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Informal Landscape Architecture: A Tool to Improve Water Quality for Informal Settlements along Waterways in Bangkok

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INFORMAL LANDSCAPE ARCHITECTURE:
A TOOL TO IMPROVE WATER QUALITY FOR INFORMAL SETTLEMENTS ALONG WATERWAYS IN BANGKOK

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ABSTRACT

The canals of Bangkok were a vital form of infrastructure from when the city was founded in 1782 until the 1850s, when the road system was introduced. Built for agricultural irrigation, the canals served as the primary means of transportation and significantly influenced the form and orientation of Bangkok's early settlements and public institutions. With the implementation of roads, new buildings were constructed to be oriented towards the streets and away from the canals. The canals and their communities subsequently decreased in visibility. Today, most of the land along the waterways is publically owned. As a result, the land adjacent to the canals has come to house squatter communities, and the canals themselves have become dumping sites.

In northern Bangkok, the Bang Bua Canal Community consists of 12 informal settlements that lie on the banks of the 13-kilometer long Bang Bua Canal. Baan Man Kong, a national slum upgrading program established by the Community Organizations Development Institute (CODI), has continuously worked in the Bang Bua Canal Community since 2004. The program's general approach has been to provide government funds in the form of housing loans and infrastructure subsidies. A component of the development program has implemented the use of organic materials and water plants for regular canal cleaning. The CODI has also funded household grease-trap installation programs that provide wastewater filters to help limit the flow of wastewater directly to the canal. Despite these efforts, as of 2014, the canal is still polluted and the 3,400 families of this settlement still lack access to the water as an open space amenity. Most importantly, this illustrates that appropriate urban water management systems have not been utilized in this area.

Using the Bang Bua Canal Community as a case study, this design thesis focuses on developing strategies to upgrade these informal settlements along Bangkok's waterways with a holistic approach to reconnect these communities to the city. The proposal aims to develop systems for a dynamic landscape that will transform the water's edge into a healthier urban environment. The study will illustrate how the built environment impacts society. In a broader

sense, this proposal provides a vision for the use of urban water management techniques and landscape treatment systems in order to improve the water quality and the use of the water's edge as public spaces in highly dense areas.

CHAPTER 1. INTRODUCTION AND PROJECT BACKGROUND

1.1 Addressing the Issues

The Bang Bua Canal communities have been coping with environmental degradation and contaminated water issues for over a decade. This brings many negative social and environmental impacts to the people and the communities. It also affects the city as a whole. This thesis will investigate the potential of a multi-purpose landscape system of green infrastructure and public space in the informal community along the water edge in this high density area. The design goal for this project is to proposed landscape strategies for the water treatment facilities and for addressing the informal communities as a part of the city. The project also aims to provide a system of public spaces for the communities that connect to the city and perform many other functions. In the role of landscape architects, this thesis will examine how the public space along the water edge of Bang Bua Canal can help to improve social and environmental opportunities in the informal community along Bang Bua Canal.

1.2 Overview of Bangkok

1.2.1 Population and Density

Thailand has an area of approximately 513,120 square kilometers (approximately 198,117 square miles) with a population of 63.9 million in 2010 (National Statistics Data Office) and is estimated to reach 67.1 million by 2013 (World Bank). Thailand's population density in 2010 was 128.6 people per square kilometer, which is an 8.3 percent increase from the 2000 census.

Bangkok, the capital city of Thailand, occupies 1,568.7 square kilometers in the Chaophraya River Delta, located in the central part of Thailand (BMA). Bangkok comprises only 0.306 percent of Thailand's total area. According to a report published by the UN-Habitat in 2003, drastic change occurred in the population of Bangkok after World War II, increasing from 3.5 million in 1958 to 5.6 million in 1999 ("2003 The Challenge" 201). In 2010, the official statistics registration systems of Thailand reported that Bangkok's registered population was only 5.7

million (5,701,394). However, the 2010 census from National Statistical Office reported that Bangkok contained about 8.3 (8,249,117) million people, 12.6 percent of the 63.9 million people that inhabit Thailand. Therefore, Bangkok has the highest population density in the nation with about 5,294.3 people per square kilometer (NSC, 2010).

The differences between the registered population statistic and the census indicate that there are approximately 2.6 million people unregistered in Bangkok. Typically they are rural-urban migrants, foreign workers and daytime commuters. Most of the unregistered live in rental rooms and informal settlements.

According to a 2001 National Housing Authority (NHA) statistic and the data from Community Organizations Development Institute or CODI, there are 283,566 households in 1,604 slums around Bangkok (CODI qtd. in Usavagowitvong et al. 3). In 2008, statistics from CODI and other related community networks have shown that there are 1,266 informal settlements in Bangkok containing 364,344 households in which 225,440 households need housing issues.

