughout the delta are low, and some localized depressions are below sea level. The only significant natural relief in the area is outside the delta to the south and west, including a plateau area gradually rising from Cairo to elevations of about 600 m near the Gulf of Suez in the east and extending southward into the Arabian Desert, as well as a narrow ridge running west-southwest from Cairo. A few peaks in the eastern plateau/Arabian desert area reach elevations of 2,100 m along the coast of the Red Sea. To the west, the Western Desert (or Libyan Desert) contains a vast expanse of sand known as the Great Sand Sea as well as several areas below sea level. The Qattarah Depression is the most extensive, covering an area of about 18,000 km^2 and reaching a depth of 133 m, the lowest elevation anywhere in Africa.

Geology and Soils

Silt and other materials deposited by the Nile have formed the vast and highly fertile Nile Delta.

* Asterisked items are defined or described in the glossary.

Layout of CLAR



Description of CLAR

Map Coordinates	Elevation
30° 32 ' N and 31° 44' E	6 m
General	**Water Supply**
CLAR was divided into nine departments: aquaculture, limnology, nutrition, genetics, biology/ecology, aquacultural economics, processing/quality control, fish health, and hatchery/reproductive physiology. CLAR facilities included staff and administrative offices, a library, an auditorium, numerous dry and wet laboratories, a garage/workshop, central stores, and 155 earthen ponds and 56 concrete tanks/raceways that were all available for research. Pond areas ranged from 0.05 to 2.1 ha and totaled approximately 46 ha, while concrete tank/raceway areas ranged from 15 to 250 m^2. PD/A CRSP research was conducted in 0.01 (round ponds), 0.1 (P series), and 0.42 ha (B series) earthen ponds. CRSP research at the CLAR included studies to identify methods for dealing with the continuing problem of encroachment of emergent and floating vegetation into the ponds. Foremost among problem species were *Phragmites* (papyrus) and *Typha*—both emergent types—,and *Azolla* (water fern) and water hyacinths—both floating plants. CLAR and CRSP collaborators also worked to reduce problems associated with the contamination of ponds by "wild" fish. All laboratories were well equipped, with sophisticated analytical instruments that permitted most routine analyses to be conducted in-house.	The source of most surface water in Egypt is the Nile River. CLAR was supplied with water from the Ismalia canal by way of the El Wadi El Quadim supply canal. The Ismalia canal originated from the Nile River in Cairo and flowed eastward to the Suez Canal. Water flowed from the El Wadi El Quadim supply canal to the CLAR sedimentation pond and then into the CLAR supply canal. Ponds could be drained only partially by gravity; pumps were required to completely drain them. Water flowed from the ponds to CLAR drain canals, which drained into an existing irrigation drainage canal. Water entering the ponds at CLAR was alkaline, with a pH of about 8.0, total alkalinity of about 220 mg l-1, total hardness of near 190 mg l^{-1}, and calcium hardness of about 120 mg l^{-1}.
Soils	
Soils of most of the CLAR research ponds used in CRSP research were clayey (40–60% clay), with CECs* that ranged from 34 to 45 meq per 100 g. The soils were alkaline and contained high levels of Ca, Mg, and Na.	

* Asterisked items are defined or described in the glossary.

Support Facilities at CLAR

There were 21 other research institutes and central laboratories within the Agricultural Research Center. CLAR researchers were able to consult with colleagues in these institutes as necessary. Many CLAR senior researchers had advanced degrees (Ph.D.s), and were affiliated with one or more universities in Egypt, where they directed student research and periodically taught. The majority of the CLAR technical staff were pursuing advanced degrees (M.S. or Ph.D.) at Egyptian universities; these students conducted their thesis research at CLAR under supervision of the major professors and the CLAR department head.

Affiliations

In-Country	US
Central Laboratory for Aquaculture Research Agricultural Research Center Ministry of Agriculture and Land Reclamation Abbassa, Abou Hammad, Sharkia Egypt	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA Zoology Department University of Oklahoma Norman, OK 73019-0235 USA

Current Contacts

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Burkina Faso
Volta Rouge
Bawku
Tumu
Navrongo
Bolgatanga
Wulugu
0 100 km
0 75 mi
Kulpawn
Wa
8°
Mole Game Res.
White Volta
Tamale
Yendi
Daka
Oti
Ouémé
Sawla
Bole
Ghana
Bimbila
Togo
Benin
Côte D'Ivoire
Salaga
Brong-Ahafo
Dumbai
Anie
Mono
Zou
Pru
Ba
Wenchi
Kwadjokrom
Kantankufri
Techiman
Lake Volta
Berekum
Sunyani
Kouffo
Ashanti
Hohoe
Tano
Kpandu
Goaso
Kumasi
Nkawkaw
Ho
Sio
Bia
Bibiani
Anum
Birim
Awaso
Ofin
Obuasi
Kade
Koforidua
Volta
Todzie
Lomé
6°
Dunkwa
Oda
Nsawam
Keta
Tema
Pra
Prestea
Swedru
Accra
Bight of Benin
Ankobra
Tarkwa
Gulf of Guinea
Cape Coast
Axim
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0°
2°
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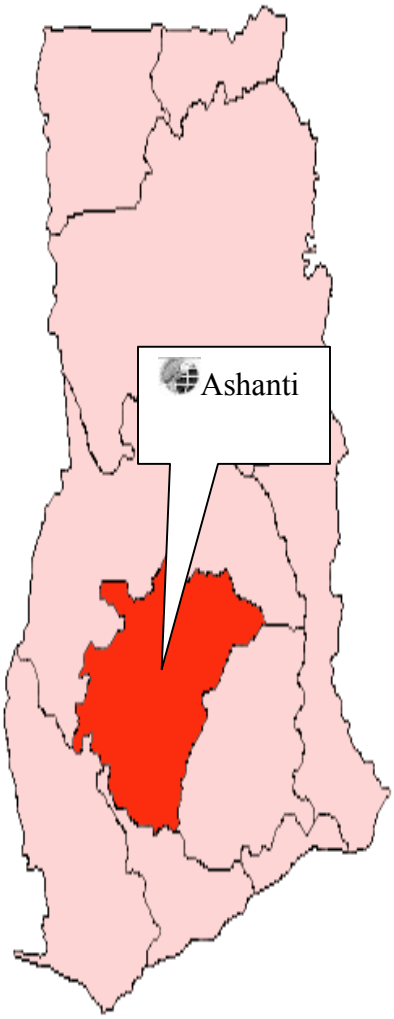
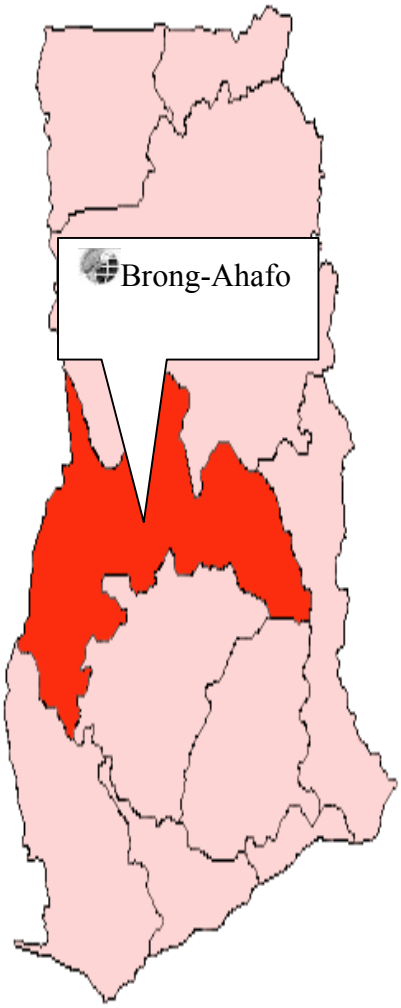
Ashanti and Brong-Ahafo



Map of Ghana showing
the Ashanti Region



Map of Ghana showing
the Brong-Ahafo Region

Ashanti and Brong-Ahafo, and Kwame Nkrumah University of Science and Technology (KNUST) Department of Fisheries and Watershed Management Aquaculture Facility

Site Status: New site.
Location: Ashanti Region (capital is Kumasi) is an administrative region in central Ghana and Brong-Ahafo Region (capital is Sunyani) is located in mid-western Ghana, between Ashanti the Côte d'Ivoire border.
Caption/Description: Kwame Nkrumah University of Science and Technology (KNUST) Department of Fisheries and Watershed Management Aquaculture Facility is 8 miles east of Kumasi, Ashanti Regional Capital.

Description of Area/Regions

Climate

Köppen-Trewartha classification* **Am***: *tropical monsoon*.

Temperatures	Precipitation
Climatic conditions in the two regions are similar, with temperatures ranging between 20.2°C and 37.2°C, varying with day and season. The regions are marked with fairly high incidence of solar radiation.	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	**Seasonality**
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 during the dry season.	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.

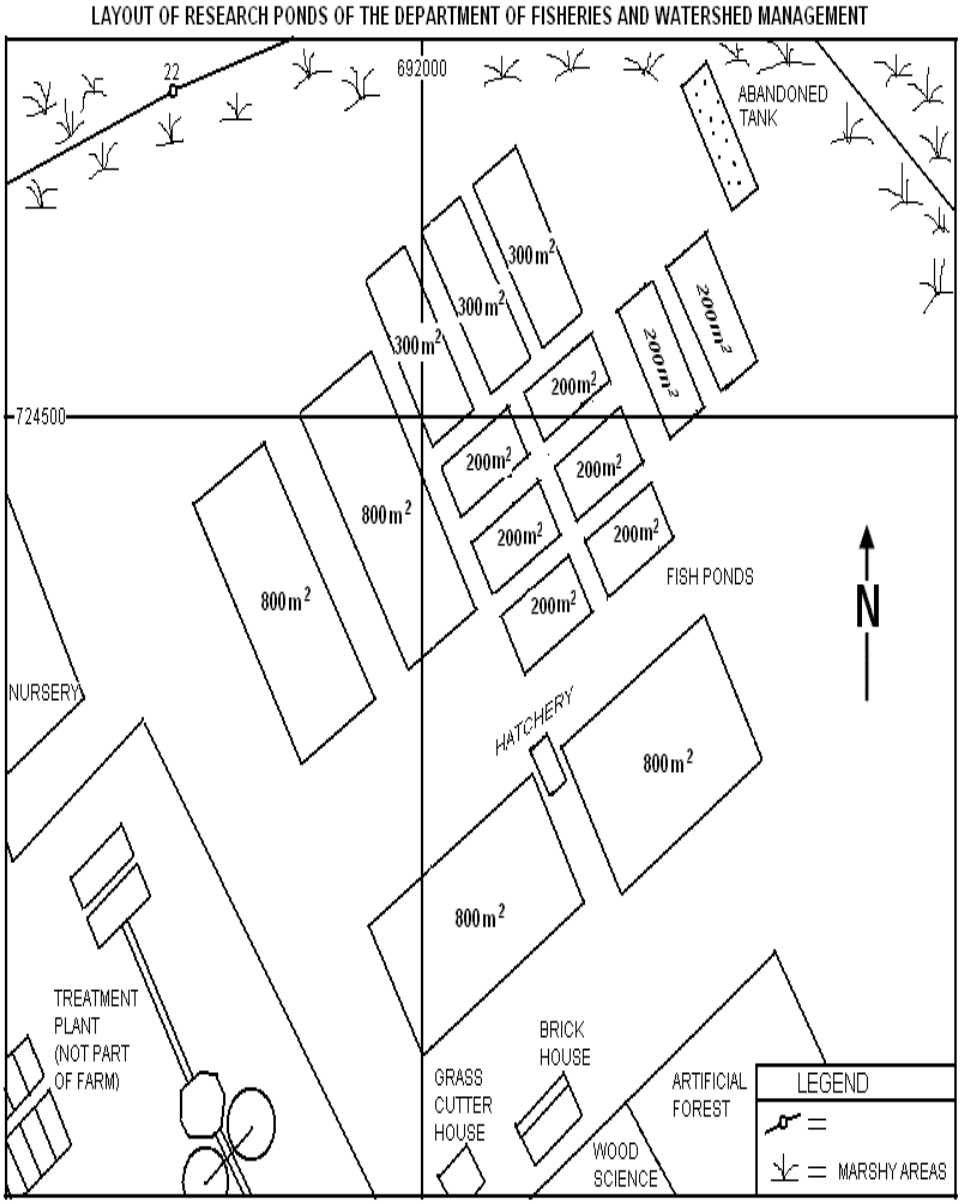
Topography

The regions' topography ranges from low lying, gently undulating regions to distinctly hilly and mountainous regions as well as some rocky surfaces. 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.

Geology and 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. Both regions are well drained by several major rivers. Clayey areas are dominant, presenting potential opportunities for earthen pond construction for successful aquaculture.

* Asterisked items are defined or described in the glossary.



Department of Fisheries & Watershed Management – Aquaculture Teaching and Research Ponds

Description of Ashanti and Brong-Ahafo, and Kwame Nkrumah University of Science and Technology (KNUST) Department of Fisheries and Watershed Management Aquaculture Facility

Map Coordinates	Elevation
Regions are between 6° 40' N-7° 11' N and 1° 110' W- 2° 20' W. KNUST Aquaculture Facility: Approx. 06° 43' N and 01° 34' W	Mostly < 150 m across regions. Kumasi Airport: 287 m (8 miles west of KNUST Aquaculture Facility).
General	**Water Supply**
The Kwame Nkrumah University of Science and Technology (KNUST) Department of Fisheries and Watershed Management aquaculture teaching and research ponds are a major component of the farm complex of the Faculty of Renewable Natural Resources. There are 15 earthen ponds of varying sizes, all of which are spring-fed. The ponds lie near a river, the River Wiwi, which traverses the university campus from the south end. Three of the ponds have a total surface area of 300m^2, eight have a total surface area of 200 m^2 ponds, and four have a total surface area of 800 m^2. The average pH values of the pond waters range from 6.5 to 7.5, while water temperatures range from 25.3°C to 26.5°C. 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. Both regions represent the main locations where Tilapia and Catfish farming is carried out in the country.	All ponds at the Faculty of Renewable Natural Resources are spring-fed.
Soils	
Regions: Sandy loam; clay 21-23%; high sand content in certain areas: 69-72%.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Ashanti and Brong-Ahafo

Regions' workshops and farmer training programs are conducted at the Department of Fisheries and Watershed Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Affiliations

In-Country	US
Kwame Nkrumah University of Science & Technology (KNUST) Kumasi Ghana.	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

Current Contacts

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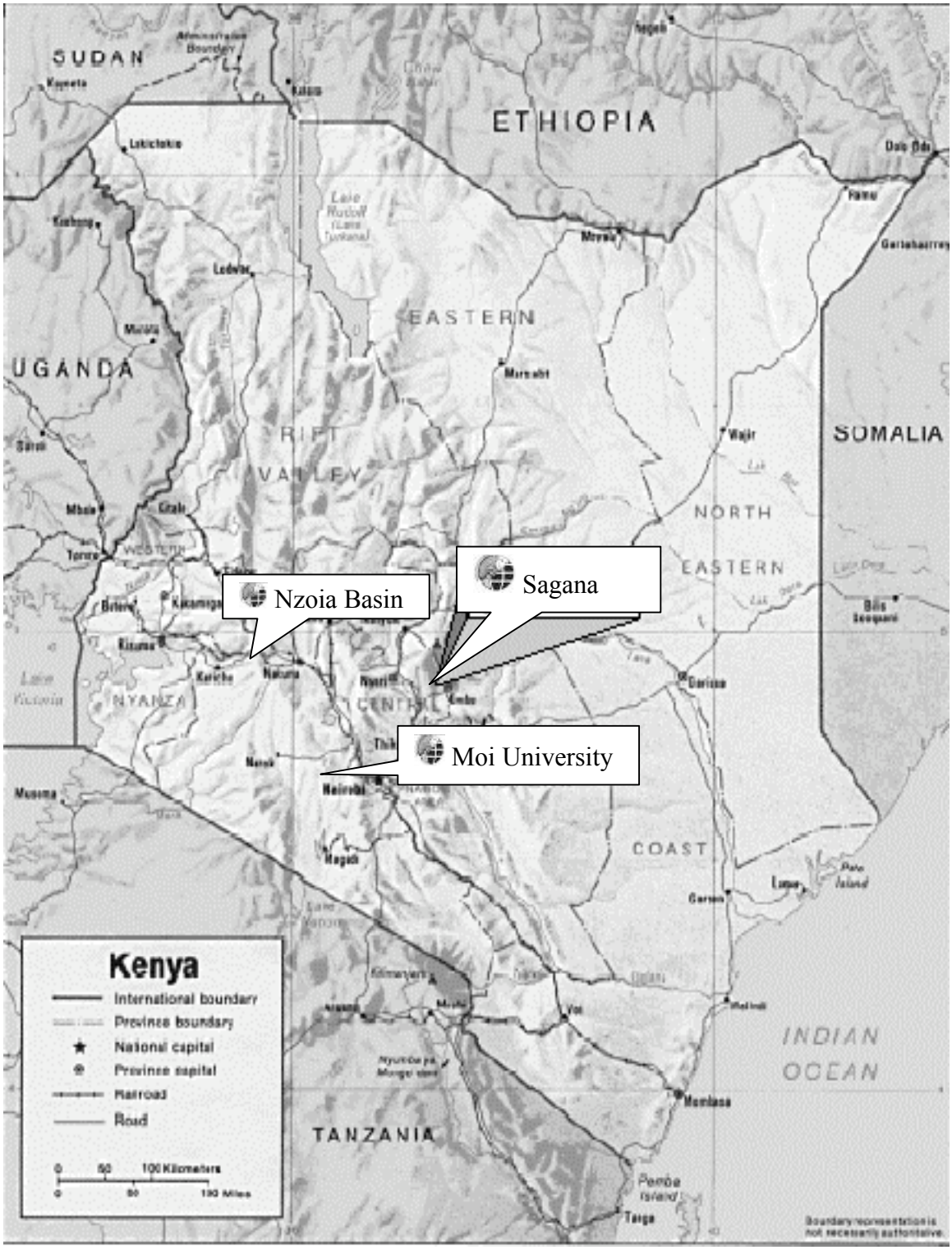
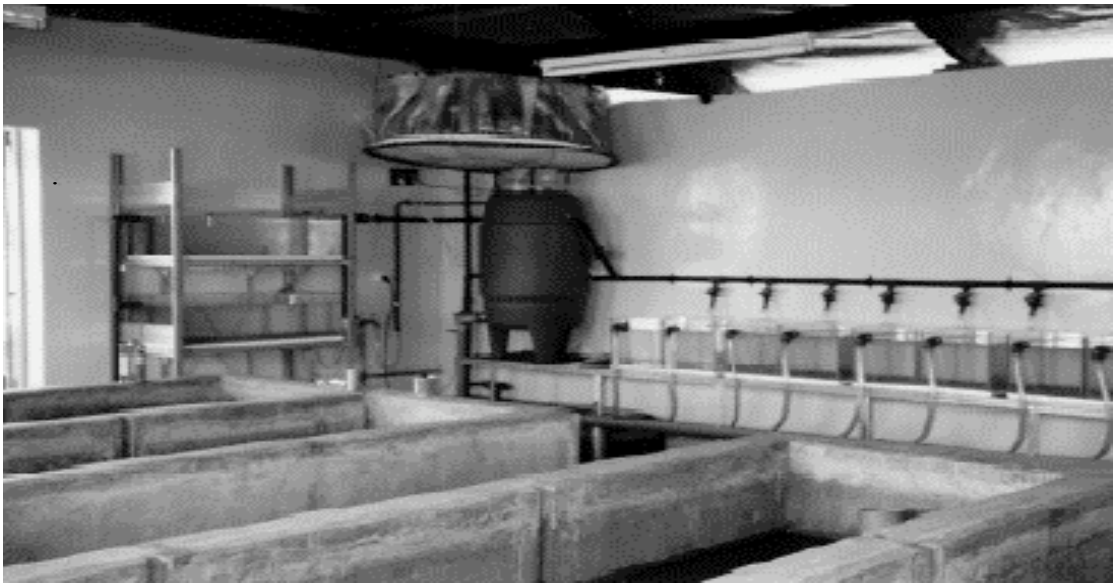

Nzoia Basin
Sagana
Moi University
SUDAN
ETHIOPIA
UGANDA
SOMALIA
EASTERN
RIFT VALLEY
NORTH EASTERN
NYANZA
COAST
INDIAN OCEAN
TANZANIA
Kenya
International boundary
Province boundary
National capital
Province capital
Railroad
Road
0 50 100 Kilometers
0 50 100 Miles

Sagana Aquaculture Center
Sagana



Sagana Aquaculture Center facilities include a hatchery (shown above), water quality laboratory, poultry unit, zero-grazing unit, and agro-forestry project.

Sagana Aquaculture Center comprises 20 ha of ponds on a 50 ha site in Kenya's Central Province. Ponds are dug in black cotton soils formed from volcanic rocks on a gently sloping plateau approx. 60 km south of Mt. Kenya.

Sagana Aquaculture Center

Site Status: Active Prime Site*, 1996 to present
Location: Sagana Aquaculture Center, Sagana Township, Kirinyaga District, Central Province, Kenya
Caption/Description: Sagana Aquaculture Center is located 2 km outside of Sagana Township, in Kenya's Central Province, 105 km northeast of Nairobi.

Description of Area/Region

Climate

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

Temperatures**

Daily average:	17-23°C
Cool season average:	17-19°C
Warm season average:	19-23°C
Daily minimum:	14-19°C
Daily maximum:	20-30°C

Precipitation

The 30-year average annual rainfall at Sagana is 1,166 mm. Total rainfall for the interval from 26 November 1997 to 26 November 1998 was 1,385 mm, as compared with a total of 1,570 mm for 1997.

Humidity

Humidity in the highland region surrounding Sagana ranges from around 90% in the early morning to about 40% in the afternoon during the dry season to 50-60% in the rainy season (Nelson, 1984)***. Monthly averages of pond side humidity observations at Sagana during the CRSP's first year ranged from 63% (October) to 79% (July). Observations were made at 2400 hours daily.

Seasonality

The warmest period is February through April. There is a distinct cool season between June and August when rainfall is at a minimum; 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. The "long rains" fall from March through May with a single-month peak of 500 mm or more in April.

Topography

Sagana is situated at the edge of a large plain at the southern foot of Mt. Kenya, resulting in a climate that is slightly warmer than areas just 30 km farther north. The farm is characterized by gently rolling topography with several steep hills in the immediate area. The ponds are located on a relatively flat area that slopes gently from north to south.

Geology and Soils

Soils are formed on volcanic rocks from Mt. Kenya—latest Pliocene to Pleistocene basalts, phonolites, and pyroclastics. In areas with free drainage conditions on moderate to steep slopes, lateritic* and red to reddish brown soils are present. In Sagana, 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.

* Asterisked items are defined or described in the glossary.

** Temperatures are based on measurements from late 1997 to late 1998. According to local residents, 1997-1998 was cooler than normal for the Sagana area.

*** Nelson, H.D., 1984. Kenya, a Country Study. Foreign Area Studies, The American University, Washington, D.C.

Description of Sagana Aquaculture Center

Map Coordinates	Elevation
0° 39' S and 37° 12' E	Sagana Aquaculture Center is at 1,230 m. Mt. Kenya (elevation 5,199 m) lies approx. 58 km to the north.
General	**Water Supply**
Sagana Aquaculture Center is the largest government-run warm fresh water fish farm in Kenya and Eastern Africa. It was established as a demonstration and fingerling production centre as well as a training facility for fisheries personnel and fish farmers. The basic infrastructure for demonstrable research work was already established. Sagana Aquaculture Center, situated immediately outside the small town of Sagana, covers an area of 128 acres or approx. 58 ha, of which 20 ha is in ponds. There were originally 60 ponds of various sizes, ranging from 0.0005 to 2 ha in size. During 1997, three of the original 0.4 ha ponds were converted to twelve 0.08 ha ponds suitable for research. At present the farm has 148 ponds with a total area of 20 ha. Site facilities include office buildings and a conference room, a storage building for supplies and equipment, a small wet-lab/hatchery building, a water quality laboratory renovated with CRSP assistance, a library/computer room, staff housing, and two guest houses. Electricity, telephone service, and clean water are provided. Two Land Rovers (one provided by the CRSP) are available to support farm activities.	Water for the station is diverted from the Ragati River by a small rock barrier and delivered by gravity through a canal that runs along the north side of the pond area. The supply canal can provide 10 to 30 m^3 min^{-1}; it is normally managed to carry about 15 m^3 min-1. Most of the canal is earthen, but there are several concrete control structures between the river and the farm. Parts of the canal near the station are lined with concrete, and concrete diversion structures are used to force water into secondary canals and ponds as needed.
Soils	
Mainly black cotton soils, high in 2:1 type clay minerals (70 to 90% clay), with CECs* typical for that type of soil (30 to 55 meq per 100 g), and pH values ranging from 5.4 to 7.5.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Sagana Aquaculture Center

Sagana Aquaculture Center is operated by the Fisheries Department of the Government of Kenya, which assigns officers to the station. Students from the University of Nairobi, Moi University, and several other institutions conduct field studies at Sagana. A water quality laboratory has been developed at the station through CRSP support; some other types of analysis (e.g., fish and feed analyses) are carried out at the University of Nairobi. Supplies of fertilizers, chicken feed, and feed ingredients such as rice bran are generally readily available, at least in Nairobi, which is approximately 100 km away.

Affiliations

In-Country	US
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Moi University
Eldoret

Aerial photographs of the Moi University Aquaculture production research facility

Extension of aquaculture research results to K-12 students and families.

Fish production research.

ACRSP Principal Investigators at the Moi University Aquaculture research farm.

Moi University

Site Status: Active Prime Site*, 1999 to present
Location: Moi University Chepkoilel Fish Farm, Eldoret Town, Uasin Gishu District, Rift Valley, Kenya
Caption/Description: Moi University is located in Eldoret, a distance of 310 km northwest of Nairobi, Kenya.

Description of Area/Region

Climate

Köppen-Trewartha classification*: *tropical humid*.

Temperatures	Precipitation
Highest temperatures are in March and lowest are in July. The daily average temperature was 16 to 22°C. During the cool season, average temperature was 13 to 19°C, and 17 to 25°C during the warm season.	Rainfall averages 1,223 mm. Rains are uni-modal 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. Between June and August, rainfall is minimal. A rainy period known as the "short rains" occurs between October and December.
Humidity	**Seasonality**
Humidity in the highland region surrounding the campus ranges from around 90% in the early morning to about 40% in the afternoon during the dry season and to 50-60% during the rainy season.	The "long rains" fall from March through May. There is a distinct cool season between June and August when rainfall is at a minimum; the skies tend to be overcast much of the day during this period. The "short rains" occur 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.

Geology and 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.

* Asterisked items are defined or described in the glossary.

Description of Moi University

Map Coordinates	Elevation
Eldoret is located at 0.53° N and 35.28° E	2,180 m
General	**Water Supply**
Moi University 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 farm. Supplies of fertilizers, chicken feed, and feed ingredients such as rice bran are generally readily available, at least in Eldoret town and its environment. The Fish Farm has an area of approximately 10 ha, of which 5 ha is in ponds. There are 47 fish ponds of various sizes, ranging from 0.01 to 0.2 ha in size. Site facilities consist of a hatchery, quarantine unit and fish ponds 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.	Water supply to the ponds is from a 1.2 ha spring-fed reservoir. Ponds were designed according to FAO recommendation with features such as inflow by gravity, drainable with adjustable pipes sloping sides, and effluent intercepted by *Cyperus papyrus* swamp prior to entering the exit stream.
Soils	
The area is characterized by brown loamy soil with acidic pH. Clay content averages 30% and the soils have a high water holding capacity.	

Support Facilities at Moi University

Chepkoilel Fish Farm is operated by the Moi University 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. Good quality water is provided by a spring-fed reservoir. Supplies of fertilizers, chicken feed, and feed ingredients such as rice bran are generally readily available at least in Eldoret town and the surrounding area.

Affiliations

In-Country	US
Department of Fisheries and Aquatic Sciences Moi University PO Box 1125 Eldoret, Kenya	Department of Fisheries and Wildlife Oregon State University 418 Snell Hall Corvallis, OR 97331-1643 USA

Current Contacts

In-Country	US
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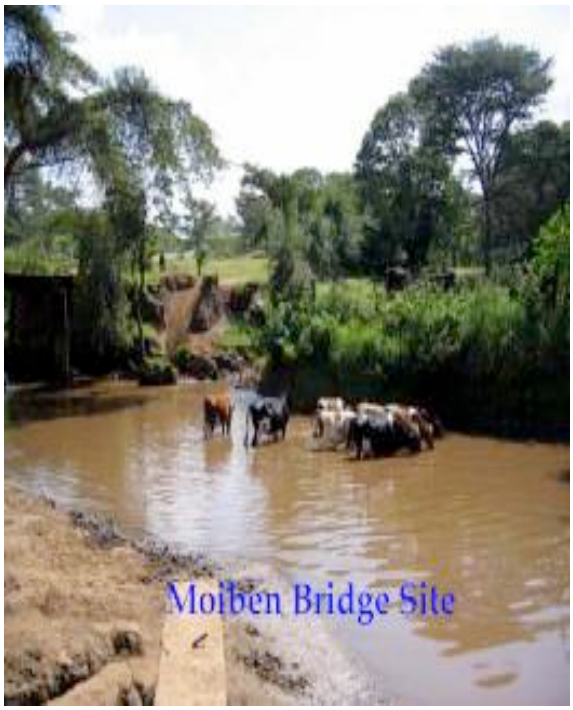
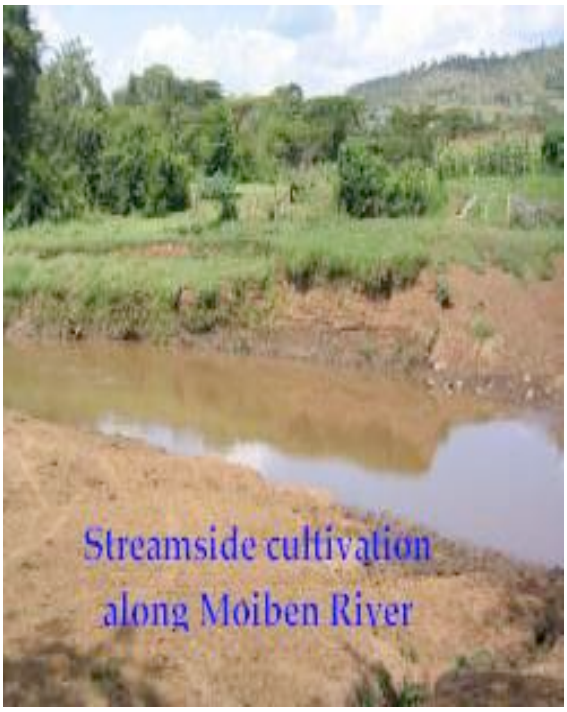
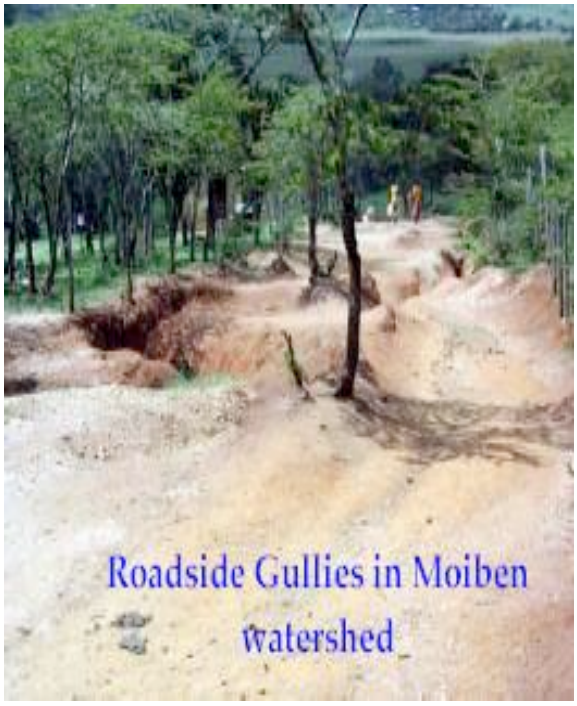
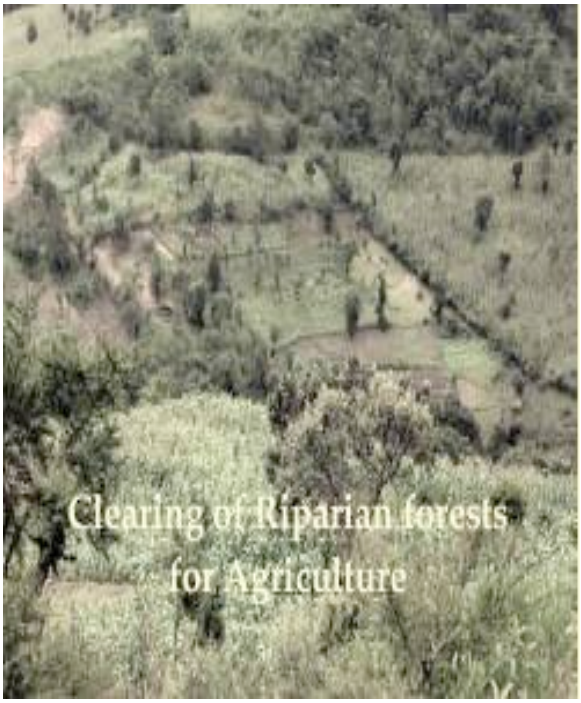
Nzoia Basin


Moiben Bridge Site


Streamside cultivation along Moiben River


Roadside Gullies in Moiben watershed


Clearing of Riparian forests for Agriculture

Nzoia Basin

Site Status: New site

Location: Southwestern Kenya

Caption/Description: The Nzoia River originates from the western slopes of Chengani Hills and south eastern parts of Mount Elgon and drains into Lake Victoria

Description of Area/Region

Climate

Köppen-Trewartha classification*: *tropical humid*.

Temperatures	Precipitation
The temperature of the basin varies from 16°C in the highland areas of Cherangani and Mount Elgon to 28°C in the lower semi-arid areas. The mean annual night temperatures vary between 4°C in the highland areas to 16°C in the semi-arid areas.	The mean annual rainfall varies from a maximum range of 1,100–2,700 mm to a minimum range of 600– 1,100 mm.
Humidity	**Seasonality**
The mean annual humidity at Kakamega averages approx. 71%, and approx. 85% at Eldoret. The average humidity in the basin varies from 70 to 85%.	The basin experiences four seasons in a year influenced by the Inter-Tropical Convergence Zone (ITCZ). The four seasons consist of two rainy and two dry seasons. The rainy seasons are characterized by short rains from October to December, and long rains from March to May. The dry seasons are in January to February, and June to September. The variations in seasonality are greatly influenced by the Lake Victoria climatology.

Topography

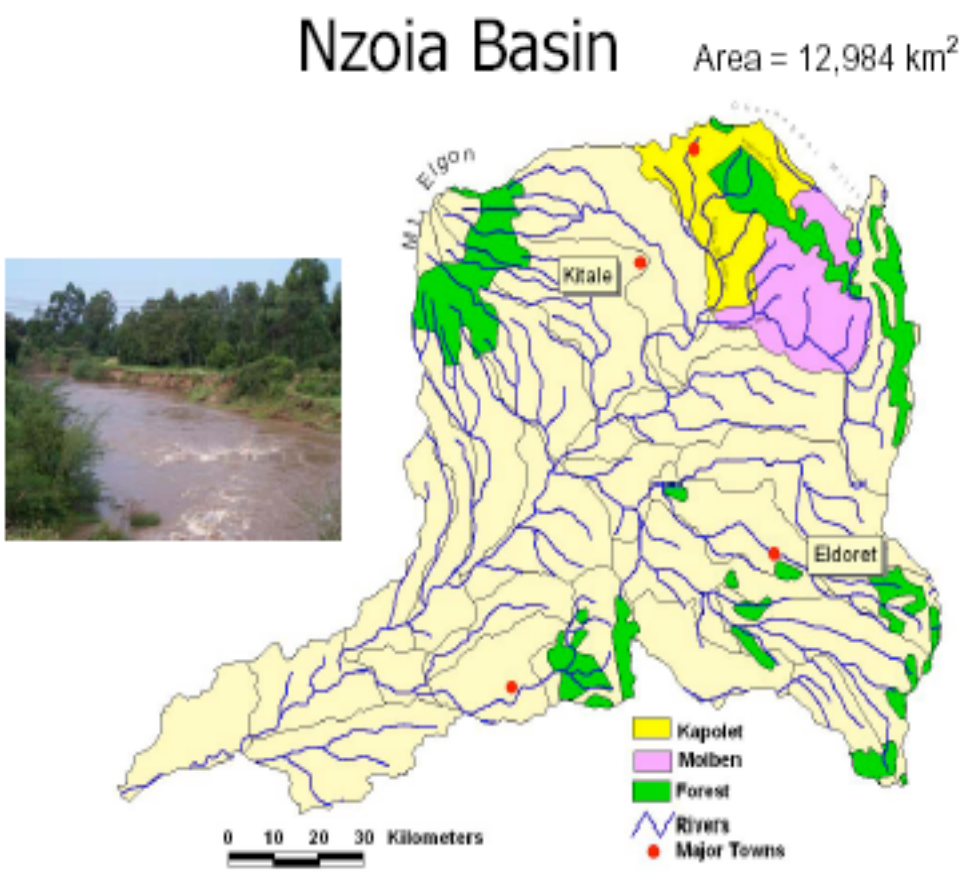
The Nzoia River originates from the western slopes of Chengani Hills and south eastern parts of Mount Elgon at mean elevation of about 2,300 m above sea level (asl), and drains into Lake Victoria at an elevation of about 1,000 m asl. The basin encompasses three geographic regions that include the highlands around Mount Elgon (4,320 m asl) and Chengani hills, the upper plateau that includes Eldoret, and the lowlands.

Geology and Soils

The soils of the flood plains in the lower of the Nzoia River are of the alluvial type. The major parts of the river contain black cotton soils while other areas have coarse textured sand–silt mixture. Some of the areas are characterized by saline soils.

* Asterisked items are defined or described in the glossary.

Layout of Nzoia Basin



Description of Nzoia Basin

Map Coordinates	Elevation
Latitude: Between 1° 30' N and 0° 05' S Longitude: Between 34° E and 35° 45' E	Eldoret Airport is at 2,120 m. Airport is approx. 16 km south of Eldoret.
General	**Water Supply**
The Nzoia River Basin covers an area of 12,842 km^2 and drains through several districts on its way to Lake Victoria. These include Uasin Gishu and Trans Nzoia Districts in the Rift Valley Province; Mt. Elgon, Lugari, Teso, Bungoma, Kakamega, Butere-Mumias and Busia Districts in Western Province; and Siaya District - Nyanza Province. Nzoia River is 355 km long with a mean discharge of 118 $m^3 s^{-1}$ and is the largest basin within the Lake Victoria Basin. The river originates from Cherengany Hills and Mt Elgon at 4,320 meters above sea level and is fed by several streams including Kamukuywa, Moiben, Sosio, Kimilili, Kibisi, Kuywa, Malakisi, Tisi, Lwakhakha, Suam, Kisawai and Kimothon. On its way to the lake the river drains through small and large-scale maize and wheat farms, coffee plantations, Pan Paper Factory in Webuye, Nzoia and Mumias Sugar Factories. Runoff from rural & urban centers and areas with mixed land use practices occurs before the river reaches the Budalangi floodplains. The river presumably causes periodic flooding of the Budalangi floodplains, which brings heavy silt from the upper deforested areas. Pollution of Lake Victoria is significant as the river drains areas with high agro-industrial activities. Further input of pollutants comes from improperly treated wastewater from industries and urban centers situated along the river. The wetlands found within the Nzoia river basin differ depending on the section of the basin where they are found. The main wetlands in the Nzoia river basin include Chepkoilel, Budalangi, Maji Mazuri, Ziwa-Sirikwa Dam, Saiwa Swamp, Siaga Wetland, Nyasanda Wetland, Kaplogoi Stream, Sosiot Wetland, Kaptule Wetland, Kapkis Wetland, Sergoit Dam/Lake Sergoit, Kerita Swamp, Kholera Stream, Saf Stream Wetland, Ukwala Wetlands, Nambusi Wetland, Kisama Wetland, Tande Wetland, Kipsaina and Anyiko Wetland.	The Nzoia River Basin encompasses an area of 12,842 km^2 and drains into Lake Victoria.
Soils	
Major parts of the river contain black cotton soils while other areas have coarse textured sand–silt mixture. Some of the areas are characterized by saline soils.	

Support Facilities at Nzoia Basin

The overall goal is to contribute towards a comprehensive understanding of threats to the Lake Victoria fishery. The current project focus is to evaluate the threats of urbanization and increasing intensive agriculture to the Nzoia River, a major tributary of Lake Victoria. The project represents a new direction for aquaculture research in that it recognizes the systems nature of stream ecology and stream protection, and helps focus efforts on pollution management at the pollution source level. Results of this project will be integrated to similar efforts on other major source streams flowing into Lake Victoria.

Affiliations

In-Country	US
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Current Contacts

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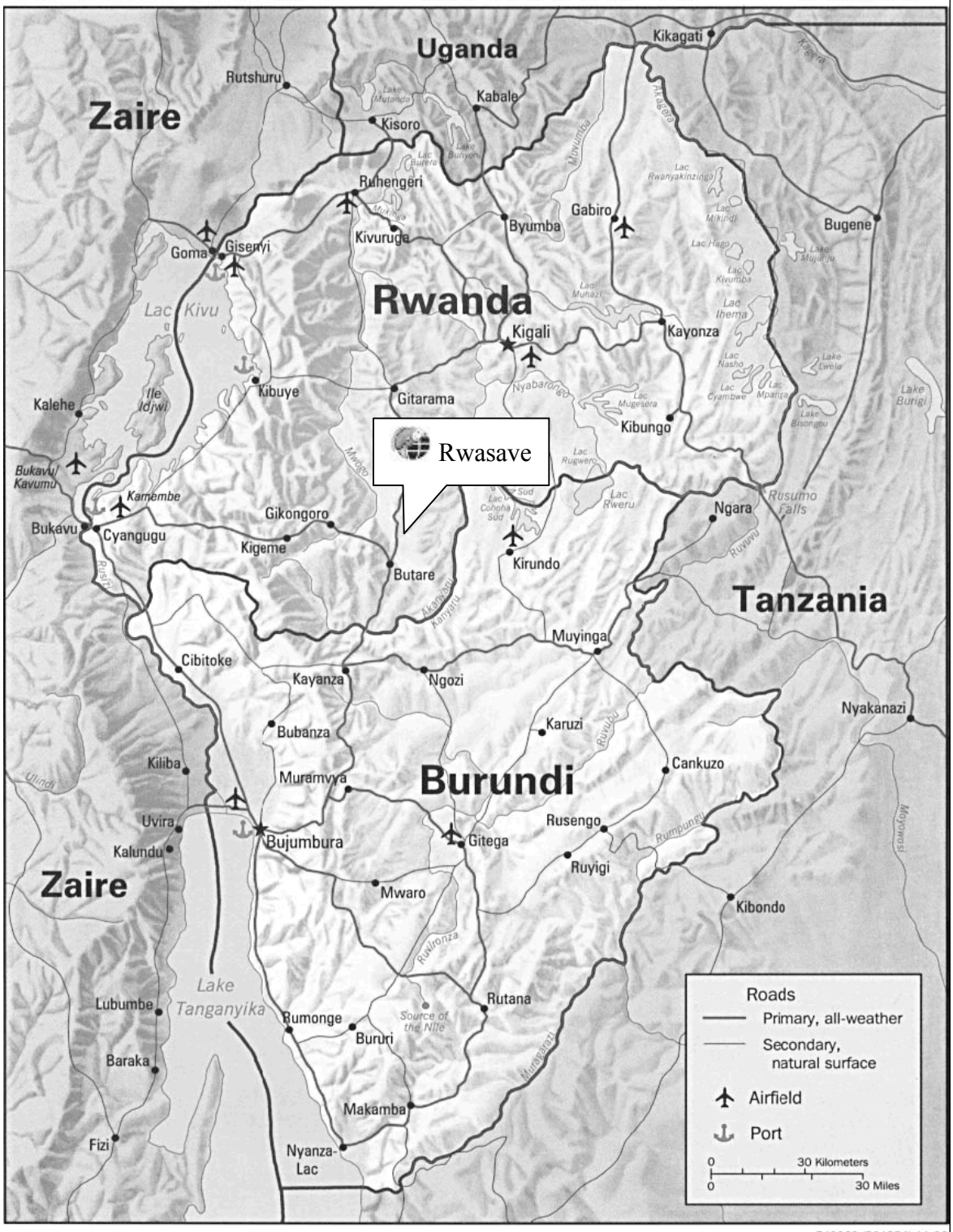
Rwanda and Burundi



Rwasave Fish Culture Station

The Rwasave Fish Culture Station consisted of more than 60 research and production ponds, as well as office, laboratory, training, fish processing, and holding tank facilities.

The steep slopes and deep valleys of much of central and western Rwanda limited fish pond development to smaller-sized ponds on valley bottoms. Access to markets and supplies was also made difficult by the rugged terrain.