1.2.2 Canal Networks

Situated in the Chaophraya River Delta, Bangkok's most vital resource continues to be water. Prior to 1782, the capital of the Thonburi Kingdom spanned over both sides of the Chaophraya River. The uprising of King Rama I against King Taksin consolidated the capital of the new kingdom on the East Bank, making the location more defensible. This marked the founding of present day Bangkok.

Bangkok's network of waterways was immensely important for people on a daily basis because it served as the city's major food source and transportation network. It also played a significant role in shaping the social, economic and cultural values of Bangkokians and the country. The newly established city and its districts were formed out of the canals and river. Trading places, temples, government buildings and many important places were established along the canal systems. The renowned floating markets of Thailand are a prime example of traditional water-dependent settlements.

The establishment of roadways in 1851 undermined the importance of the canal system. Places and buildings turned their backs to the canals and left the canal system abandoned and contaminated. Bangkok's canals gradually became used for drainage rather than as a bustling transportation network.

1.2.3 Urban Poverty and Informal Communities

Informal settlements are often referred to as slums or squatter settlements. The UN-HABITAT (2003) makes a distinction between slums and squatter settlements according to the types of land they occupy and state, "squatter settlements are largely sited on illegally occupied lands, with slums being mostly on rented land" ("2003 The Challenge" 202). However, in some areas of Bangkok, the land and the house belong to the residents (UN-Habitat, "2003 The Challenge" 202). Despite the construction of new slums as an alternative land use, the overall number of slums in Bangkok is decreasing, mostly as a result of increasing land prices and slum demolition (UN-Habitat, "2003 The Challenge" 202).

A report from the Asian Development Bank in 2011 states that, "income inequality in Thailand is among the highest in Southeast Asia" (Bird et al.1). Thailand's Gini index of household incomes, a common measure used to determine income inequality, is at 0.51. Thailand's rating is comparable to many countries that are still experiencing severe income inequality, such as Argentina, Brazil, Costa Rica and Mexico (Bird et al.1). The statistic indicates that the richest 20% of households account for more than 50% of the household income in Thailand (Bird et al. 2-3). Moreover, this top 20% of households own 70% of total financial assets (Bird et al. 3).

This disparity relates to a study by Ratchapan Choiejit and Ratiporn Teungfung (2005), at the World Bank Resources, which discusses how Bangkok provides better opportunities for the average impoverished Thai migrating into highly urban areas. This results in a rapid urban growth, presenting additional problems (Choiejit and Teungfung 7). The lack of affordable dwellings for people in the city forces new migrants to build temporary or semi-temporary homes on the inadequate land they can afford, resulting in slum communities (Choiejit and Teungfung 7).

The increasing occurrence of slums in Bangkok is mainly from natural growth, not from rural- urban migration (UN-Habitat, “2003 The Challenge” 202). The information from UN-HABITAT illustrates that “approximately 60 percent of the population in the slums of Bangkok were born in their existing slum and 30 percent of the population are a dependent population” (“2003 The Challenge” 202). The UN-HABITAT data in 2003 shows that rural–urban migration into Bangkok is relatively low since the rural people tend to move to other unoccupied rural areas in Thailand (“2003 The Challenge” 202). The urbanization of rural areas has led to Thailand increasing its urban population from 19% in 1990 to 31% in 2001 (UN-Habitat, “2003 The Challenge” 202).

The data shows that 62 percent of slum residents in Thailand are in Bangkok, while 22 percent are in its larger metropolitan region. This phenomenon resulted from linear urbanization along roads and the expansion of populations into adjacent areas in the 1960s (UN-Habitat, “2003 The Challenge” 201). However, the number of slums in Bangkok has been decreased from time to time. The statistics show that almost one fourth of Bangkok’s accommodations in 1974 were in informal settlements and by 1994 had dropped to 6 percent (UN-Habitat, “2003 The Challenge” 201). The proportion of residents who could afford a residence in the housing market grew from 20 percent in 1980 to 50 percent in 1993 (UN-Habitat, “2003 The Challenge” 202). The UN-HABITAT (2003) attributes the decline in the number of slums to the prevalence of affordable housing, the prohibition of tree cutting and the drop in prices of permanent construction materials (“2003 The Challenge” 202). Despite the more affordable dwellings in the housing market, currently 75 percent of the slum’s residents are unable to pay the down payment for the more affordable home (UN-Habitat, “2003 The Challenge” 202). They are unable to afford US$2000 for the down payment even though they are above Thailand’s poverty line. (UN-Habitat, “2003 The Challenge” 202). The average population density in the informal sectors of Bangkok is three times higher than in normal neighborhoods (UN-Habitat, “2003 The Challenge” 202).