Rwasave Fish Culture Station
(Station Piscicole de Rwasave)

Site Status: Former Prime Site*, 1983 to 1994
Location: Rwasave, Butare, Rwanda
Caption/Description: Rwasave is located approx. 2 km from Butare, Rwanda's second-largest city, and about 130 km south of the capital city of Kigali.

Description of Area/Region

Climate

Köppen-Trewartha classification* **GAw***: *Hills or low mountains* (G), *humid tropical* group (A), *tropical wet-and-dry* type (w).

Temperatures	Precipitation
Mean monthly temperatures for the country range from 21.3°C in October to 19.0°C in November. Nighttime temperatures can fall below 10°C in the mountainous areas where aquaculture is practiced. Afternoon temperatures seldom exceed 35°C. Average annual air temperatures at Rwasave range between 14 and 28°C, and pond temperatures range between 19 and 23°C.	Rainfall for the country as a whole ranges from 700 to 2,000 mm annually. Mean monthly rainfall at Rubona (near Rwasave) ranges from a low of 7.3 mm (July) to a high of 182.7 mm (April) with an average annual rainfall of 1,139 mm. Average annual rainfall at the Rwasave Station is about 1,200 mm.
Humidity	**Seasonality**
Mean monthly humidity values at Rubona range from 59% in July to 83% in April.	Rwanda has four identifiable seasons: a long dry season (mid-June to mid-Sept.), a short rainy season (mid-Sept. to mid-Dec.), a short dry season (mid-Dec. to mid-Feb.), and a long rainy season (mid-Feb. to mid-June).

Topography

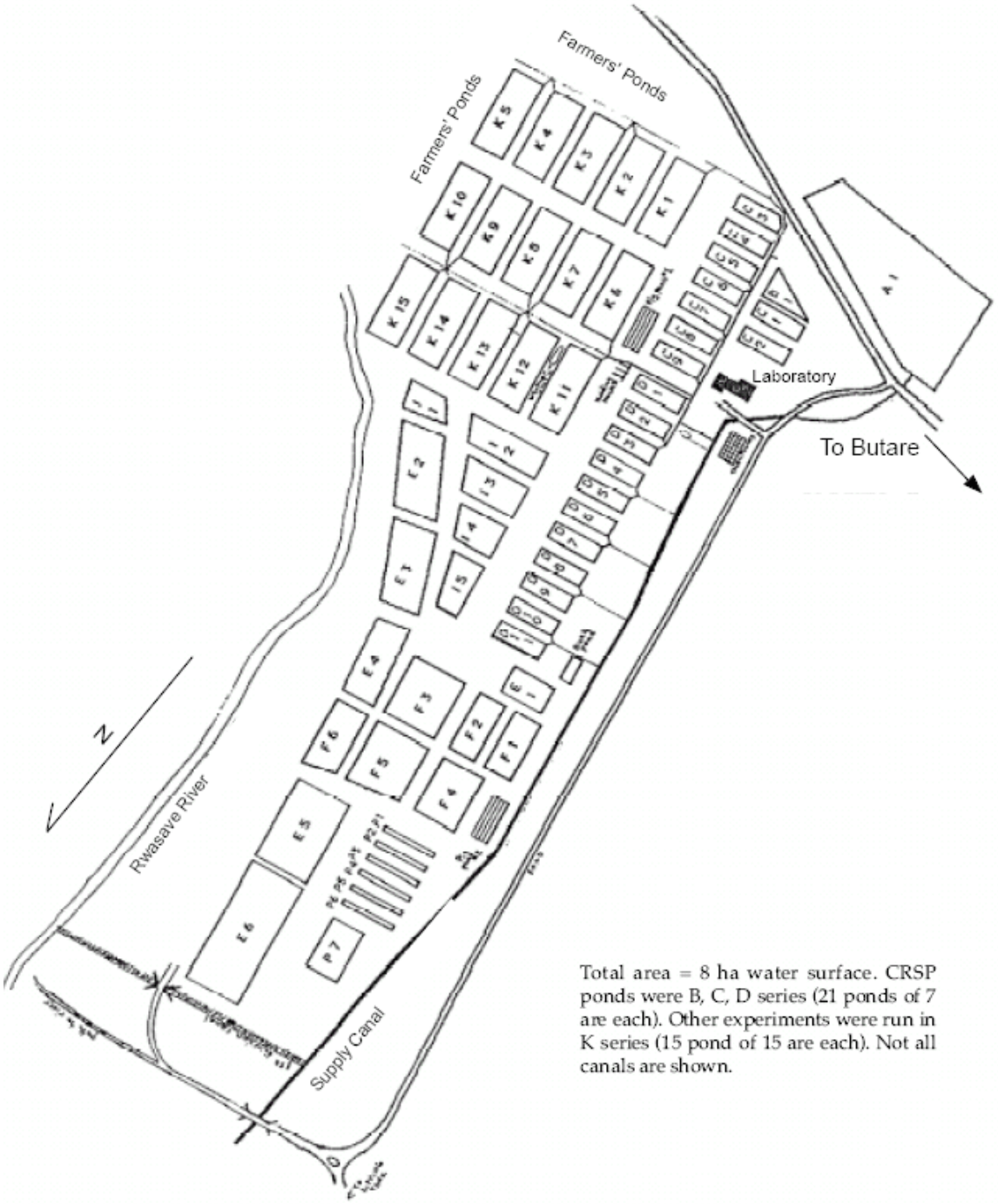
Rwanda's three major geographic regions are the Eastern Shelf (1,000-1,500 m), a hilly Central Plateau (1,500-2,000 m), and the Zaire/Nile divide, which is a range of high mountains (2,000-3,000 m) running north-south parallel to Lake Kivu on the western border with Zaire. Most of the country is hilly or mountainous and lies above 1,500 m. The western mountain range includes five volcanoes whose peaks range from 3,000 to 4,500 m. Rwanda has 23 major lakes (including the 2,370 km^2 Lake Kivu) and numerous rivers. Most aquaculture occurred at altitudes of 1,300 to 2,500 m because water was limited at lower elevations. The ruggedness of the terrain of most of the aquaculture area limited the sizes of ponds as well as access to supplies and markets. Pond development was restricted to marais*. Marais belong to the state, while uplands are private lands.

Geology and Soils

Most of the landmass of Rwanda is very rugged and broken, with steep mountain slopes and deep valleys. The exposed materials are weathered Precambrian rocks and outcrops, or sedimentary deposits derived from such materials. Soils in the Virunga Mountains, a chain of volcanoes in the north, are poorly developed and mostly uncultivable due to the young age of the volcanoes. Some valleys in the north have organic soils, but much of the Central Plateau is dominated by lateritic soils* on the hillsides and alluvial soils in the valley marais*, with occasional pockets of organic soils.

* Asterisked items are defined or described in the glossary.

Layout of Rwasave Fish Culture Station



Total area = 8 ha water surface. CRSP ponds were B, C, D series (21 ponds of 7 are each). Other experiments were run in K series (15 pond of 15 are each). Not all canals are shown.

Description of Rwasave Fish Culture Station

Map Coordinates	Elevation
2° 40' S and 29° 45' E	1,625 m
General	**Water Supply**
The station was approx. 3 km from the National University of Rwanda, Butare campus. It had a total area of 18 ha, of which more than 7 ha were in ponds. There were 21 - 700 m^2 ponds, 15 - 1,500 m^2 ponds, and at least 25 other ponds of various sizes. The 21 - 700 m^2 ponds were reserved for CRSP research. The remaining ponds served for fingerling production and grow-out. The laboratory building had three offices, each with an area of 12 m^2, a laboratory, and a storage area. Another building included a training room; an office; a holding tank/aquarium area; and a large, covered outdoor multipurpose area for training, aquarium experiments, fish processing, and other activities. Another, smaller building included a wet lab and a holding tank area. Personnel at the station included a station manager, a CRSP research associate, a driver, and a secretary/computer operator.	Water was supplied by the Rwabuye River. The supply canal ran 2.5 km from a small dam in the river to the station. The canal passed through some cultivated marshlands where there was some exchange with standing water. At the beginning of CRSP work at Rwasave, the supply water had a pH of 6.5 to 7.0, alkalinity of 17 mg l^{-1}, and a hardness of 43 mg l^{-1} (alkalinity and hardness given as mg $CaCO_3$ l^{-1}).
Soils	
Soils at the Rwasave Station were quite acidic, with pH values reported prior to the beginning of experiments in 1995 ranging from 4.5 to 4.8. Organic matter contents ranged from 0.7 to 5.1, and CECs* ranged from 4.5 to 17.6.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Rwasave Fish Culture Station

Library and university facilities were near but limited. The station employed one laboratory technician and two assistants, a computer-trainee, and 60 station workers and guards. The only feed available was rice bran, which was available in limited but adequate quantities. Fertilizer was available but expensive. Animal manure was in short supply but adequate for station needs.

Affiliations

In-Country	US
Faculté d'Agronomie Université Nationale du Rwanda B.P. 56 Butare, Rwanda	AquaFish CRSP Oregon State University 418 Snell Hall Corvallis, OR 97331-1643 USA Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA

Current Contacts

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Honduras
International Boundary
Department Boundary
Road
River
National Capital
Department Capital
City or Town
0 25 50 75 100 KM
0 25 50 75 100 Miles
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Santa Maria del Real
Zamorano Aquaculture Project
Caribbean Sea
Pacific Ocean
HONDURAS
GUATEMALA
BELIZE
EL SALVADOR
NICARAGUA
Belize City
Belmopan
Dangriga
Big Creek
Poptcen
Punta Gorda
Modesto Mendez
Puerto Barrios
Puerto Cortes
Tela
La Ceiba
Trujillo
Puerto Castilla
Roatan
Isla de Guanaja
Islas de la Bahia
Isla de Utila
Olanchito
San Pedro Sula
El Progreso
San Lorenzo
Los Amates
Gualan
Nueva Arcadia
El Liano
Santa Rita
Yoro
Santa Barbara
Salama
Catacamas
Juticalpa
Dulce Nombre de Culmi
Puerto Lempira
Auasbila
Leimus
Cayos Miskitos
Puerto Cabezas
Bonanza
Siuna
Rio Prinzapolka
Prinzapolka
Rio Matagaloa
Rio Coco
Rio Patuca
Rio Jalan
Rio Bocay
Rio Kukalaya
Laguna de Caratasca
Tegucigalpa
Danli
Yuscaran
Sabana Grande
Pespire
Ocotal
Santa Clara
Ouilali
Somoto
Condega
San Sebastian de Yali
Esteli
Jinotega
Matagalpa
Rio Blanco
Nuevo Amanecer
El Sauce
Chinandega
Corinto
Leon
Lago de Managua
Boaco
La Virtud
Concepcion
Lepaterique
San Salvador
Sensuntepegue
San Vicente
San Francisco
Nacaome
La Libertad
San Miguel
Usulutan
La Union
Cholutecae
El Triunfo
Somotillo
Potosi
Golfo de Fonseca
Gulf of Honduras
Turneffe Islands
Glover Reef
Belize River
Rio Montagua
Lago de Izabal
Rio Aguan
Laguna

Santa Maria del Real




Typical tilapia culture ponds

Santa Maria del Real

Site Status: New site
Location: Santa Maria del Real, Olancho, Honduras
Caption/Description: Santa Maria del Real tilapia culture is located in a valley approx. 6 km from Catacamas.

Description of Area/Region

Climate

Köppen-Trewartha classification*: *Tropical savannah*.

Temperatures	Precipitation
Temperatures are stable year around. The average daily maximum temperature is approx. 25°C. The average daily minimum temperature is approx. 15°C.	The highest rainfall occurs during May, June and September (150-200 mm/month). The lowest rainfall occurs December through March (< 12 mm/month).
Humidity	**Seasonality**
Humidity averages approx. 70% and is relatively stable, ranging from 60 to 75%.	The wet season is April through November. The dry season is December through March.

Topography

The Valle de Catacamas (Catacamas Valley) is roughly 15-20 km wide by 50 km long and lain out southwest to northeast. This broad flat valley is surrounded by high relief topography on all sides, especially to the north and east.

Geology and Soils

The Cacaguapa schist is the rock unit, which is thought to underlie all of the rocks in Honduras and is considered to be the basement rock of the Chortis block. Soils are humus-clay.

* Asterisked items are defined or described in the glossary.

Description of Santa Maria del Real

Map Coordinates	Elevation
Latitude (DMS): 14° 46’ N Longitude (DMS): 85° 57’ W	329 m
General	**Water Supply**
For more than two decades, a cluster of successful tilapia producers has existed. The cluster, located around the communities of Santa María del Real and El Guayabito, was the source of data for a study that took place during the months of July-August of 2002. The study of this cluster of tilapia producers elucidated the benefits of cluster membership and other factors that favor the development of tilapia culture.	Streams and groundwater.
Soils	
Soils are humus-clay.	

Support Facilities at Santa Maria del Real

Escuela Agricola Panamericana El Zamorno staff did site visits to Santa Maria del Real tilapia farms.

Affiliations

In-Country	US
Escuela Agricola Panamericana Zamorano PO Box 93 Tegucigalpa FM Honduras	AquaFish CRSP Oregon State University 418 Snell Hall Corvallis, OR 97331-1643 USA

Current Contacts

In-Country	US
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Zamorano Aquaculture Project
Escuela Agrícola Panamericana

Site Status: Prime site* since 1999
Location: Panamerican Agriculture School, approx. 36 km east of Tegucipalpa.
Caption/Description: The Zamorano Aquaculture Project is located on the campus of the Panamerican Agriculture School in the Yegüare River Valley.

Description of Area/Region

Climate

Köppen-Trewartha classification* **Aw***: *Humid tropical* group (A), *tropical wet-and-dry* type (w). The higher elevations among the interior mountains moderate local temperature regimes in Honduras.

Temperatures	Precipitation
The temperature regimes in Honduras are related to elevation and season of the year. Zamorano is located at approx. 14° north latitude and 750 m above sea level. The mean monthly air temperatures in Zamorano are approx. 21°C in January, and 28°C in June and July. The mean annual ambient temperature in Zamorano is between 24 and 25°C. The average water temperatures in aquaculture ponds at Zamorano range from 20 to 27°C.	Mean annual precipitation in the Yegüare River Valley is approx. 1,100 mm in distinct dry (December through April) and wet (May through November) seasons. Generally, the months of greatest precipitation are September and October. The northern coastal areas of Honduras have annual rainfall in excess of 2,000 mm. Rainfall in southern Honduras averages 1,500 mm per year.

Humidity	Seasonality
Mean annual humidity in Tegucigalpa, 36 km to the West of Zamorano, averages about 74%. The relative humidity is lowest during the dry season and highest during the rainy season.	The Honduran climate is characterized by distinct dry (December through April) and wet (May through November) seasons. Generally, the dry season has reduced temperatures and little or no rainfall in comparison to the rainy season. The coastal areas of Honduras experience generally higher ambient temperatures due to their lower elevation, compared to locations in the interior of the country.

Topography

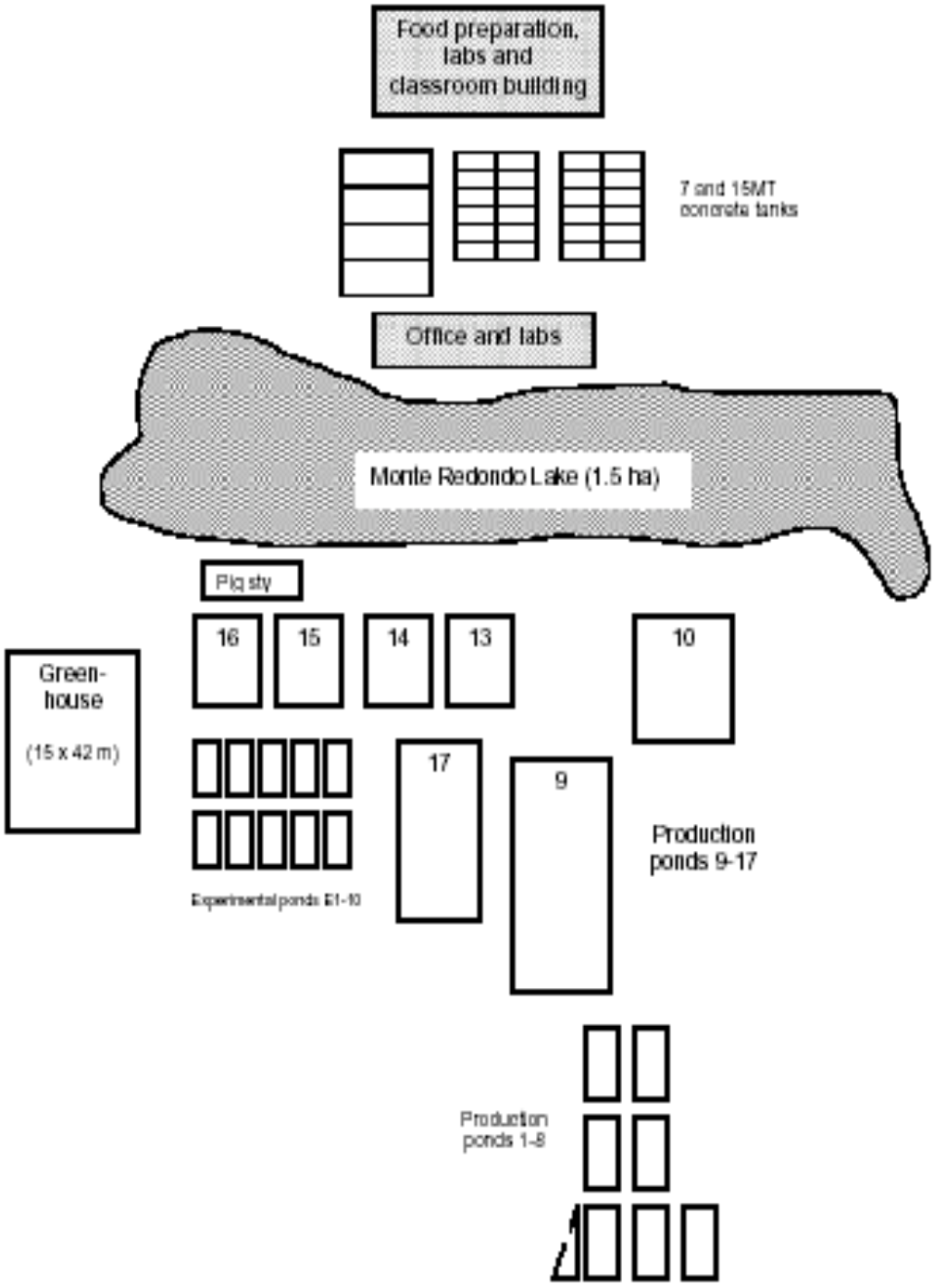
Honduras is characterized by a very mountainous topography and few fertile valleys. The interior portions of the country include several important valleys with soils deposited through alluvial processes. The mountains of Honduras have elevations from 500 to 2,200 m. Honduras has both northern (Caribbean Sea, 640 km long) and southern (Gulf of Fonseca, 64 km long) coasts. The southern coast of Honduras provides direct access to the Pacific Ocean. Honduras is a mountainous country with few fertile valleys for cultivation. The mountains, of volcanic origin, generally run in ridges with an orientation parallel to the north coast (west-east).

Geology and Soils

In general, Honduran soils are of volcanic origin with a high alluvial influence. The overall mountainous topography in Honduras tends to promote erosion with deposition of soils in valley floors. In the Yegüare River Valley, most soils are only slightly acidic due to their high calcium content derived from the local parent material.

* Asterisked items are defined or described in the glossary.

Layout of the Zamorano Aquaculture Project



Description of Zamorano Aquaculture Project, Escuela Agrícola Panamericana

Map Coordinates	Elevation
14° 00' N and 86 °59' E	Zamorano is at 750 m. The Yegüare River Valley floor has elevations between 700 and 850 m.

General	Water Supply
The Escuela Agrícola Panamericana (Panamerican Agriculture School) is also known as Zamorano. It is located in Francisco Morazán Department, Honduras. Zamorano is a private, non-profit, USA university, operating in Honduras since 1942 (related websites: www.zamorano.edu; www.acuacultura.org.) The Aquaculture Project at the Panamerican Agriculture School (Zamorano) was initiated in 1976. It has been developed as a training and research facility. The project consists of 17 production and 10 experimental ponds ranging in water surface area from 200 to 2,000 m^2. The total area for fish production in ponds is approx. 12,000 m^2. The project also includes several concrete tanks (total of 48). Fish are also cultured in cages placed in several reservoirs on the Zamorano campus. There is a wet lab, water chemistry lab, feed preparation area, a classroom, and a modern, well-equipped office for project staff and students in the Zamorano Aquaculture Project. In 2004, a greenhouse was constructed to better control water temperatures on a year-round basis. The greenhouse contains six culture units ranging from 25 to 80 m^3. Two experimental ponds (200 m^2 each) were covered with plastic to maintain tilapia reproduction activities on campus during the coolest months (November thru February) of each year. Activities at the project focus on training and research of finfish, especially diverse aspects of tilapia* culture. Stocks of other finfishes (common carp*, guapote tigre*, common snook) and crustacean species (*Cherax quadricarinatus*, *Macrobrachium rosenbergii* and *Litopenaeus vannamei*) are maintained in the project.	Water for the Zamorano Aquaculture Project is supplied from two man-made lakes with an estimated 30,000 m^3 of storage capacity. Run-off and rainwater stored in these lakes is also used for irrigated cultivation of cereal crops in Zamorano. Several of the aquaculture ponds receive gravity-fed water conducted through a 300 m long system of 10 cm diameter PVC pipes from a 10,000 m^2 lake located at a higher elevation. Other ponds receive water pumped (15 HP) from a 15,000 m^2 reservoir through an 8 cm diameter PVC pipe. The surface waters in the Yegüare River Valley are characterized as soft (total alkalinity < 30ppm) and have typically low pH values (< 5.5).

Soils
The soils at the Zamorano Aquaculture Project have high clay content (clay-loams or clay-sandy-loams, generally > 30% clay content) and are strongly acidic (pH values typically from 4.8 to 5.5). These soils have CECs* between 10 and 12 meq, and low to medium content of organic matter (1 to 3%).

* Asterisked items are defined or described in the glossary.

Support Facilities at Zamorano Aquaculture Project
Escuela Agrícola Panamericana

Zamorano has important support facilities that include diagnostic (plant pathogens and veterinary clinic) and analytical laboratories (soils and water chemistry, animal feeds and nutrition). Zamorano has excellent communications capabilities (internal and external telephone and fax lines, e-mail, and a direct "up-link" for internet access, which is provided to offices, dormitories and residences, via a system of fiber-optic cables), and the Wilson Poponoe Library with more than 20,000 volumes and subscriptions to 700 journals, focused on the agricultural sciences and related fields.

Affiliations

In-Country	US
Zamorano works closely with several Honduran government agencies such as the Ministry of Agriculture and Animal Production, non-government organizations (NGOs) devoted to development, international donor agencies such as USAID and BID, European Community, Taiwanese Mission and local universities such as the National Autonomous University of Honduras and the National Agriculture School. Regional collaborators include: University of San Carlos in Guatemala; University Juarez de Tabasco in Mexico; Catholic Agriculture University in Esteli, Nicaragua; Superior Institute of Agriculture Education in the Dominican Republic; and Catholic University of Temuco, Chile.	Zamorano has ongoing collaborations with several North American universities including Purdue University, Cornell University, University of Florida, University of Georgia, Auburn University, Louisiana State University, University of Southern Mississippi, University of Arkansas, University of Arizona and University of Oregon.

Current Contacts

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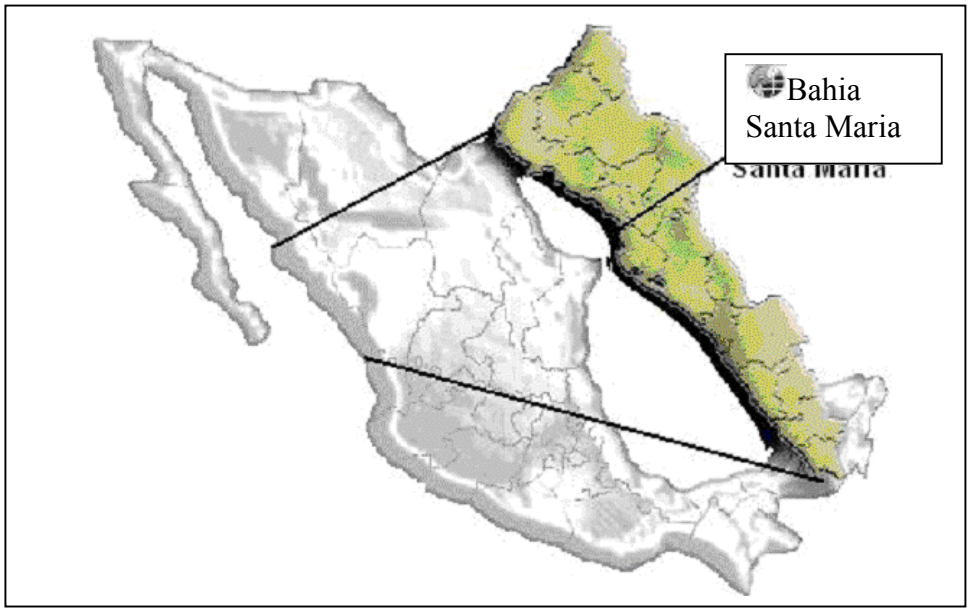
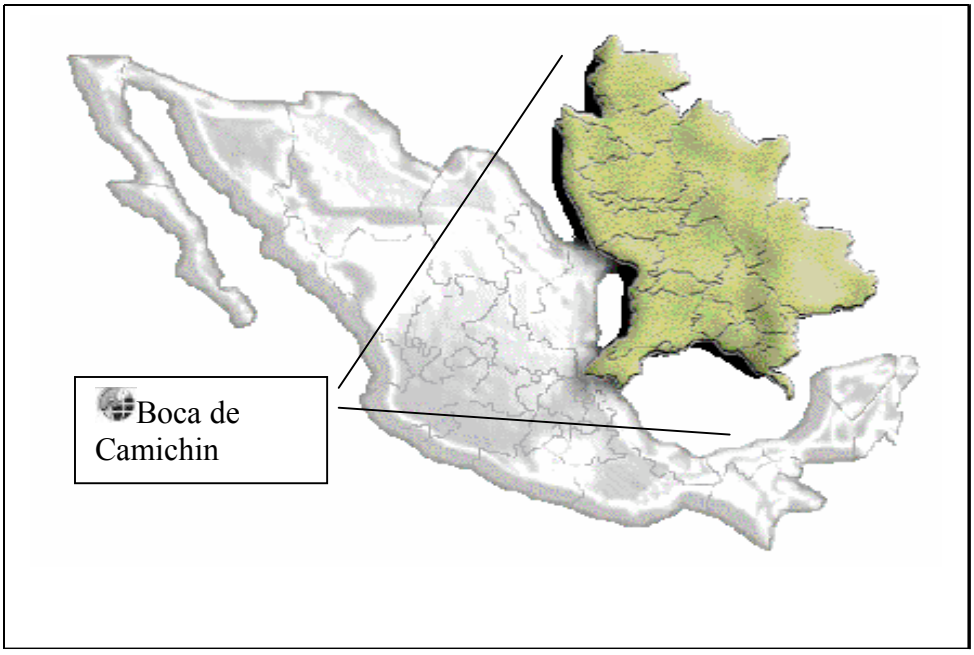
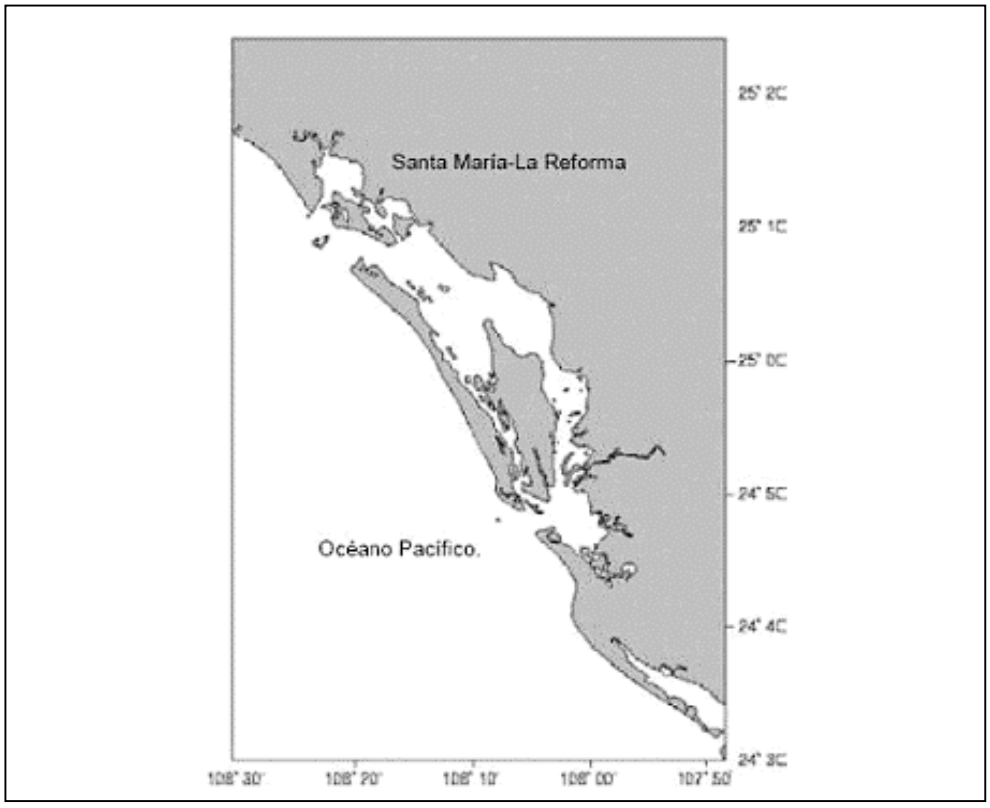

Bahia
Santa Maria


Boca de
Camichin

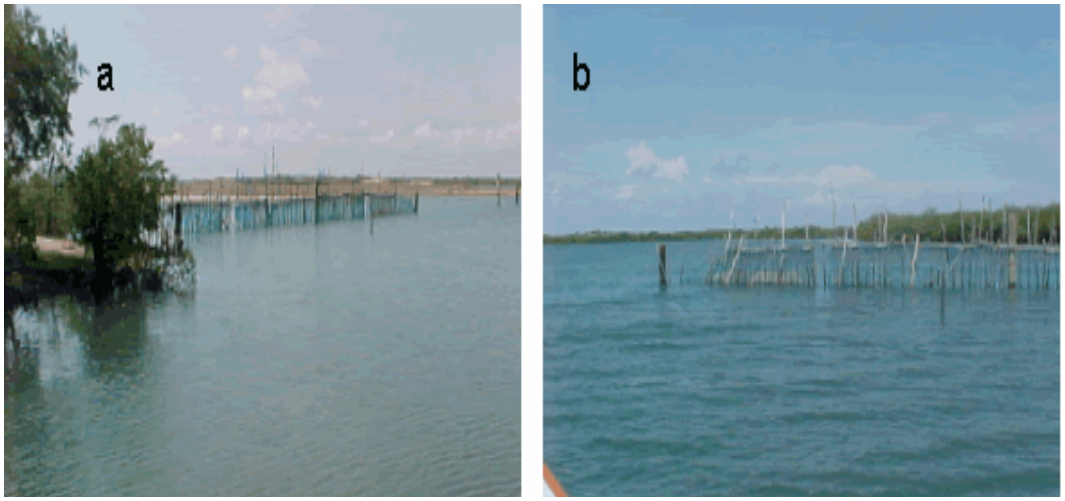


Bahia Santa Maria

Boca de Camichin

Bahia Santa Maria

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



Oyster culture sites

Bahia Santa Maria

Site Status: New site
Location: Bahia Santa Maria, Sinaloa, Mexico
Caption/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.

Description of Area/Region

Climate

Köppen-Trewartha classification* **Bw(h')w(e)***, or hot, dry and desert-like.

Temperatures	Precipitation
There are distinct hot and cold seasons. Highest temperatures occur during May and June rising as high as 36°C. Lowest temperatures are around 12 °C in January and February.	Total rainfall averages 819 mm, 6% over the national average.
Humidity	**Seasonality**
Humidity tends to be high and can exceed 85% during summer.	Between June and December, 67% of the precipitation falls. 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 and Soils

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

* Asterisked items are defined or described in the glossary.

Description of Bahia Santa Maria

Map Coordinates	Elevation
The northern extent of Bahia Santa Maria is at 25° 09' 43" N and 108° 21' 52" W and the southernmost point is at 24° 46' 42" N and 108° 03' 03" W.	0 m
General	**Water Supply**
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. The area encompasses 46,000 ha of water surface. 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 is being monitored as a prelude to classification of waters for shellfish sanitation purposes.	Ocean
Soils	
Predominant soil types are Solonetz and Solonchak, characterized by the presence of salt in the upper layer.	

Support Facilities at Bahia Santa Maria

Experiments and activities are aided by Universidad Autonoma de Sinaloa (AUS), Center for Food and Development Research (CIAD), and the Sinaloa State Committee for Aquatic Sanitation.

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

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Boca de Camichin

Oyster farming community in Marismas Nacionales.

Oyster culture activities at Boca de Camichin

Boca de Camichin

Site Status: New site
Location: Boca de Camichin, Nayarit, Mexico
Caption/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.

Description of Area/Region

Climate

Hot and humid, or sub-humid.

Temperatures	Precipitation
Highest temperatures occur during May and June rising as high as 29.4°C. Lowest temperatures are approx. 20.2 °C in January and February.	The region encompasses three climatic zones in which annual rainfall varies between 800 mm and than 1,200+ mm annually.
Humidity	**Seasonality**
Humidity tends to be high and can exceed 85% during summer.	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 and 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

Map Coordinates	Elevation
21° 42' 08" N and 105° 27' 57" W	0 m
General	**Water Supply**
Marismas Nacionales is an extensive wetlands and mangrove area located on the Pacific Coast of Mexico, in the state of Nayarit. Water surface area is 2,000 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 in developing oyster culture, implementing improved shellfish sanitation and monitoring water quality. The oyster cultured is a native species, *Crassostrea corteziensis*. Some shrimp farming also occurs in the area.	Ocean
Soils	
Predominant soil types are Solonetz and Solonchak, characterized by the presence of salt in the upper layer.	

Support Facilities at Boca de Camichin

Experiments and activities are aided by Universidad Autonoma de Sinaloa (AUS) and the Center for Food and Development Research (CIAD).

Affiliations

In-Country	US
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Pueblo Nuevo
Los Horcones
HONDURAS
EL SALVADOR
COSTA RICA
NORTH PACIFIC OCEAN
Caribbean Sea
Golfo de Fonseca
Lago de Nicaragua
ZELAYA
CHONTALES
RÍO SAN JUAN
CARAZO
SEGOVIA
Tegucigalpa
Managua
Nicaragua
International boundary
Departamento boundary
National capital
Departamento capital
Railroad
Road
Departamentos have the same name as their capitals except where noted.
0 25 50 Kilometers
0 25 50 Miles
Boundary representation is not necessarily authoritative.
800265 (545340) 10-85

Pueblo Nuevo and Los Horcones, Estelí

Typical tilapia culture ponds in Esteli area.

Pueblo Nuevo and Los Horcones, Estelí

Site Status: New sites
Location: Pueblo Nuevo and Los Horcones, Estelí, Nicaragua
Caption/Description: Esteli is in northwestern Nicaragua, and is 150 km north of Managua.

Description of Area/Region

Climate

Tropical savannah

Temperatures	Precipitation
Average maximal temperature range is 31-34°C. Average minimal temperature range is 21-23°C.	The highest rainfall occurs June through October (140-280 mm/month). The lowest rainfall occurs December through March (< 10 mm/month).
Humidity	**Seasonality**
Monthly average humidity ranges from a high of 84% during summer to a low of 54% in the early spring (April).	The rainy season occurs between May and November. The dry season occurs between December and April.

Topography

Pueblo Nuevo: Valley
Los Horconones: Hills

Geology and Soils

Mainly sandy or clay soils

Description of Pueblo Nuevo and Los Horcones, Esteli

Map Coordinates	Elevation
Latitude (DMS): 13° 22’ 60" N Longitude (DMS): 86° 28’ 60" W	599 m
General	**Water Supply**
In 2005, a study on tilapia culture in Nicaragua indicated that 90% of the tilapia producers in that country were members of the cooperative COOSEMPROTIR, R.L. The members of the cooperative have their farms located in the communities of Pueblo Nuevo and Los Horcones. The results of the analysis indicated that producers had a basic level of technical knowledge on tilapia culture. Further development of tilapia* culture requires particular attention in areas of knowledge, economic use of resources, management, and marketing.	Esteli River watershed
Soils	
Mainly sandy or clay soils	

* Asterisked items are defined or described in the glossary.

Support Facilities at Pueblo Nuevo and Los Horcones, Esteli

Escuela Agricola Panamericana El Zamorno staff did site visits and workshops at local tilapia farms.

Affiliations

In-Country	US
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Caribbean Sea
NORTH PACIFIC OCEAN
Gulf of Panama
COLOMBIA
COSTA RICA
PANAMA
DARIÉN
SAN BLAS
COLÓN
VERAGUAS
LOS SANTOS
HERRERA
Gualaca
Aguadulce
Panama
International boundary
Province boundary
National capital
Province capital
Railroad
Road

Aguadulce
Brackishwater Experiment Station "Ingeniero Enrique Ensenat"

Site Status: Former Prime Site*, 1983 to 1987

Location: Aguadulce, Cocle, Panama

Caption/Description: The Ingeniero Enrique Ensenat Brackishwater Experiment Station (BES) is located approx. 5 km south of the town of Aguadulce, 0.5 km north of the Port of Aguadulce, and 190 km west of Panama City. It is within a zone of approx. 1,500 ha of commercial shrimp farms adjacent to Parita Bay on the Pacific coast of Panama.

Description of Area/Region

Climate

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

Temperatures	Precipitation
Average annual temperatures for Panama as a whole range from 23 to 27°C. At higher altitudes in the interior regions, the average annual temperature is nearer to 19°C. Average annual temperatures at the BES were between 23.8 and 33.5°C. Average pond water temperatures were 28.4°C.	Average annual rainfall for the Pacific side of the country is about 1,650 mm; while at the BES, it is 1,453 mm.
Humidity	**Seasonality**
Humidity is generally high (85-90%) during the rainy season but lower (down to 60%) during the remainder of the year.	Panama experiences a tropical wet-and-dry climate, with a dry season that lasts from December to April. It rains during the remainder of the year.

Topography

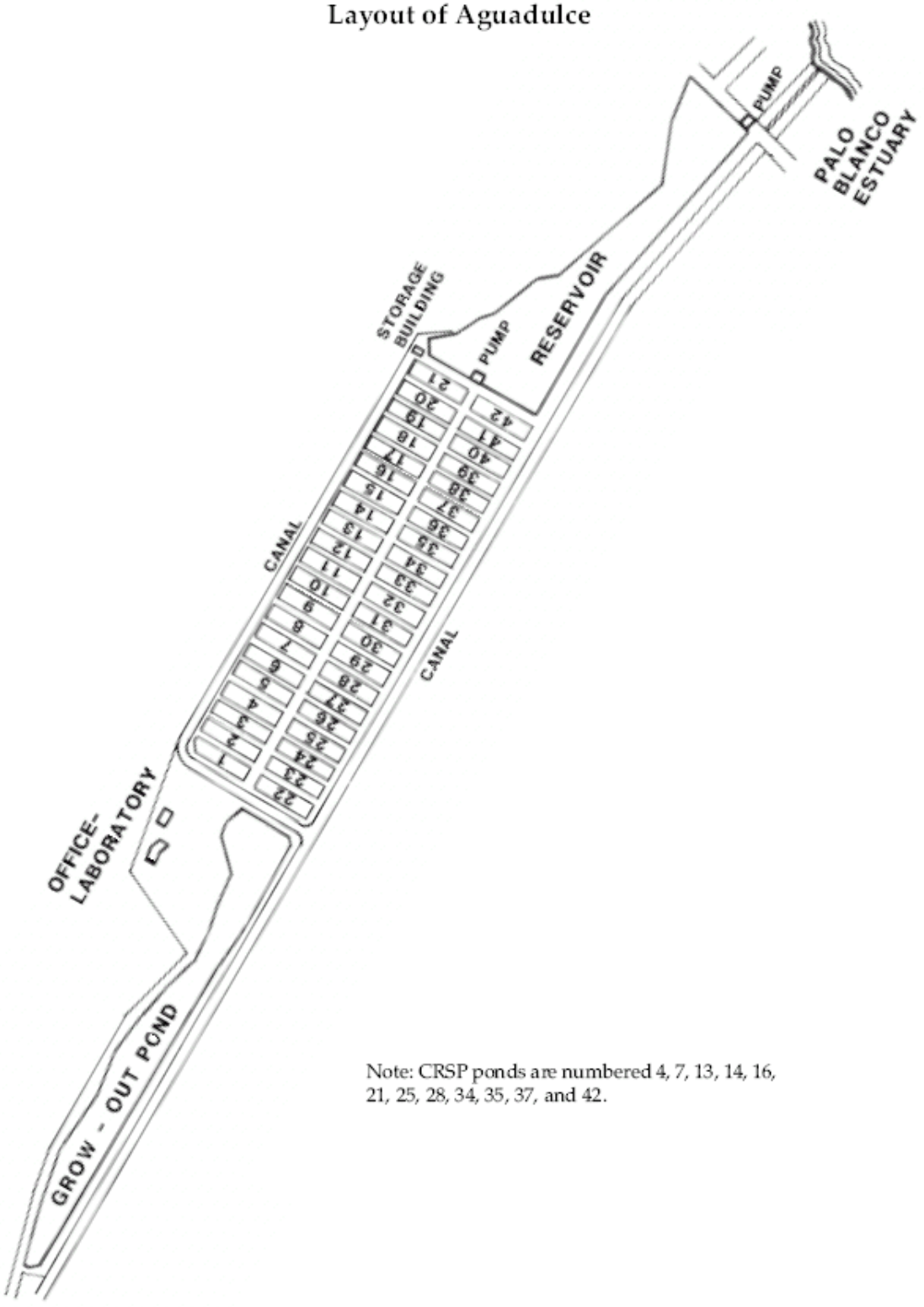
The area immediately around the station is characterized topographically by extensive mud flats and mangrove forests on the seaward side and coastal plain on the landward side.

Geology and Soils

Mountain ranges throughout Central America are a part of the Andes–Rockies mountain chain, stretching through the western portion of the Americas from Alaska to Chile. The Central American isthmus is considered semi-stable with respect to seismic activity, and the entire southern (Pacific) side is considered a seismic area, containing several active volcanoes. Soils in Panama are of volcanic origin, although in the flat coastal area around Aguadulce they are predominantly formed by recent alluvial processes together with changes brought about by weathering, sedimentation, and exposure to seawater. Soils around Aguadulce have high clay content, and the influence of seawater is reflected in relatively high content of elements such as sodium (Na).

* Asterisked items are defined or described in the glossary.

Layout of Aguadulce



Note: CRSP ponds are numbered 4, 7, 13, 14, 16, 21, 25, 28, 34, 35, 37, and 42.

Description of Aguadulce
Brackishwater Experiment Station "Ingeniero Enrique Ensenat"

Map Coordinates	Elevation
8° 15' N and 80° 29' W	< 5 m

General	Water Supply
The Brackishwater Experiment Station (BES) was part of the aquaculture station network established and administered by the General Directorate of Aquaculture (Dirección Nacional de Acuicultura—DINAAC) of the Ministry of Agriculture Development (Ministerio de MIDA) of the government of the Republic of Panama. Its primary functions included both research and seed production. The BES consisted of two phases of earthen ponds. Phase 1 included 42 experimental ponds measuring from 0.05 to 0.0650 ha in surface area, a 1.4 ha reservoir pond, a 1.1 ha production pond, two pump stations, an office-laboratory building, a processing building, and a storage building. Phase 2 was located 1 km from Phase 1 and consisted of 10 production ponds ranging from 0.2 to 1.0 ha in area, a pump station, and a storage building.	Water for Phase 1 and Phase 2 was pumped from a branch of the Palo Blanco Estuary. The same branch served both as a source of water and a drainage canal for the BES and neighboring shrimp farms. Water to Phase 1 CRSP ponds was pumped by a diesel-powered hydraulic pump from the estuary to the 1.4 ha reservoir pond, and then pumped to the ponds by a diesel-powered hydraulic pump. This water had a pH between 7.2 and 8.6. Salinity ranged from about 10 ppt during the wet season to more than 45 ppt during the dry season.

Soils
The texture of soils in the CRSP research ponds averaged 51% clay, 31% silt, and 16% sand, and soils contained an average of approx. 1% organic matter (range of 0.7 to 1.5 in 12 ponds). Soils were approx. neutral with pH values ranging from 6.4 to 7.6, and contained very little free $CaCO_3$ (0.2% in all ponds).

Support Facilities at Aguadulce
Brackishwater Experiment Station "Ingeniero Enrique Ensenat"

A joint agreement with the Agricultural Research Institute of Panama (IDIAP) allowed DINAAC to request occasional assistance in the analysis of feedstuffs and fertilizers and to determine concentrations of chemical constituents in water and soil samples. All fertilizer and feed was generally provided by DINAAC for the CRSP experiments. Organic fertilizer was in short supply, and inorganic fertilizer could be purchased in unmixed form from importers and blended to the desired combinations. University of Panama students conducted thesis research at the BES on special topics related to the pond dynamics trials. There was a small library at the BES; a larger collection was available at the DINAAC offices in Santiago, one hour from the BES.

Affiliations

In-Country	US
Dirección Nacional de Acuicultura (DINAAC) Ministerio de Desarrollo Agropecuario (MIDA) Santiago de Veraguas Republica de Panama	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA

Current Contacts

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Gualaca Freshwater Aquaculture Research Station
"Estacion Experimental Dulce Acuicola de Gualaca"

Site Status: Former Prme Site*, 1983 to 1987

Location: Estación Experimental Dulce Acuicola de Gualaca, Agricoles de Panama, Gualaca, Chiriqui, Panama

Caption/Description: The Gualaca Freshwater Aquaculture Research Station (Estación Experimental Dulce Acuicola de Gualaca) is located at the base of the Andes mountain chain, 2 km south of the town of Gualaca, in western Panama. The nearest city, David, is 27 km to the southwest.

Description of Area/Region

Climate

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

Temperatures	Precipitation
Annual air temperature at Gualaca ranges from 17 to 34°C, and pond water temperatures at the station ranged from 23 to 29°C.	Average annual rainfall at Gualaca is 4,320 mm. Most of this rainfall occurs during the rainy season (May–November), with little rain falling between December and April.
Humidity	**Seasonality**
Mean annual relative humidity in the Gualaca area is 83%. It ranges from lows of 67 to 68% in February and March to highs of 88 to 90% from June through November.	A distinct dry season, running from December through April, is observed in the Gualaca area. During this period, there is often no rainfall. Towards the end of April, rainfall begins to increase, reaching an average of 11 to 13 mm per day during May and June, slacking off a bit during July, and then again increasing to a maximum of around 27 mm per day in September.

Topography

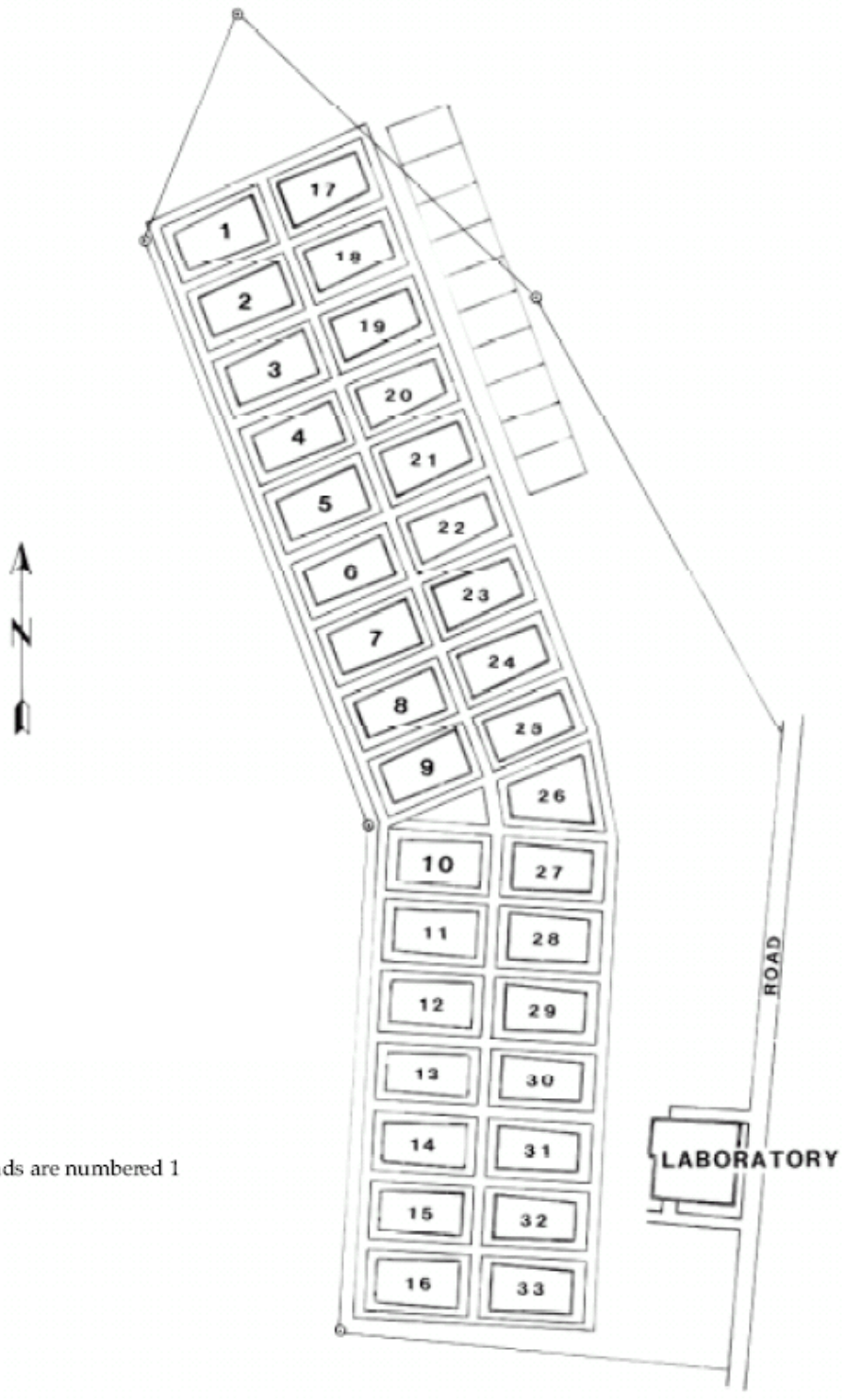
The Cordillera Central mountain chain forms the backbone of the portion of Panama west of the Panama Canal. Average elevations here range from 1,000 to 2,000 m, but the highest peaks, including the Volcan de Chiriqui, approximately 45 km northwest of Gualaca, rise to elevations of over 3,350 m. Gualaca lies near the foot of the southern slopes of these mountains, at an elevation of 100 m, and approx. 25 km from the coast at the Gulf of Chiriqui on the Pacific Ocean.

Geology and Soils

Mountain ranges throughout Central America are a part of the Andes–Rockies mountain chain, formed by plate tectonic activity and stretching through the western portion of the Americas from Alaska to Chile. All of the Central American isthmus is considered only semi-stable with respect to seismic activity, and the entire southern (Pacific) side is considered a seismic area, containing several active volcanoes. Soils in Panama are thus of volcanic origin; those in the area around the Gualaca site are alluvial Inceptisols* that are acidic and highly permeable.

* Asterisked items are defined or described in the glossary.

Layout of Gualaca



Note: CRSP ponds are numbered 1 through 10.

Description of Gualaca Freshwater Aquaculture Research Station "Estacion Experimental Dulce Acuicola de Gualaca"

Map Coordinates	Elevation
8° 31' N and 82° 19' W	100 m

General	Water Supply
The Gualaca station was built in 1984 to supply fingerlings of tilapia*, carp*, and other fish to producers in the area and to conduct aquacultural research. It was administered by DINAAC (Dirección Nacional de Acuicultura), but it also functioned as part of an IDIAP (Instituto de Investigacion Agropecuaria de Panama) facility located in Gualaca. The station was comprised of 33 earthen ponds of 800 m^2 each; 10 earthen ponds of 300 m^2 each; a water analysis laboratory; a feed formulation laboratory; a wet laboratory for aquarium studies; a drive-in fish holding area with 16 concrete tanks equipped with gravity-fed running water; space for a fish hatchery; and a dormitory for students.	The water supply for the station was gravity-fed by a canal (Quebrada del Pueblo) that diverted water from the Rio Chiriqui, a river draining the mountains north of the station. Water from these mountain watersheds was typically soft. At the beginning of CRSP research at this site (1983), water from the canal had a pH of 6.4 and low alkalinity and hardness readings of 18.4 and 14.6 mg l^{-1} (as $CaCO_3$), respectively.

Soils

The ponds at Gualaca were excavated in the alluvial soils that are typical of the area, but because these soils proved to be too permeable, a layer of red clay (ultisol*) material was later added in an attempt to reduce seepage. Ultisols are typically high in kaolinitic clay minerals, however, and although clay contents ranged from 24 to 36% in the Gualaca ponds, seepage remained high even after the ponds were lined. The soils were quite acidic at the beginning of CRSP work, with pH values ranging from 4.7 to 5.2 and base saturations between 8 and 13%. The CECs* of the soils were less than 24 meq per 100 g. Organic matter in these pond soils ranged from 2.0 to 3.9%.

* Asterisked items are defined or described in the glossary.

Support Facilities at Gualaca Freshwater Aquaculture Research Station "Estacion Experimental Dulce Acuicola de Gualaca"

During the time that the CRSP conducted research at the Gualaca aquaculture station, it was jointly supported by IDIAP and DINAAC. IDIAP supplied the land, helped maintain the facility, and paid the salary of the station manager. IDIAP also ran a chemical analysis and soil lab near the fish station, where feed, soils, and minor elements of water could be analyzed. Laboratory personnel provided expertise on topics related to local soils, chemical analysis, forage, and animal husbandry. A library with materials pertinent to aquaculture was located 2.5 hours away at DINAAC headquarters in Santiago. Fertilizer and limestone were readily available in David, and feed could be obtained in bulk from a supplier near Santiago. Additional personnel resources in the form of student labor were occasionally available from a branch of the University of Panama in David. These students had the option of doing their thesis work in an area of aquaculture or aquatic biology.

Affiliations

In-Country	US
Dirección Nacional de Acuicultura (DINAAC) Ministerio de Desarrollo Agropecuario (MIDA) Santiago de Veraguas Republica de Panama Instituto de Investigacion Agropecuaria de Panama (IDIAP) Gualaca, Chiriqui Republica de Panama	Department of Fisheries and Allied Aquacultures Auburn University, AL 36849 USA AquaFish CRSP Oregon State University 418 Snell Hall Corvallis, OR 97331-1643 USA

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COLOMBIA
ECUADOR
CRI–Loreto
Quito
Manta
Ambato
Guayaquil
Cuenca
Tumbes
Loja
Talara
Sullana
Piura
Paita
Chiclayo
Trujillo
Salaverry
Chimbote
Huacho
Lima
Callao
Pisco
Ica
Nazca
Iquitos
LORETO
Leticia
Benjamin Constant
Yurimaguas
Moyobamba
Tarapoto
Chachapoyas
Cajamarca
TUMBES
PIURA
AMAZONAS
LAMBAYEQUE
CAJAMARCA
LA LIBERTAD
SAN MARTIN
ANCASH
HUANUCO
PASCO
UCAYALI
Pucallpa
Cruzeiro do Sul
BRAZIL
Rio Branco
Cobija
SOUTH PACIFIC OCEAN
Tingo Maria
Huanuco
Cerro de Pasco
JUNIN
Huancayo
LIMA
Huancavelica
HUANCAVELICA
Ayacucho
AYACUCHO
APURIMAC
Abancay
CUSCO
Cusco
Machupicchu
Quillabamba
MADRE DE DIOS
Puerto Maldonado
PUNO
Juliaca
Puno
BOLIVIA
La Paz
Desaguadero
AREQUIPA
Arequipa
MOQUEGUA
Moquegua
Matarani
Ilo
TACNA
Tacna
Arica
CHILE
ICA
Peru
International boundary
Department boundary
National capital
Department capital
Railroad
Road
Callao is the capital of the Constitutional Province of Callao which has the status of a department but is too small to be shown on this map.
0 100 200 Kilometers
0 100 200 Miles
Transverse Mercator Projection, CM 71° W
Boundary representation is not necessarily authoritative
Base 800746 (B01044) 4-91

Centro Regional de Investigaciones-Loreto (CRI-Loreto)

Marcos J. De Jesús

IIAP crew seining for *Colossoma macropomum* broodstock at the CRI–Loreto research site in Peru.

Marcos J. De Jesús

Hatchery facilities at the CRI–Loreto research site. Broodstock tanks, egg incubators, and larvae-rearing circular tanks are visible.

Centro Regional de Investigaciones-Loreto (CRI-Loreto)
Instituto de Investigaciones de la Amazonia Peruana

Site Status: Active Companion Site*, 1996 to present

Location: Instituto de Investigaciones de la Amazonia Peruana (IIAP), Centro Regional de Investigaciones–Loreto (CRI–Loreto), Iquitos, Peru

Caption/Description: CRI–Loreto is located 7 to 10 km southeast of Iquitos, Peru. The region is heavily populated, and commercialization and industrialization have led to significant deforestation. Secondary succession tropical forests are predominant.

Description of Area/Region

Climate

Köppen-Trewartha classification* **Af***: *Humid tropical* group (A), *tropical wet* type (f). No dry season; at least 60 mm of rainfall in the driest month

Temperatures

Average temperature: 26.5°C
Average high temperature: 31.5°C
Average low temperature: 21.4°C

Precipitation

Annual precipitation in the Iquitos region exceeds 2,500 mm. Monthly rainfall is greatest in March (310 mm) and lowest in July and August (150 mm).

Humidity

A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 55% (September) to 63% (April).

Seasonality

Most of the rain occurs between January and June. Temperature does not vary greatly throughout the year (monthly average highs and lows vary by < 2.3°C throughout the year).

Topography

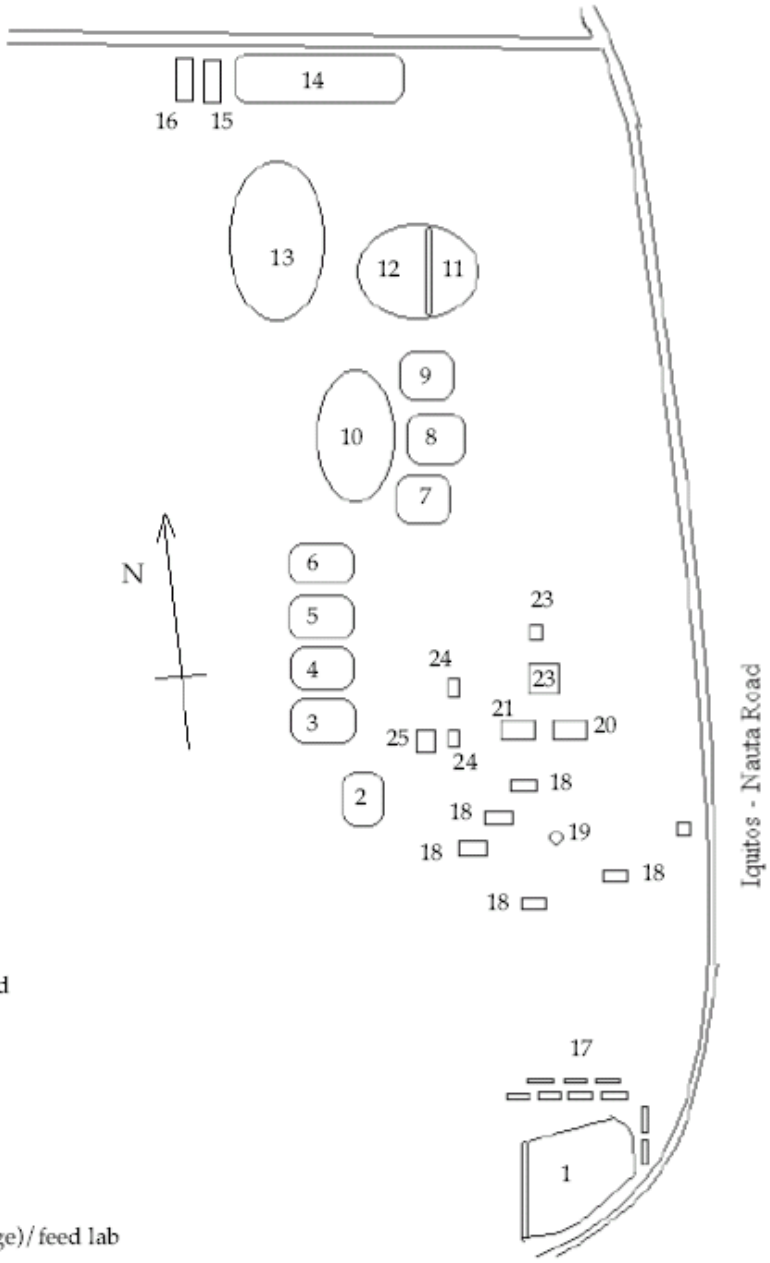
The region is sloping and full of hills. Most of the facility is declared floodplain since it divides the Itaya and Nanay tributaries to the Amazon River. It is built within a densely vegetated area on a land gradient suitable for gravity-fed ponds.

Geology and Soils

The Amazon floodplain in Peru started to develop as the river drainage began to flow east with the rise of the Andes mountain range 15 million years ago. Silt carried from the Andes formed most of the islands throughout the river course. This highly nutritive silt provided large areas for trees to colonize. With constant changes in river paths, still occurring today, silt deposits remain exposed as forested hills. Lower regions become subject to flooding when river levels rise to 10 to 11 m. The site is located in a hilly region, where some hilltops stand approximately 140 m above sea level. Soil and terrain were moderately suitable for aquaculture ponds: 2–8% slope; 75–150 cm effective soil depth; 40–80% gravel and stones; soil and texture loamy or clayey without swell-shrink, and not organic; 4–8 dS m^{-1} salinity; pH 5.5–7.2; catclays not present; and gypsum not present.

* Asterisked items are defined or described in the glossary.

Layout of CRI–Loreto



Legend

1. 3,100-m^2 pond
2. 650-m^2 pond
3. 1,347-m^2; 1,368-m^3 pond
4. 1,198-m^2; 1,532-m^3 pond
5. 1,158-m^2; 1,278-m^3 pond
6. 1,015-m^2; 900-m^3 pond
7. 600-m^2 pond
8. 600-m^2 pond
9. 600-m^2 pond
10. 2,443-m^2 pond
11. 1,408-m^2 pond
12. 2,642-m^2 pond
13. 5,320-m^2; 4,490-m^3 pond
14. 2,940-m^2 pond
15. 1,000-m^2 pond
16. 1,000-m^2 pond
17. 60-m^2 ponds (nine)
18. Offices/housing
19. Water tower (well)
20. Laboratory
21. Administration
22. Service building (storage)/feed lab
23. Supply and tool house
24. 45- and 50-m^3 cisterns
25. Fish hatchery

Description of Centro Regional de Investigaciones-Loreto (CRI-Loreto) Instituto de Investigaciones de la Amazonia Peruana

Map Coordinates	Elevation
3° 45' 10" S and 73° 11' 29" W	100 to 120 m
General	**Water Supply**
There are nine - 60 m^2 rectangular fry ponds, and sixteen grow-out and brood ponds, ranging from 600 m^2 to 5,320 m^2 each. The hatchery facility is approximately 65 m^2 and is equipped with a sand-based mechanical filter, 6–757 l concrete brood tanks, a 12-30 l jar incubating system with a 151 l fry receptacle, a laboratory table, cabinets, and counter top with sinks for prep work.	Water is gravity-fed throughout the facility from two cisterns (45 and 50 m^3) that are filled with rainwater. An artesian well-filled water tower is used as an auxiliary source. Ponds are filled during the flood season with rainwater. The precipitation increase affects the water chemistry in rivers and ponds. The ponds at CRI–Loreto exhibit a mixture between white (turbid, with silt particles, ochre-colored, transparency of 0.1–0.5 m, pH of 6.2–7.2) and black (transparency of 1.3–2.9 m, olive-brown to coffee-brown in color, pH 3.8) water properties. Minimum dissolved oxygen levels generally remained above 1.0 mg l^{-1}, and usually averaged above 4.0 mg l^{-1}. Total ammonia nitrogen remained below 1.0 mg l^{-1}. Carbon dioxide levels were less than 22 mg l^{-1}. Waters are soft (hardness 20 mg l^{-1}, alkalinity 20 mg l^{-1}, conductivity 96 mohm cm^{-2}) and slightly acidic (morning pH 6.3–7.1). Average transparency ranged from 29 to 125 cm.
Soils	
Soils are predominantly sand in a mixture with clay and a little silt.	

Support Facilities at Centro Regional de Investigaciones-Loreto
Instituto de Investigaciones de la Amazonia Peruana

During the CRSP research in Peru, IIAP, Universidad Nacional de la Amazonia Peruana (UNAP), and Southern Illinois University at Carbondale collaborated jointly to support all activities performed at the site. IIAP and UNAP have their own libraries, and the Amazon and Municipal Libraries are available in the city of Iquitos as additional sources of information. Feed ingredients for research fish and pond organic and inorganic fertilizers are provided by reliable sources in town. Diets are formulated by Dr. Fernando Alcántara and prepared at the IIAP facility. IIAP also provides maintenance, security, and other professional personnel that assist in operations. An on-site meteorological station was created to obtain weather data with consultation from Servicio Nacional de Meteorología y Hidrología (SENAMHI). The IIAP facilities are equipped with several internet-ready computer stations, telephone and fax services, and shortwave radio communication devices. Professional consultation is provided by IIAP scientists and UNAP faculty. Valuable help is volunteered by dedicated students from UNAP, who benefit from the experiences offered though CRSP research.

Affiliations

In-Country	US
Instituto de Investigaciones de la Amazonia Peruana Iquitos Peru Universidad Nacional de la Amazonia Peruana Iquitos, Peru	Fisheries Research Laboratory Southern Illinois University at Carbondale Carbondale, IL USA

Current Contacts

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Xiamen
University
Hainan
University
Chongqing
Wuhan
Hubei
Anhui
Hangzhou
Ningbo
Zhejiang
Sichuan
Guizhou
Guiyang
Zunyi
Zhangjiajie
Changsha
Hunan
Nanchang
Jiujiang
Jiangxi
Fuzhou
Wenzhou
Guilin
Guangxi
Zhuang
Autonomous
Region
Nanning
Guangdong
Guangzhou
Shenzhen
Hong Kong SAR
Zhuhai
Shantou
Quanzhou
Zhangzhou
Xiamen
Fujian
Taipei
Taichung
Tainan
Taitung
Hualien
Taiwan Strait
VIET NAM
Hanoi
Hai Phong
Beihai
Zhanjiang
Haikou
Hainan
Sanya
Wenchang
Gulf of Tonkin
South China Sea
PHILIPINAS
PHILIPPINES
johomaps 2006

Hainan University

Site Status: Active Companion Site*, China, since 2005

Location: No. 58, Renmin Road, Haikou City, Hainan Province, China

Caption/Description: Hainan University is located in Hainan Province at the southernmost tip of China. It is the second largest island of China with land area of 38,000 square kilometers. It has 1,528 km of coastline. The population is approximately 78 million. The island has three large rivers, the largest river is Nandu River, which flows from middle island to the northern sea; the second largest is Changhua River, which flows from the mountainous area of middle island to the west sea; and the third largest is Wanquan River, which flows to the sea from the middle island to the east.

Description of Area/Region

Climate

Hainan Island is situated at the tropics and the subtropics. It has a tropical marine monsoon climate. It enjoys abundant sunlight, with the annual amount of solar radiation totaling 110-120 kilocalories per square cm and annual duration of sunshine averaging 1,700-2,000 hours.

Temperatures

Annual averages for the area: 23–26℃
Range of monthly averages: 17– 0℃
Absolute minimum temps: 7–20℃
Absolute maximum temps: 37–39℃

Precipitation

Rainfall range is 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, 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 square kilometers. It is located between 108° 37’ and 111° 03’ east longitude, and between 18° 10’ and 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 of different parts varies greatly. The highest peak of Wutzushan Mountain, which is located in the middle of island, is 1,811 m above sea level. The coastal area is only 0-20 m above sea level.

Geology and Soils

The coastal area is made up of sand and silt, while the interior area is red loam. The rivers’ estuarine areas were formed by the continual deposition of clay, silt, and sand.

Hainan Province

Hainan University in Haikou City

Description of Hainan University

Map Coordinates	Elevation
20° 05' N and 110° 10' E	5-6 m
General	**Water Supply**
Hainan University, financially supported by both Ministry of Education and Hainan Provincial Government, is the only comprehensive and key university in Hainan Province. It is located in the tropical seaside city of Haikou. Hainan University, a school of higher education, young and vigorous, is quickly developing and expanding day by day as society forges ahead towards the future. It covers an area of 202 ha and borders the sea in the north in a setting that is characterized by picturesque scenery and an amiable climate. Hainan University has a relatively large scope and strength with balanced multi-level system of graduate, undergraduate, higher vocational education, adult education and foreign students education. The university has 14 colleges including: Science and Engineering, Information Science and Technology, and Oceanography. Hainan University currently offers 44 graduate programs including MBA, MPA and JM program, 34 undergraduate programs and 10 higher vocational education programs. The school has a modern library and a well-equipped information center with internet access. The school has more than 1,300 faculty and more than 20,000 on-campus students. In recruiting faculty members, preference is given to those holding high level academic positions. Full-time teachers that hold Master's degree or higher comprise 62.1% of the 661 teachers; 104 hold Ph.D. degrees. 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, Singapore, etc. Thousands of international students from Asia, Europe, America and Oceania have studied at the university.	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 ppt. Ammonia-N was 0.02-0.05 mg l^{-1}, and nitrate-nitrite-N was 0.005-0.01 mg l^{-1}. Reactive phosphorus was measured at 0.05-0.20 mg l^{-1}.
Soils	
HNU pond complex has heavy clay soil like the Nandu River Basin. Heavy clay soils are typical in the surface layer with an organic matter layer at 30-80 cm depth, followed by an acid sulfate soil layer*.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Hainan University

HNU has closely followed the tracks of international scientific development, and unfolded in a big way the spread of aquaculture science and technology. HNU's scientific and technological network comprises three principal systems: (1) basic theoretical research system of modern biology which centers around Molecular Biology, Cell Biology, Development Biology and Environment 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.

HNU has a close working relationship with national universities, research institutes, related ministries, and department and local offices for enhancing opportunities, collaboration, knowledge, and facility sharing. It has also built, over the years, a broad network of international cooperation. 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 in doing research. HNU is always striving to achieve high quality in all of its academic programs.

Affiliations

In-Country	US
Hainan University Haikou, Hainan province P.R. China.	School of Natural Resources and Environment University of Michigan 128 Dana Drive Ann Arbor, MI

Current Contacts

In-Country	US
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Xiamen University

Site Status: Active Companion Site*, China, since 2005

Location: No. 422, South Siming Street, Siming District, Xiamen City, Fujian Province, China

Caption/Description: Xiamen University is situated in southeast China on the southeast coast of Fujian Province at the estuary of Jiulong River. It lies at 118° 04' 04" east longitude and 24° 26' 46" north latitude. At the back of Xiamen lies the Zhangzhou-Quanzhou Plain, and facing Xiamen across the Taiwan Strait are Taiwan Island and the Penghu Islands.

Description of Area/Region

Climate

Xiamen Harbor is a natural haven with deep water that is ice-free all the year round. Islands scattered along the waters beyond the harbor form a natural barrier to protect the harbor from turbulent waves, whereas the mountains surrounding the harbor provide an excellent windbreak. Average annual wind velocity is 3.2 m/sec. Because of such favorable conditions, Xiamen has always been an important seaport for foreign trade on the southeast coast of China ever since ancient times.

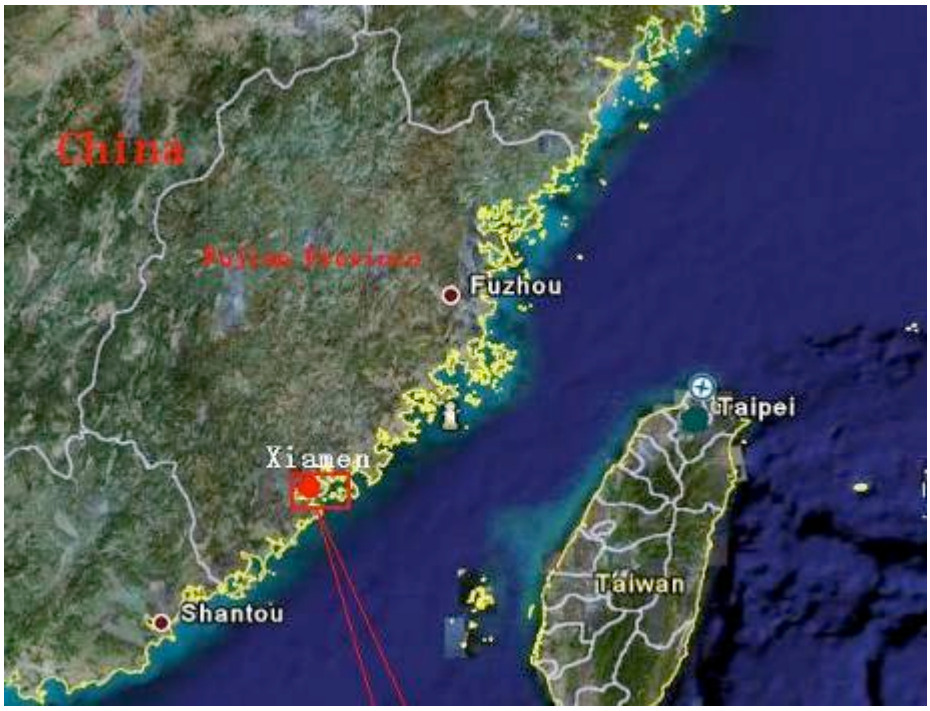
Temperatures	Precipitation
Annual average for the area: 20.6°C Range of monthly averages: 4–18°C Absolute minimum temps: 5– 8°C Absolute maximum temps: 35–38°C	1,315 mm annually. Low rainfall months are November to February, and high rainfall months are May to August.
Humidity	**Seasonality**
A warm and humid atmosphere prevails throughout the year with an annual mean relative humidity of 78-80%.	Xiamen has a subtropical climate, which is generally temperate with abundant rainwater. There is no intense heat in summer and no extreme cold in winter. Xiamen is hit by typhoons three or four times annually on average. Typhoon season mainly occurs from July to September.

Topography

The topography of Xiamen is characterized by a gradual descent from the south to the north, with the northwestern part being relatively flat and the southern part mountainous and hilly. Yunding Rock, which stands 339.6 meters above sea level, is the highest peak in the south. Xiamen Harbor has a coastline that measures 234 kilometers. In most parts of the harbour, the water is < 12 meters deep. The islands scattered along the waters beyond the harbor form a natural barrier to protect the harbor from turbulent waves, whereas the mountains surrounding the harbor provide an excellent windbreak.

Geology and Soils

The coastal area is made up of sand and silt, while the interior area is red loam. The rivers' estuarine areas were formed by the continual deposition of clay, silt, and sand.



Fujian Province

Xiamen Island

Xiamen University

Description of Xiamen University

Map Coordinates	Elevation
118° 04' 04" E and 24° 26' 46" N	18 m (airport)
General	**Water Supply**
Xiamen University was founded in 1921 by Mr. Tan Kah-Kee, the well-known patriotic overseas Chinese leader honored by Chairman Mao Zedong as the "Standard of the Overseas Chinese and Glory of the Nation". It was the first university in the modern history of education in China founded by an overseas Chinese. The University is one of the key universities under the State "211" and "985" projects. The "211 Project" is a national project concerning 100 universities given the highest priority for development during the 21st century, and the "985 Project" is the title of a construction project for the establishment of world-class universities. The University has a total campus area of over 538 ha. The main campus on Xiamen Island has an area of 167 ha; the Zhangzhou Campus is 171 ha in area; and the Jimei Campus is 200 ha. With green hills behind and the sea close by, the three campuses are set amidst delightful scenery and are generally recognized as the most beautiful campuses in China. **Facts and statistics** Faculty and staff: More than 4,600 Doctoral supervisors: 348 Chinese students: Undergraduates, 17,847; Master's candidates, 8,785; and Doctoral candidates 1,501 State Key Disciplines: Thirteen including Political Economy, Public Finance, Finance, Statistics, Accounting, Higher Education, History of Special Field (Economic History), International Law, Physical Chemistry, Analytical Chemistry, Zoology, Marine Biology, Marine Chemistry	Ocean
Soils	
The rivers, estuarine areas were formed by the continual deposition of clay, silt, and sand.	

Support Facilities at Xiamen University

Xiamen University College of Oceanography and Environmental Science enhances the spread of aquaculture science and technology.

Xiamen University has a close working relationship with national universities, research institutes related ministries and department and local offices for enhancing opportunities, collaboration, knowledge, and facility sharing. t has also built, over the years, a broad network of international cooperation. Xiamen has established linkages with many major international organizations as well as training and research institutes worldwide.

Affiliations

In-Country	US
College of Oceanography and Environmental Science Xiamen University Xiamen, Fujian 361005 P.R. China	School of Natural Resources and Environment University of Michigan 128 Dana Drive Ann Arbor, MI

Current Contacts

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Myanmar
Thailand
Laos
Viet Nam
Cambodia
South China Sea
Philippines
Ujong Batee Research Station and Ladong Fisheries College
Banda Aceh
Malaysia
Pacific Ocean
Indonesia
Jakarta
Dili
E. Timor
Indiam Ocean
Australia

Ujong Batee Research Station and Ladong Fisheries College

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
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
Caption/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

Description of Area/Region

Climate

Köppen-Trewartha classification* **Af***: *Tropical rainforest*

Temperatures	Precipitation
Range: 25-30°C.	The average annual rainfall ranges from 2,000 mm to 3,000 mm.
Humidity	**Seasonality**
The humidity varies from 65 to 75%.	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 and 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.

* Asterisked items are defined or described in the glossary.

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	**Water Supply**
Ujong Batee Fisheries and Aquaculture Center had two technology and training facilities approx. 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. Ladong Fisheries 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. Ujong Batee and the Ladong Fisheries College were the sites of workshops held to train both trainers (NGO's and fisheries staff) and aquaculture producers in sustainable coastal aquaculture techniques. The coastal areas affected by the tsunami previously had been devoted primarily to mono-culture of shrimp in small ponds (tambaks). Even prior to the tsunami, the farms had been impacted by disease and water quality problems as well as low prices for shrimp. Recommendations were to consider polyculture of various other species with the shrimp, seaweed culture, and restoration of mangroves as biofilters to improve water quality and to protect the tambaks from other forms of environmental damage. The on-site workshops were followed by other workshops in more remote villages and visits to tambak restoration projects supported by various NGOs.	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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CHINA
INDIA
GREAT HIMALAYA
Indo-Gangetic Plain
Tarai
Kali
Karnali
Brahmaputra
Mahendranagar
Dhangarhi
Sarda
Nepalganj
Pokhara
Kali
Trisuli
Mount Everest
IAAS
KATHMANDU
Bhaktapur
Patan
Bharatpur
Narayani
Butwal
Bhairahawa
Hetauda
Birganj
Janakpur
Dharan Bazar
Biratnagar
Ghaghara
Gandak
BANGL.
0 50 100 km
0 50 100 mi

Institute of Agriculture and Animal Science (IAAS)

Site Status: Active Companion Site*, South Asia, since 2001
Location: Rampur, Chitwan, Nepal
Caption/Description: IAAS is located near the town of Narayangardh in the southern portion of the Nepal's central plain, and is located approx. 160 km south-west of Kathmandu.

Description of Area/Region

Climate

Humid sub-tropical; wet-and-dry type; distinct dry and rainy seasons

Temperatures	Precipitation
Annual averages for the area: 24.7 °C Range of monthly averages: 18.0–30.6 °C Absolute minimum temps: 7.8 °C Absolute maximum temps: 37.9 °C	Range of 0.6–626.5 mm per month and an annual average of 2,323 mm. Low rainfall month is January with an average of 1.5 day of precipitation, and high rainfall month is July with an average of 29 days of precipitation.
Humidity	**Seasonality**
A warm and humid atmosphere prevails throughout the year with an annual mean relative humidity of 85%.	Nepal has clearly defined wet and dry, and hot and cool seasons with wide temperature variation throughout the year. The rainy season is from June to October and the cool, dry season is from November to February. The coolest month is January. The hot dry season is from March to May, and the hottest month is generally April.

Topography

Chitwan is a valley surrounded by silwalik range in the north, and churiya range in the east, west and south.

Geology and Soils

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

Description of Institute of Agriculture and Animal Science (IAAS)

Map Coordinates	**Elevation**
27° 38' 14.1" N and 84° 21' 25.2" E	257 m
General	**Water Supply**
The IAAS Rampur campus occupies an area of approx. 210 ha near the town of Narayangardh, 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 m^2 in size, 18 concrete tanks of 24 m^2 in total 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.	Supply of water for the IAAS pond complex comes from underground water with pH of 8.3 and total alkalinity of about 130 mg l^{-1} as $CaCO_3$.
Soils	
Sandy loam soil	

Support Facilities at Institute of Agriculture and Animal Science (IAAS)

IAAS has close relationships with Fisheries Research Division, Nepal Agricultural Research Council (NARC) and Directorate of Fisheries, Department of Agriculture.

Affiliations

In-Country	US
Tribhuvan University Institute of Agriculture and Animal Science (IAAS) Department of Aquaculture Rampur Campus Chitwan, Nepal	School of Natural Resources and Environment University of Michigan 128 Dana Drive Ann Arbor, MI 48109-1041

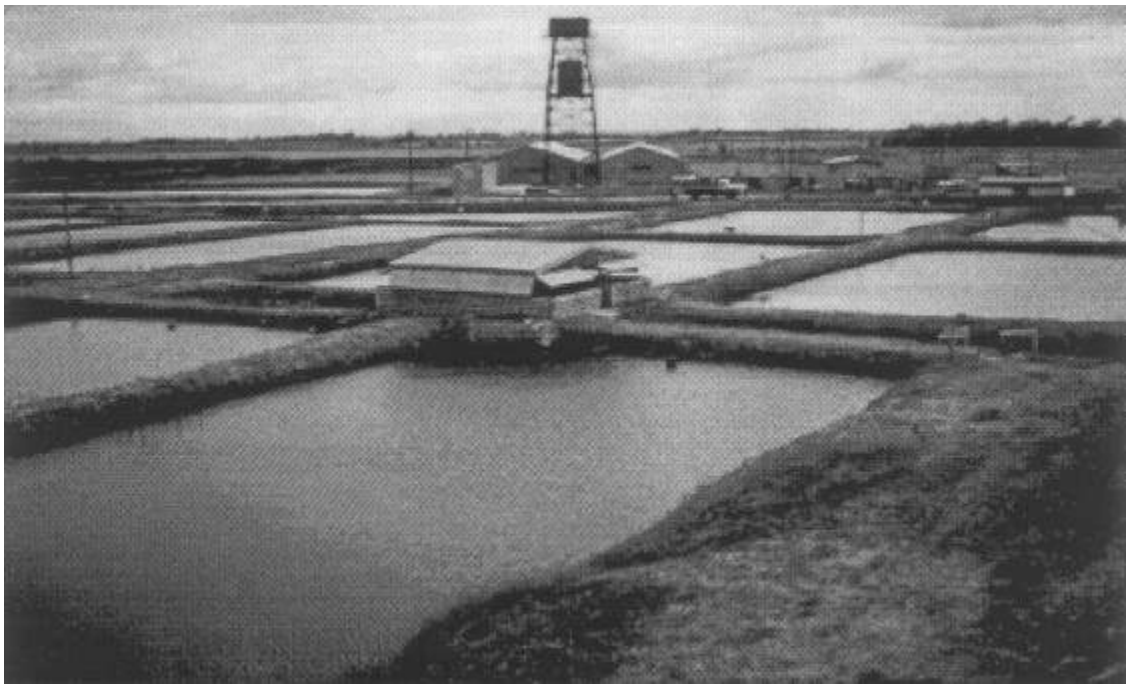
Current Contacts

In-Country	US
Madhav K. Shrestha, Ph.D. Department of Aquaculture Institute of Agriculture and Animal Science (IAAS) Tribhuvan University Rampur Campus Chitwan, Nepal Tel: 977-56-591141; 977-9851075404 Fax: 977-56-591021 Email: madhav_shrestha2003@yahoo.com	James S. Diana, Ph.D. School of Natural Resources and Environment University of Michigan 128 Dana Drive Ann Arbor, MI 48109-1041 Tel: 734-763-5834 Fax: 734-936-2195 Email: jimd@umich.edu

Freshwater Aquaculture Center (FAC)

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 to 1998; Prime Site* from 1998 to present

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

Caption/Description: FAC is located at the northeasternmost 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 approx. 150 km north of Manila and lies in the heart of the central valley of Luzon.

Description of Area/Region

Climate

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

Temperatures	Precipitation
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.	Average annual rainfall in the province is about 2,250 mm. Most rainfall occurs between May and October.
Humidity	**Seasonality**
Mean annual relative humidity ranges from 74 to 78%. It is hot and dusty from March to May.	There are two distinct seasons in this part of the Philippines. The dry season begins in December and lasts through April or May, and the rainy season begins in June and continues through November.

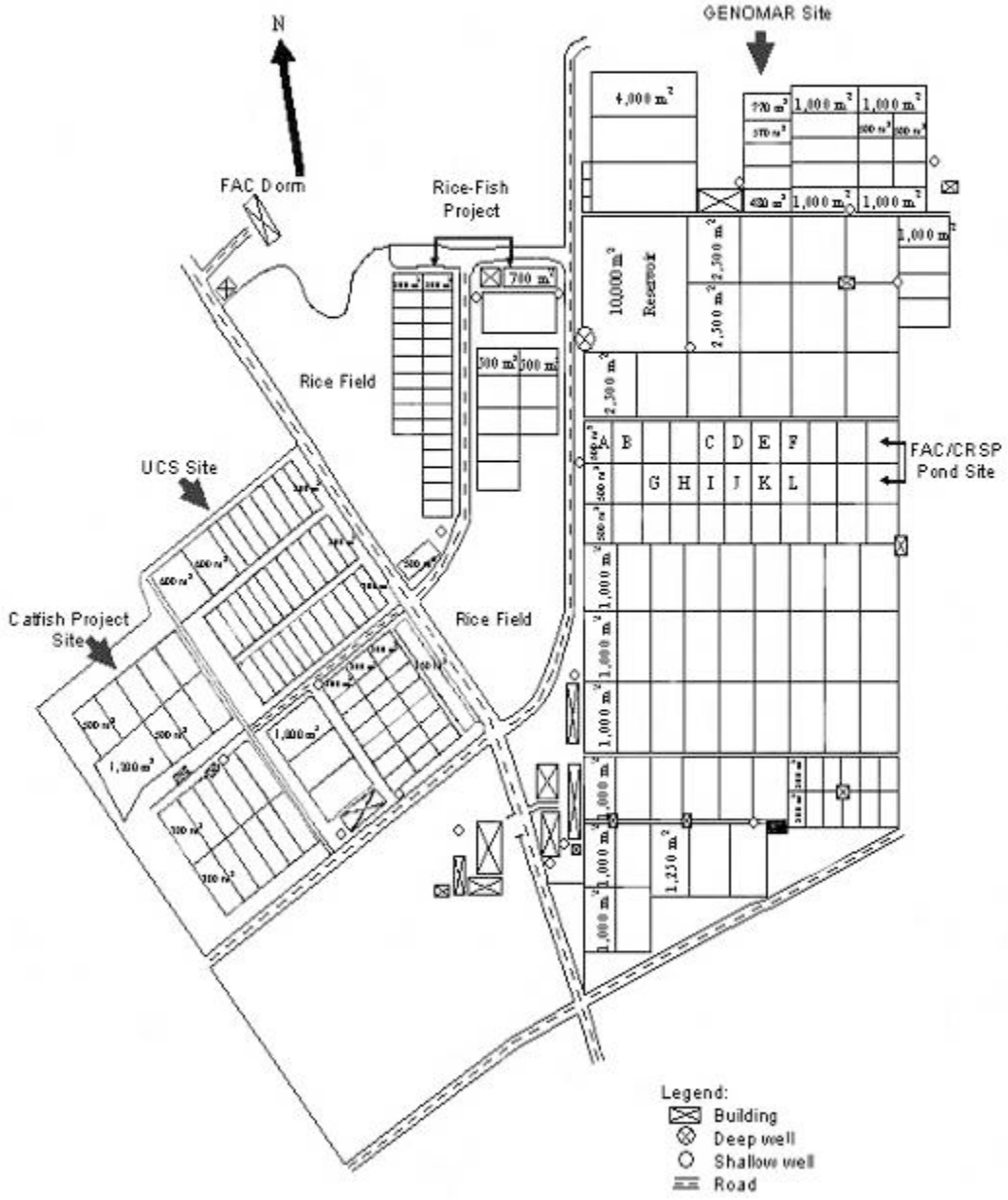
Topography

The central valley is a vast, relatively flat lowland that stretches approx. 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 and Soils

The Philippines archipelago is part of a major western Pacific seismic fault system. The entire region is has 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 the Freshwater Aquaculture Center



Freshwater Aquaculture Center (FAC)
Central Luzon State University

Map Coordinates	Elevation
15° 43' N and 120° 54' E	30 m
General	**Water Supply**
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 research 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 a 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 a 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 maintains about 100 species of native, introduced, and ornamental freshwater fish species of the Philippines.	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 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 CEC* 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.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Freshwater Aquaculture Center (FAC)
Central Luzon State University

The Center has approx. 24 personal computers. 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 use by students and researchers. This facility was established with funds from the CRSP and has become an important resource facility for students and researchers. Other support facilities include lecture rooms, library, conference room with multi-media equipment, and experimental facilities like ponds, tanks, net enclosures and aquaria.

Affiliations

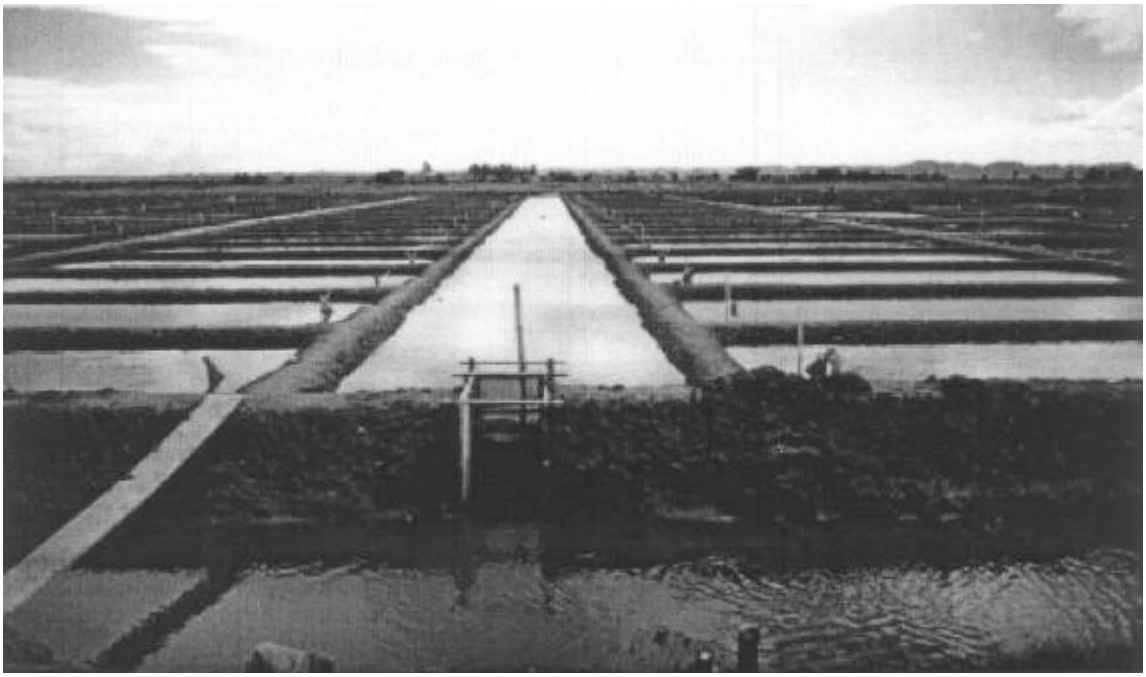
In-Country	US
Freshwater Aquaculture Center Central Luzon State University Science City of Muñoz, Nueva Ecija 3120 Philippines	US Department of Commerce Milford, Connecticut 06460 USA

Current Contacts

In-Country	US
Dr. Remedios B. Bolivar Freshwater Aquaculture Center Central Luzon State University (CLSU) Science City of Muñoz, Nueva Ecija 3120 Philippines Tel: 63-044-456-5279 or -0681 Fax: 63-044-456-0680 or 0681 Email: rbolivar@mozcom.com	Dr. Christopher L. Brown Chief, Aquaculture and Enhancement Division US Department of Commerce Milford, Connecticut 06460 USA Tel: 203-882-6540 or -6515 Fax: 203-882-6517 or -6570 Email: Christopher.L.Brown@noaa.gov

Brackishwater Aquaculture Center (BAC)
Leganes, Iloilo

Each pond at the Brackishwater Aquaculture Center in Iloilo, Philippines, was served by two water canals: one for filling by tidal flow and one for draining.



There were over 215 ponds, covering more than 18 ha, at the Brackishwater Aquaculture Center. Twenty-one 1,000 m^2 ponds were assigned to the CRSP research project.

Brackishwater Aquaculture Center (BAC)
Leganes, Iloilo

Site Status: Prime Site* 1983 to 1987

Location: Leganes, Iloilo, Philippines

Caption/Description: BAC is located 650 km south of Manila on the island of Panay in the island group known as the Visayas in the central Philippines. It is a research arm of the Institute of Aquaculture, College of Fisheries and Ocean Sciences (CFOS), University of The Philippines in the Visayas (UPV), Miag-ao, Iloilo. It is located approx. 60 km from the CFOS.

Description of Area/Region

Climate

Köppen-Trewartha classification* **Am***: *Humid tropical* group (A), *tropical rainforest* type (m). Short dry season.

Temperatures	Precipitation
Temperatures throughout the Philippines average 26°C during the dry season (December to May) with the lowest average monthly temperature (25.5°C) observed in January. The hottest average monthly temperatures (May) are around 28°C. The average annual temperature in Leganes is 27°C. Average pond water temperatures at the BAC are between 24.9 and 33.5°C.	Average annual rainfall at the BAC site is 2,100 mm.
Humidity	**Seasonality**
Humidity ranges from 71% in the dry season (March) to 85% in the rainy season (September).	Climate is characterized by a long rainy and a short dry season. Heavy rains are experienced between May and October; between July and October these may include typhoons. During the dry season from December through February, the lowland areas are generally hot and dusty although temperatures rarely exceed 37°C.

Topography

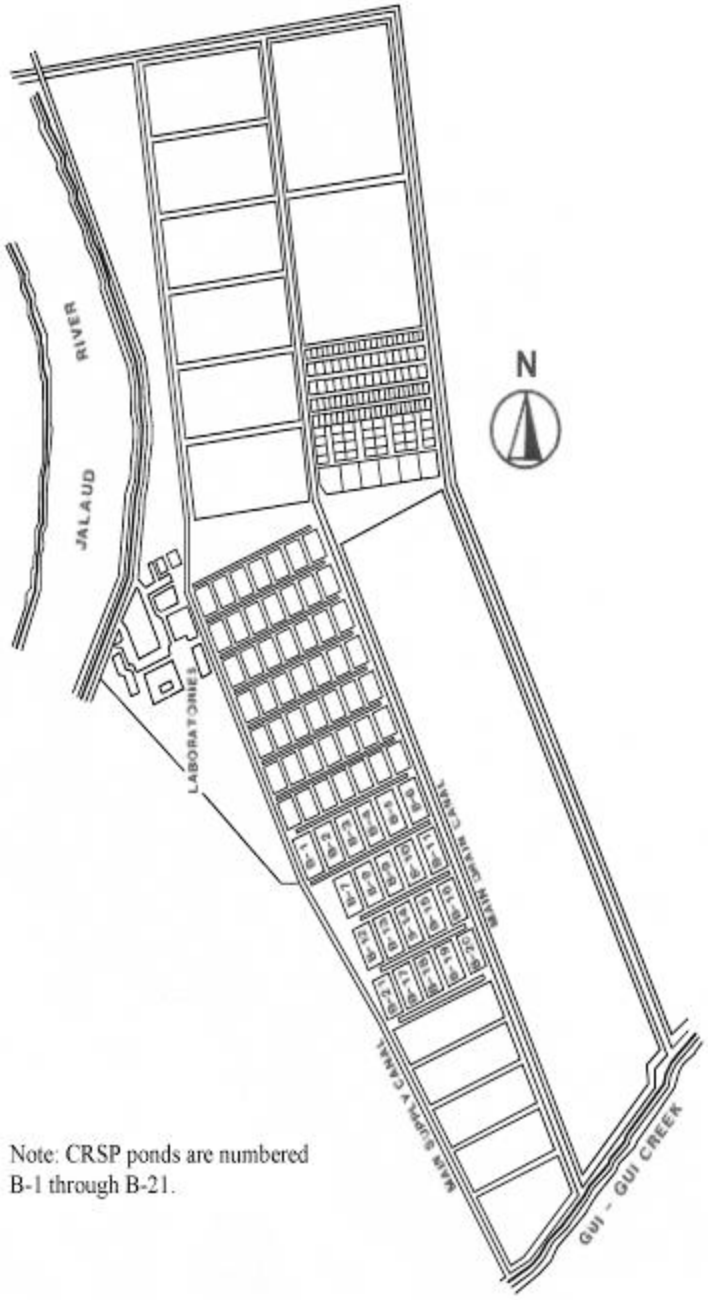
The BAC is located in a triangle of coastal flatland on the southern side of the island of Panay. The town of Leganes lies between the Jaro and Jalaud rivers, which drain the higher-elevation areas to the north and northeast and empty into Iloilo Strait east of Iloilo City. The Iloilo Strait separates the island of Iloilo from nearby smaller Guimaras Island and the larger Negros Island to the southeast.

Geology and Soils

The Philippines archipelago is part of a major western Pacific seismic fault system. The entire region has 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.

* Asterisked items are defined or described in the glossary.

Layout of the Brackishwater Aquaculture Center



Note: CRSP ponds are numbered
B-1 through B-21.

Description of Brackishwater Aquaculture Center (BAC)
Leganes, Iloilo

Map Coordinates	Elevation
10° 45' N and 122° 30' E	4 m

General	Water Supply
The BAC is one of three brackishwater sites at which CRSP has collaborated. It is a research arm under the Institute of Aquaculture, CFOS, UPV. Pond facilities included 215 ponds with a water surface of 18 ha. The 21 ponds assigned to the CRSP research program were 1,000 m^2 each. Site facilities included a comprehensive administrative building with offices, classrooms, conference room, library, radio room, and chemistry laboratory; and a wet laboratory with aquaria and supplied with fresh and seawater and compressed air. Other facilities included a feed processing and storage building, a nursery and hatchery building, a soil chemistry laboratory, a utility building, a dormitory and cafeteria for students, and staff housing for security and pond management personnel. There were more than 60 permanent employees for research and administration, and 21 faculty members from the CFOS who participated actively in research and training at the BAC.	Each of the 215 ponds was served by two water canals, which allowed independent filling and draining by tidal flow from Gui-gui Creek, Leganes. Water supplied to the ponds had a pH ranging from 7.05 to 9.72, alkalinity ranging from 51 to 194 mg l^{-1} as $CaCO_3$ and salinity ranging from 6 to 37 ppt.

Soils
The BAC was constructed on acid-sulfate soils* typical of coastal areas. Because the dikes were very large relative to pond size, acidic runoff was a major problem during the early days of the station. After several years of use and treatment, the soils at BAC had pH values ranging from 5.25 to 7.50 (dry) and levels of organic matter ranging from 1.34 to 4.52%. Aluminum levels were all low (< 0.100 ppm) but iron concentrations varied widely among ponds, ranging from a low of 36.5 ppm to a high of 2,469 ppm.

* Asterisked items are defined or described in the glossary.

Support Facilities at Brackishwater Aquaculture Center (BAC) Leganes, Iloilo

Those conducting research at the BAC included BAC staff, academic staff, and graduate students from UPV. Approx. 10 to 15 graduate students conducted thesis research at the BAC each year. Numerous commercial aquaculture operations were located in the vicinity of the BAC. Feed, and organic and inorganic fertilizers were readily available. Shrimp and prawn post-larvae could be obtained from both wild and hatchery sources. A variety of finfish fry, including tilapia, milkfish, and sea bass were also available on a seasonal basis.

Affiliations

In-Country	US
College of Fisheries and Ocean Sciences University of the Philippines in the Visayas Miag-ao, Iloilo 5023 Philippines	University of Hawaii at Manoa Hawaii Institute of Marine Biology Kaneohe, HI USA

Current Contacts

In-Country	US
Carlos C. Baylon, Ph.D. Dean College of Fisheries and Ocean Sciences (CFOS) University of the Philippines in the Visayas Miag-ao, Iloilo 5023 Philippines Tel: 63 33 3158143 Fax: 63 33 3158143	Dr. Hillary Egna AquaFish CRSP Oregon State University 418 Snell Hall Corvallis, OR 97331-1643 USA Tel: 541-737-6415 Fax: 541-737-6408 Email: egna@onid.orst.edu

Negros Occidental

Tilapia cages installed in shrimp ponds with paddlewheel aerators in Negros Occidental, Philippines.

Application of lime as a step in pond preparation for shrimp farming in Negros Occidental, Philippines.

Negros Occidental

Site Status: Off-station sites 2006 to 2007

Location: San Carlos City, Negros Occidental, Philippines

Caption/Description: Negros Occidental is a province of the Philippines located in the Western Visayas region. It occupies the western portion of Negros Island. It is bounded to the north by the Visayan Sea; to the east by the province of Negros Oriental and partly by Tañon Strait; to the west by the Strait of Guimaras; and to the south by Sulu Sea. Its capital is Bacolod City located on the northwestern coast of the province of Negros Occidental. Bacolod City is bounded on the northwest by the town of Talisay; on the east by the City of Silay; on the east and southwest by the town of Murcia; on the southwest by the City of Bago; and in the west by the Guimaras Strait. Bacolod City is the largest city of the province of Negros Occidental. It is 20 hours from Manila by boat and 50 minutes by plane. The city is nicknamed the "City of Smiles". Negros Occidental is subdivided into 19 municipalities and 13 cities. Negros Occidental has the most chartered cities among all the provinces in the Philippines, though many of the cities merely resemble medium-sized towns. San Carlos City is one of the cities in the province.

Description of Area/Region

Climate

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

Temperatures	Precipitation
The average annual temperature is 26°C.	Most of the rainfall occurs from May to January of the following year with heavy rains occurring during the months of August and September.
Humidity	**Seasonality**
Humidity ranges from 71% in the dry season (March) to 85% in the rainy season (September).	Negros Occidental has two pronounced seasons: Wet (June - November) and dry (December - May).

Topography

The City is located on a level area, slightly sloping as it extends toward the sea with average slopes of 0.9% for the city proper, and 3% to 5% for the suburbs. The altitude is 10 m above sea level.

Geology and Soils

The different varieties of soil fall into several broad types and qualities. The soil in the level areas of the City is suitable for production of primary crops such as rice, sugarcane, coconuts, and vegetables. Areas adjacent to the shoreline are suited for aquamarine culture.

* Asterisked items are defined or described in the glossary.

Description of Negros Occidental

Map Coordinates	Elevation
10° 40' N and 122° 57' E	10 m
General	**Water Supply**
Negros Occidental, popularly known as "Sugarlandia," has a total land area of nearly 8,000 square kilometers and a coastline stretching 800 kilometers. It has a population of about 2.6 million. It is the fourth most populous province in the Philippines with 54% of its people living in rural areas. Agricultural areas comprise 98% of the alienable and disposable lands including built-up space. The remaining 2% are fishponds. Fishing is likewise an industry where the province has remained focused. After all, 9 of its cities and 16 of its municipalities are located along the coast and a great portion of the population depends on fishing for their livelihood. Negros was once a main producer of shrimp in the country. Most of the land is converted to semi-intensive and intensive shrimp culture ponds. Shrimp are primarily exported thus contributing largely to the country's economy. Research work in the Central Philippines, particularly in the island of Negros Occidental, involves the investigation of the use of green water technology by incorporating tilapia in tilapia-shrimp polyculture to improve the water quality of the culture water.	Ample water supply is assured for household, commercial, industrial and agricultural uses by 73,000 ha of proclaimed and protected major watersheds, regular rainfall, and six major river systems.
Soils	
Different varieties of soil covering the entire area fall into several broad types and qualities like Bago Fine Sandy Loam, Bago Sandy Clay Loam, Guimbala-on Fine Sandy Loam, Guimbala-on Loam, Hydrosol, Rough Mountainous Land, Silay Loam, Silay Sandy Loam, and Tupi Fine Sandy Loam.	

Support Facilities at Negros Occidental

The Negros Prawn Producers Marketing Cooperative, Inc. (NPPMCI) provides technical and financial support to shrimp farmers in Negros province from shrimp fry sourcing to assessment of fry stocks before final bookings are made by the shrimp growers. It also serves as a marketing arm. NPPMCI has continued to modernize its analytical and diagnostic laboratory facilities, and has adapted a fry criteria coupled with bacterial analysis to assure shrimp growers of the quality of fry sold from shrimp hatchery operators.

Affiliations

In-Country	US
Freshwater Aquaculture Center Central Luzon State University Science City of Muñoz, Nueva Ecija 3120 Philippines	University of Arizona Environmental Research Lab 2601 E. Airport Dr. Tucson, Arizona 85706 USA

Current Contacts

In-Country	US
Dr. Remedios B. Bolivar Freshwater Aquaculture Center Central Luzon State University (CLSU) Science City of Muñoz, Nueva Ecija 3120 Philippines Tel: 63-044-456-5279 or -0681 Fax: 63-044-456-0680 or -0681 Email: rbolivar@mozcom.com	Dr. Kevin Fitzsimmons Professor, Research Scientist, Extension Specialist Environmental Research Lab Department of Soil, Water and Environmental Science University of Arizona 2601 E. Airport Dr. Tucson, Arizona 85706 USA Tel: 520-626-3324 Fax: 520-573-0852 E-mail: kevfitz@ag.arizona.edu


AIT
Nong Sua
Ayutthaya
BURMA
LAOS
VIETNAM
CAMBODIA
Andaman Sea
Gulf of Thailand
Strait of Malacca
South China Sea
MERGUI ARCHIPELAGO
Ko Chang
Ko Kut
Ko Phangan
Ko Samui
Ko Phuket
Ko Tarutao
Pulau Langkawi
Bangkok
Phnom Penh
Ho Chi Minh City
MALAYSIA
Thailand
International boundary
National capital
Railroad
Road
0 50 100 150 Kilometers
0 50 100 150 Miles

Asian Institute of Technology (AIT)

Earthen ponds used for CRSP research at the Asian Institute of Technology (AIT) outside of Bangkok, Thailand.

Aquaculture research at the Asian Institute of Technology has also included work in the area of integrated aquaculture–agriculture systems, using pigs, buffaloes, ducks, vegetables, and goats in various combinations.

Asian Institute of Technology (AIT)

Site Status: Active Prime Site*, 1987 to present
Location: Km. 42, Klong Luang, Pathum Thani Province, Thailand
Caption/Description: AIT is located near the town of Rangsit in the southern portion of Thailand's central plain, and is approx. 40 km north of Bangkok.

Description of Area/Region

Climate

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

Temperatures**	Precipitation**
Annual averages for the area: 26.7–28.9°C Range of monthly averages: 25.7–30.1°C Absolute minimum temps: 5.0–12.2°C Absolute maximum temps: 39.4–43.9°C	5.1–269.2 mm per month and 1,092–1,600 mm annually. Lowest rainfall month is January with an average of 1 day of precipitation, and highest month is September with an average of 21 days of precipitation.
Humidity**	**Seasonality**
A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 64–76%.	Thailand has clearly defined wet and dry seasons with little temperature variation throughout the year. The rainy season is from May 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

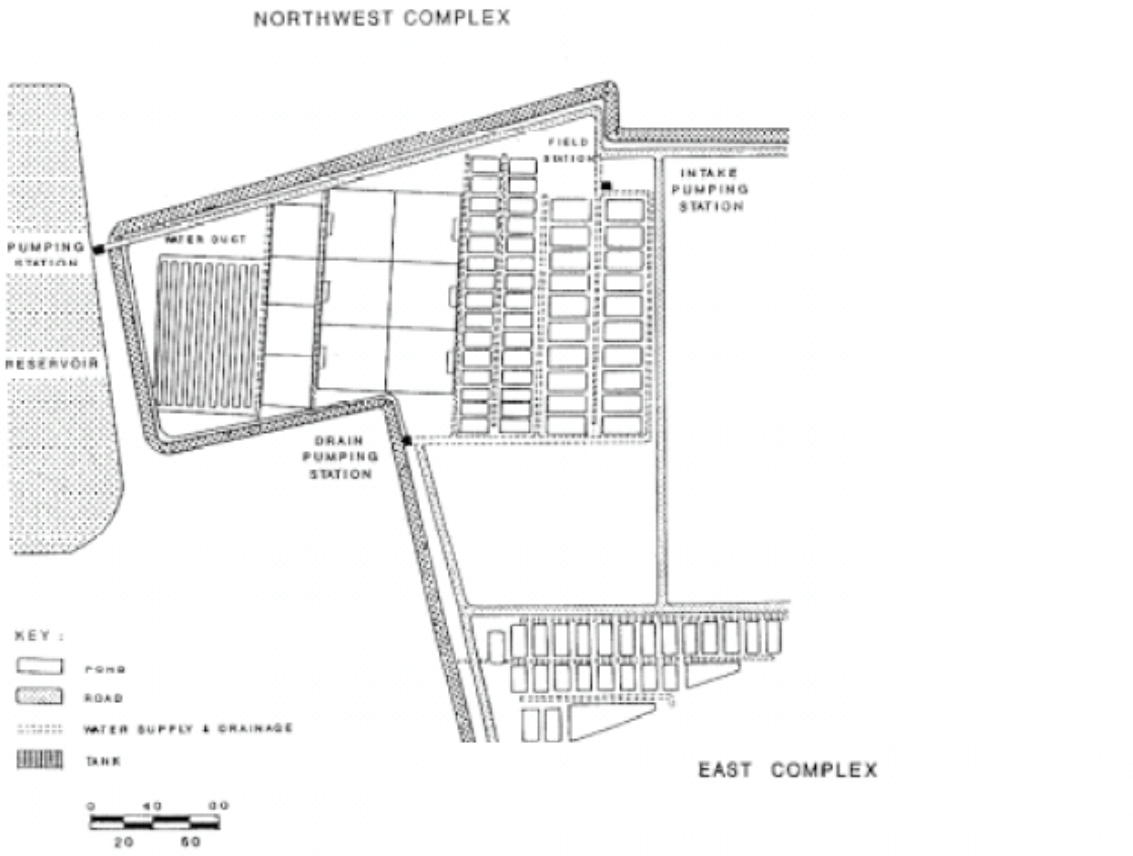
The area is part of Thailand's vast, nearly level central alluvial plain (the Chao Phraya Plain or Menam Plain). A slope of 1:10,000 results in an elevation of just 4 m at Ayutthaya, which is approx. 60 km inland from Bangkok, and 23 m at Aknampho, which is 241 km from the Gulf of Thailand. Many canals crisscross the region, connecting the Chao Phraya and other rivers, and they provide communication links and irrigation. In the dry season, tidal influences are clearly seen up to 80 km inland. During the rainy season, flooding makes the area appear as a single vast lake.

Geology and Soils

The central plain is in the basin of the Chao Phraya river and its tributaries. It was formed by the continual deposition of clays, silts, and sands by these rivers during annual flood periods, resulting in depths of alluvial material exceeding 100 m above bedrock in much of the area. The load of alluvial material carried by the Chao Phraya River has been estimated to extend the delta into the Gulf of Thailand by as much as 7 m annually. The plain is flanked in the north by the Uttaradit Mountains, in the west by the Bilauktaung Range (which forms the boundary with Burma), in the south by the Gulf of Thailand, and by the Khorat Plateau in the east. "Bangkok Dark Heavy Clay" soils are typical in the area around Rangsit and AIT. These soils have a developed profile to a depth of about 1.8 m, have nearly black surface layers, are typically low in organic matter, and are often saturated with groundwater.

* Asterisked items are defined or described in the glossary.
** Data are for Rangsit, from 1927 to 1955.

Layout of AIT



Description of Asian Institute of Technology (AIT)

Map Coordinates	Elevation
14°20' N and 100°35' E	5 m
General	**Water Supply**
The AIT campus occupies an area of approximately 160 ha near the town of Rangsit, north of Bangkok. AITs research pond complex is one of several aquacultural facilities operated by its *Agricultural and Food Engineering Division*. The complex includes about 150 earthen ponds in sizes ranging from 200 to 2,000 m^2, a 5 ha reservoir, 120 concrete tanks, and an area for growing terrestrial crops that may be of interest as fish feed components. An adjacent area is used for rearing livestock (ducks and goats) that can be used in integrated aquaculture/agriculture research. Other facilities include a 500 m^2 laboratory complex that houses instruments for measurement of the biological, physical, and chemical parameters of importance in aquaculture, a covered fish feed preparation area, a fish harvest processing area, and a covered hatchery area. The hatchery facility includes 100 indoor rearing tanks, and a water conditioning and recirculating system.	Supply water for the AIT pond complex comes from a rain-fed canal and reservoir. In 1995, the pH of this source was 7.3 and the total alkalinity was approx. 84 mg l^{-1}. Ammonia-N was 6.16 mg l^{-1}, and nitrate-nitrite was 0.01 mg l^{-1}. Reactive phosphorus was measured at 0.02 mg l^{-1}, and total phosphorus (PO_4-P) was 0.15 mg l^{-1}.
Soils	
The pond soils at AIT (20 ponds) are quite acidic with pH values averaging between 3.6 and 4.5. These soils have clay contents averaging 51% and organic matter contents averaging 1.08%.	

Support Facilities at Asian Institute of Technology (AIT)

AIT has a close working relationship with the Royal Thai Department of Fisheries, Network of Aquaculture Centers in Asia (NACA), and Kasetsart University. In addition to opportunities for collaboration in research and facility sharing, an internet database (FISHNET) on fish nutrition, aquatic animal health, and professional services in aquaculture is being initiated.

Affiliations

In-Country	US
Agricultural and Aquatic Systems Program Asian Institute of Technology Bangkok Thailand	School of Natural Resources and Environment The University of Michigan Ann Arbor, Michigan USA

Current Contacts

In-Country	US
Dr. C.K. Lin Agricultural and Aquatic Systems Program Asian Institute of Technology P.O. Box 4 Klong Luang 12120 Thailand Tel: 66-2-524-5458 Fax: 66-2-524-6200 Email: lin@ait.ac.th	Dr. James Diana School of Natural Resources and Environment The University of Michigan 128 Dana Drive Ann Arbor, Michigan 48109-1041 USA Tel: 743-763-5834 Fax: 743-936-2195 Email: jimd@umich.edu

Ayutthaya Freshwater Fisheries Station

Sampling of CRSP tilapia ponds at the Ayutthaya Freshwater Fisheries Station, which is located near the town of Bang Sai, near Ayutthaya, in the central plain of Thailand.

The Ayutthaya site, like those at AIT and Nong Sua, is located in the vast Chao Phraya Plain of central Thailand. Elevations throughout much of this area are so low that tidal influences are seen up to 80 km inland during the dry season.

Ayutthaya Freshwater Fisheries Station

Site Status: Active Prime Site*, Southeast Asia; 1984 to present
Location: Ayutthaya Freshwater Fisheries Station, Bang Sai, Ayutthaya Province, Thailand
Caption/Description: The Ayutthaya Freshwater Fisheries Station is located at Bang Sai near the town of Ayutthaya in Thailand's central plain, and is approx. 60 km north of Bangkok.

Description of Area/Region

Climate

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

Temperatures**	Precipitation**
Annual averages for the area: 26.7–28.9°C Range of monthly averages: 25.7–30.1°C Absolute minimum temps: 5.0–12.2°C Absolute maximum temps: 39.4–43.9°C	5.1–269.2 mm per month and 1,092–1,600 mm annually. Lowest rainfall month is January with an average of 1 day of precipitation, and highest month is September with an average of 21 days of precipitation.
Humidity**	**Seasonality**
A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 64–76%.	Thailand has clearly defined wet and dry seasons, with little temperature variation throughout the year. The rainy season is from May 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

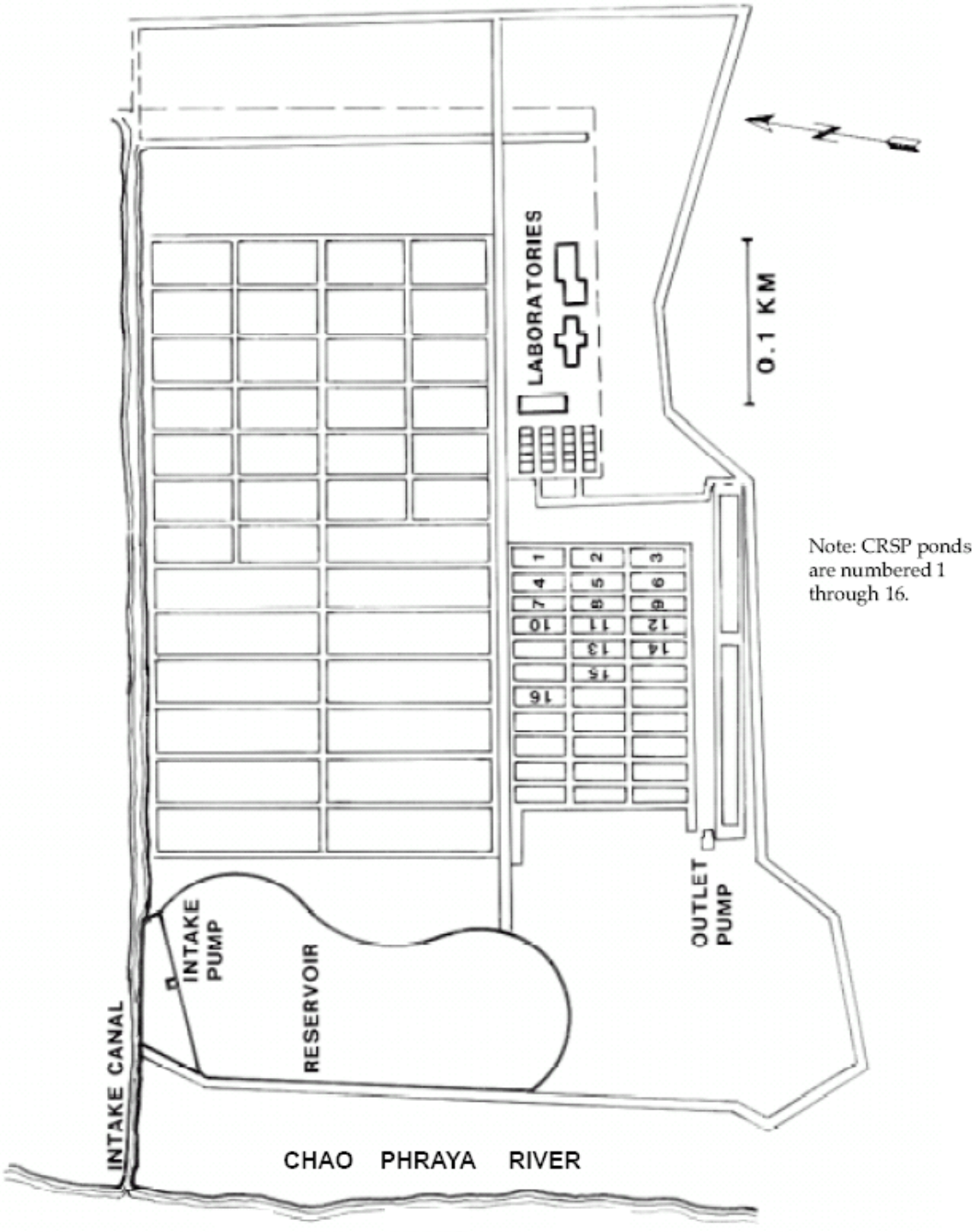
The area is part of Thailand's vast, nearly level central alluvial plain (the Chao Phraya Plain or Menam Plain). A slope of 1:10,000 results in an elevation of just 4 m at Ayutthaya, which is approx. 60 km inland from Bangkok, and 23 m at Aknampho, which is 241 km from the Gulf of Thailand. Many canals crisscross the region, connecting the Chao Phraya and other rivers, and they provide communication links and irrigation. In the dry season, tidal influences are clearly seen up to 80 km inland. During the rainy season, flooding makes the area appear as a single vast lake.

Geology and Soils

The central plain is in the basin of the Chao Phraya river and its tributaries. It was formed by the continual deposition of clays, silts, and sands by these rivers during annual flood periods, resulting in depths of alluvial material exceeding 100 m above bedrock in much of the area. The load of alluvial material carried by the Chao Phraya River has been estimated to extend the delta into the Gulf of Thailand by as much as 7 m annually. The plain is flanked in the north by the Uttaradit Mountains, in the west by the Bilauktaung Range (which forms the boundary with Burma), in the south by the Gulf of Thailand, and by the Khorat Plateau in the east. "Bangkok Dark Heavy Clay" soils are typical in the area around Rangsit and AIT. These soils have a developed profile to a depth of about 1.8 m, have nearly black surface layers, are typically low in organic matter, and are often saturated with groundwater.

* Asterisked items are defined or described in the glossary.
** Data are for Rangsit, from 1927 to 1955.

Layout of Ayutthaya



Description of Ayutthaya Freshwater Fisheries Station

Map Coordinates	Elevation
14° 11' N and 100° 30' E	5 m

General	Water Supply
The Ayutthaya Freshwater Fisheries Station covers a total area of 32 ha, which includes an office building, laboratory, hatchery complex, a pumping station, 20 concrete ponds, 68 earthen ponds varying in size between 400 and 3,200 m^2, a 29,200 m^2 reservoir, and staff housing. Sixteen ponds, each approximately 245 m^2 in area, were available for CRSP research.	The water is pumped to a reservoir from which it is supplied to the ponds by gravity flow or pumping. Water supplied from the reservoir is alkaline with a pH of approx. 8.6 and a total alkalinity of 92 mg l^{-1}. Ammonia is approx. 0.038 mg l^{-1}, nitrate-nitrite is approx. 0.033 mg l^{-1}, total phosphorus is approx. 0.05 mg l^{-1}, and orthophosphate is less than 0.005 mg l^{-1}.

Soils
The soils at the Ayutthaya Freshwater Fisheries Station have high clay and low sand contents. The clay fraction in ponds used by the CRSP averages approx. 66%, whereas the sand fraction averages approx. 11%. The soils are alkaline with an average pH of 7.4, and have relatively high calcium and magnesium contents. They have relatively low organic matter content, averaging around 0.75% in the CRSP-operated ponds.

Support Facilities at Ayutthaya Freshwater Fisheries Station

Laboratory and personnel at the National Inland Fisheries Institute (NIFI) and the Faculty of Fisheries at Kasetsart University are available to the CRSP project. NIFI has an adequate library including FAO literature. Fish feeds are available through commercial dealers or manufactured by NIFI's nutrition department. Organic fertilizers are abundantly available from local farms.

Affiliations

In-Country	US
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Current Contacts

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Nong Sua Fish Hatchery

Site Status: Former Prime Site*, Southeast Asia; 1983 to 1984
Location: Nong Sua Fish Hatchery, Nong Sua, Pathum Thani Province, Thailand
Caption/Description:. The Nong Sua Fish Hatchery is located on the eastern edge of Thailand's Chao Phraya plain near the village of Nong Sua, and is approx. 100 km northeast of Bangkok.

Description of Area/Region

Climate

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

Temperatures**	Precipitation**
Annual averages for the area: 26.7–28.9°C Range of monthly averages: 25.7–30.1°C Absolute minimum temps: 5.0–12.2°C Absolute maximum temps: 39.4–43.9°C	5.1–269.2 mm per month and 1,092–1,600 mm annually. Lowest rainfall month is January with an average of 1 day of precipitation, and highest month is September with an average of 21 days of precipitation.
Humidity**	**Seasonality**
A warm and humid atmosphere prevails throughout the year, with an annual mean relative humidity of 64–76%.	Thailand has clearly defined wet and dry seasons with little temperature variation throughout the year. The rainy season is from May 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

The area is part of Thailand's vast, nearly level central alluvial plain (the Chao Phraya Plain or Menam Plain). A slope of 1:10,000 results in an elevation of just 4 m at Ayutthaya, which is approximately 60 km inland from Bangkok, and 23 m at Paknampho, which is 241 km from the Gulf of Thailand. Many canals crisscross the region connecting the Chao Phraya and other rivers, and provide communication links and irrigation. In the dry season, tidal influences are clearly seen up to 80 km inland. During the rainy season, flooding makes the area appear as a vast lake.

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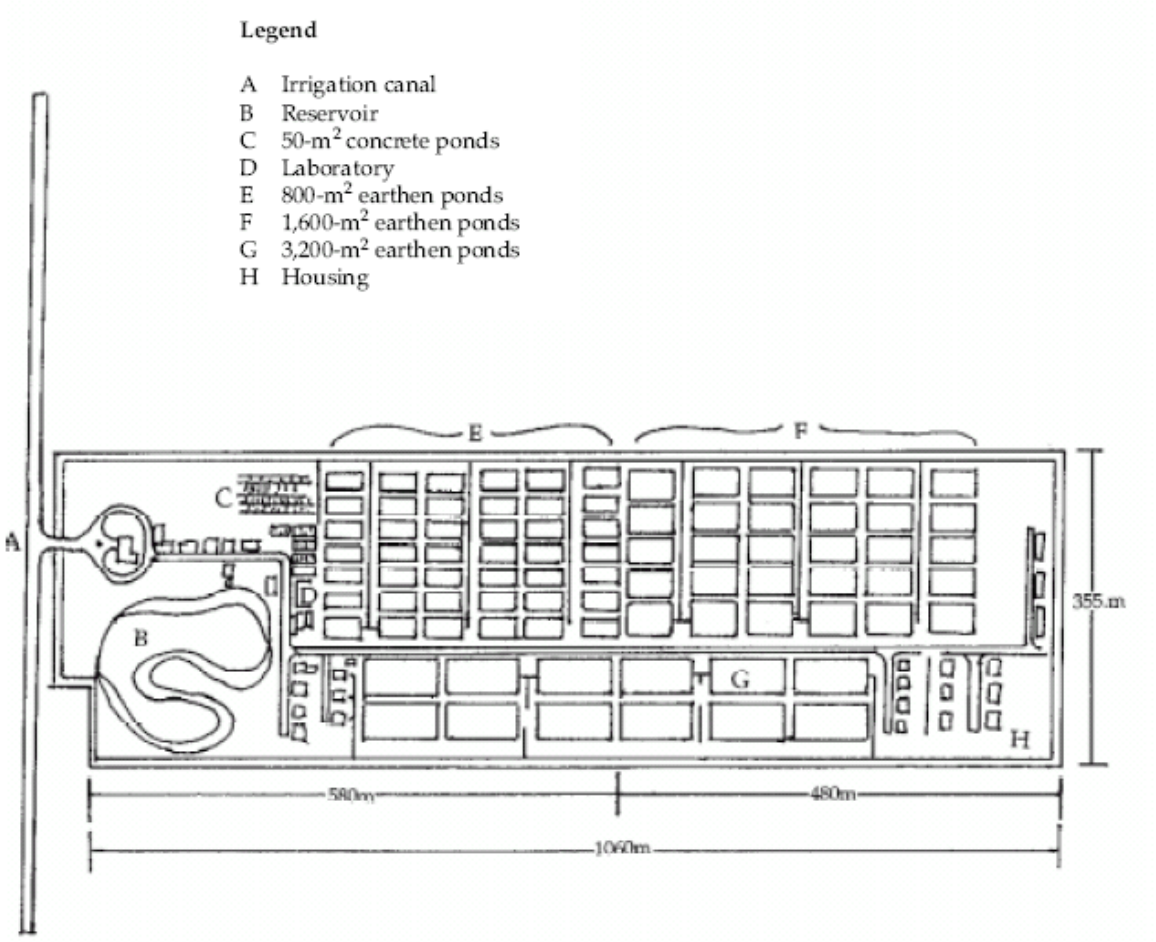
** Data are for Rangsit, from 1927 to 1955.

Layout of Nong Sua



Description of Nong Sua Fish Hatchery

Map Coordinates	Elevation
14° 11' N and 100° 54' E	5 m
General	**Water Supply**
The Nong Sua facility covered a total of 38 ha. Pond facilities included 50 - 10m^2 concrete ponds, 30 – 50 m^2 concrete ponds, 42 - 800 m^2 earthen ponds, 30 - 1,600 m^2 earthen ponds, 12 - 3,000 m^2 earthen ponds, and a 14,500 m^2 reservoir. In addition to the ponds, facilities included an office building, 2 laboratories, 30 staff housing units, a water tower and treatment pond, a pumping station, and a storage building.	The water supply for the station was from the Krong Yai irrigation canal, which filled the station reservoir through a sluice gate. Water for the irrigation canal came from the Chao Phraya River. Fish ponds received water from the reservoir through a series of primary and secondary concrete inlets. The ponds could be filled by gravity flow when the reservoir water level was higher than 5 m. Pumping was occasionally required to fill the ponds. Water quality in the canal was adversely affected by large quantities of silt from the Chao Phraya River, leachates from the acid sulfate soils of the area, and a variety of pesticides from nearby plantations. The oxygen content of the water was often low, particularly during the dry season, and nutrient levels were too low to be detected.
Soils	
The soils at Nong Sua were typical acid-sulfate soils* with pH readings averaging 4.1 for the 12 ponds used in CRSP research. The highly acidic nature of these soils was reflected in their lime requirements, which ranged between 16.6 to 21.05 tons ha^{-1} during the first CRSP experiments at Nong Sua. Aluminum concentrations in the soils were relatively high, averaging 1,131 ppm. The clay content of these soils was also very high, averaging close to 67%, and the sand content was correspondingly low, averaging just 9.8%.	

* Asterisked items are defined or described in the glossary.

Support Facilities at Nong Sua Fish Hatchery

Excellent logistic and facility support was received by the CRSP project at Nong Sua. Almost all of the laboratories and personnel at the National Inland Fisheries Institute (NIFI) and the Faculty of Fisheries at Kasetsart University were accessible for the project. In addition, many laboratories of the Thai Department of Agriculture were located on the Kasetsart campus and available to the project on request. There was a modest library facility at NIFI. Fish feeds were available either from commercial dealers or from NIFI's nutrition section. Both organic and inorganic fertilizers were readily available in the area.

Affiliations

In-Country	US
National Inland Fisheries Institute Royal Thai Department of Fisheries Bangkok Thailand	School of Natural Resources and Environment The University of Michigan Ann Arbor, Michigan USA

Current Contacts

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Glossary

Acid-sulfate soils: highly acidic soils (pH usually < 3.5) that derive their acidity from the presence of acidforming minerals (e.g., sulfur compounds), rather than from simple exchange acidity; oxidation of the sulfur compounds (e.g., upon exposure to air and drying) produces sulfuric acid.

Af climate (Köppen system): climatic regime in which the average temperature of the coldest month of the year is 18°C or higher (A) and in which every month has 60 or more mm of precipitation (f).

Am climate (Köppen system): climatic regime in which the average temperature of the coldest month of the year is 18°C or higher (A) and which has a short dry season; precipitation in the driest month is less than 60 mm, but equal to or greater than [10 - (annual rainfall in cm/25)] (m).

Aw climate (Köppen system): climatic regime in which there are well-defined wet and dry seasons ("tropical wet-and-dry" climate); the average temperature of the coldest month of the year is 18°C or higher (A) and in which there is a well-defined dry season during the winter, with precipitation during the driest month is less than [10 - (annual rainfall in cm/25)] (w).

Base saturation (also sometimes referred to as Base Saturation Percentage): the portion (percentage) of the cation exchange capacity of a soil that is occupied by basic cations; the remainder is occupied by acidic cations and is referred to as the "base unsaturation."

Base unsaturation: the portion (percentage) of the cation exchange capacity of a soil that is occupied by acidic cations; the remainder is occupied by basic cations and is referred to as the "base saturation."

BWh climate (Trewartha system): dry, desert climate; hot, tropical-subtropical, and constantly dry. Potential evaporation exceeds precipitation, and the average annual temperature is not less than 18°C.

Cation exchange capacity (CEC): the capacity of a soil to adsorb cations; cations are adsorbed at exchange sites and can be released in exchange for other cations.

CEC: see cation exchange capacity.

Chinese carp: any of several cyprinid (family Cyprinidae) fishes originating from China, including the grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molotrix*), and bighead carp (*Aristichthys nobilis*).

Common carp: the species *Cyprinus carpio*.

Companion site: a secondary research site of the CRSP in a given geographic region; a limited program of research is supported by periodic visits by the US researcher stationed at a prime site.

GAw climate (Köppen-Trewartha system): Aw climate modified by effects of higher elevation (i.e., cooler temperatures) in low hills or mountains. In the case of high mountains, the modifier H is used instead of the G.

Guapote tigre: the common name of *Cichlasoma managuense*.

Inceptisols: in the Soil Taxonomy classification, soils in humid regions that are as yet poorly developed, e.g., with little accumulation of clay or iron or aluminum oxides; a cambric horizon (a subsurface layer that has been changed by physical movement or chemical reactions) is often present.

Köppen classification: the most commonly used system of classification of climates worldwide, based primarily on temperature and precipitation regimes; published first in 1901, the most commonly referred-to version, including maps, is the publication *Grundriss der Klimakunde*, published in Berlin in 1931.

Köppen-Trewartha classification: climatic classification system modified from the Köppen and Trewartha systems, as described by Willy Rudloff in *World Climates*, with tables of climatic data and practical suggestions, 1981.

Lateritic soils: tropical soils that contain a subsurface layer that is rich in iron and that becomes very hard upon exposure and drying and will not soften when re-wetted; the presence of iron often lends a distinctive red color to the soil.

Marais: swampy, moist valley floors and river flood plains (Rwanda).

Prime site: the primary research site of the CRSP in a given geographic region; a full research program is carried out at the site.

Tambaquí: the species *Colossoma macropomum*.

Tilapia: may include any of several species in the genus *Oreochromis*, the genus *Sarotherodon*, or the genus *Tilapia*; in PD/A CRSP usage, "tilapia" most commonly refers to the species *Oreochromis niloticus* (sometimes also classified as *Tilapia nilotica*).

Trewartha classification: a modification of the Köppen climate classification system by Glenn Trewartha (most recent publication is *An Introduction to Climate*, fifth edition, by Glenn Trewartha and Lyle Horn); like the Köppen system, this system is based mainly on temperature and precipitation patterns.

Ultisols: in the Soil Taxonomy classification, soils that have subsurface accumulations of clay but are low in bases (low base saturation); usually moist, but some are dry some of the time during the warm season; often high in 1:1 clay minerals such as kaolinite.