The location of slums in Bangkok is completely related to the availability of work for its residents. Employment opportunities attract and encourage the residents to build slum communities nearby (Department of City Planning qtd. in Choiejit and Teungfung 7). Most of the

slum’s residents are low-skill laborers due to their lack of education (Department of City Planning qtd. in Choiejit and Teungfung 7). The slums of Bangkok are scattered throughout the early settlement area and central business district (Choiejit and Teungfung 7). They are also located near the industrial areas and the transport hubs (Department of City Planning qtd. in Choiejit and Teungfung 7).

1.3 Site Location and Context

Bang Bua community is located in two districts in the northeast of Bangkok, Laksi and Bangkhen, with Bang Bua canal as a natural boundary dividing the two districts. The canal begins in the city’s outer rims, previously agricultural land which has since been urbanized, and stretches out through suburban areas and finally into farmland.

This thesis will focus on 7 communities that are on one end of Bang Bua Canal in the city area, starting from Phahonyothin Road to Cheang Wattana Road.

1.3.1 Bang Bua Canal and the Communities

Bang Bua Canal, or Klong Bang Bua in Thai, means the canal that is *full of water lilies*. It is a 13-kilometer long canal in the north of Bangkok (CODI,2013). According to the information from Bang Bua Canal Development Network (BCDN), the 80-meter wide canal was constructed during the King Rama V reign (1868-1910). It was turned into an irrigation canal in 1927. The paper by Nattawut Usavagovitwong from Sripatum University’s Center for Integrated Socio-Spatial Research (CISR), one of the organizations that works with the Bang Bua community, mentions that people started to settle along Bang Bua canal more than 80 years ago (Sirisrisak qtd. in Usavagovitwong 2). In the early days, the canal was full of red water lilies (Sirisrisak qtd. in Usavagovitwong 2). The early settlers of Bang Bua Canal were farmers and charcoal burners. Later, locals started to make clay bricks using the clay found locally. The community shifted from agriculture to depending more on a market-based economy through the sale of rice, charcoal and bricks at Bang Bua market (BCDN).

The significant change to the Bang Bua Community occurred between 1987 and 1992, when the country developed from a predominantly agrarian society into an industrial base with high economic growth (Usavagovitwong 3). Without any regulations to control the development, the area turned into a slum. Usavagovitwong mentions that the migrants in Bang Bua communities are mainly from the south and the northeast. They moved into the city for the better economic opportunities by working in the informal or service sectors, and occupied the vacant public lands along Bang Bua Canal (Usavagovitwong 3).

Today, there are 12 informal settlements containing 3,400 families along Bang Bua canal and the residents in these communities are mainly “vendors, laborers and daily-wage workers” (Wungpatcharapon and Tovivich).

1.3.2 Environment, Water, Canal and Sanitization

Bang Bua communities have been supported by the Danish Cooperation for Environment and Development (DANCED) and other organizations since 1996 (Usavagovitwong 5). At that time, the government used the contaminated canals as the reason to demolish the informal settlements (Usavagovitwong 5). The residents have since tried to make the water in the canal cleaner, so they can claim they are not responsible for the canal’s pollution (Usavagovitwong 5).

To improve the water quality in the canals, the Bang Bua Canal community network, according to the handbook, holds canal cleaning activities regularly by using effective microorganisms compost and aquatic plants. Currently, every household installs D.I.Y. “grease-trap wastewater filters” that cost less than $10 USD in their kitchens. Moreover, the Bang Bua people continually “negotiate with upstream polluters to reduce toxic effluents in the canal” (Wungpatcharapon and Tovivich).

1.3.3 Land Tenure

The land along the Bangbua Canal belongs to the Treasury Department of Thailand (Wungpatcharapon and Tovivich). Negotiations regarding the land tenure are a part of the community upgrading process. It is mentioned in the “Baan Mankong at Klong Bang Bua

Handbook" that the Bang Bua Canal communities were "the first network of canal communities in Bangkok to successfully negotiate a long-term lease to the public land" (Wungpatcharapon and Tovivich). As a network of 12 canal communities with support from other community networks in Bangkok, Bang Bua Communities increased their negotiating power with the government of Thailand in order to remain in their homes, upgrade the communities, and preserve the Bang Bua Community (Wungpatcharapon and Tovivich). The preservation and recognition of this canal community would benefit all informal communities and the city as a whole by acting as a model for successful transformation.

The informal communities have managed to negotiate a "30-year renewable lease" (CODI, 2013), ensuring that people in the communities will have a place to live. The rental fee after the negotiation is about 1 Baht per square meter with "adjustment for inflation every 5 years" (Wungpatcharapon and Tovivich). Therefore, based on the size of the land occupied, the monthly land rental fee for each family is approximately 40 to 70 Baht (equivalent to $2- 3 USD) (Wungpatcharapon and Tovivich). Under the current agreement, rents will be paid to the community cooperative, which will handle collections. Then, all the rent will be paid to the Treasury Department by the cooperative.

As stated in the handbook, the upgrading program for the communities also includes new infrastructures and plans for a revitalized environment. The new development provides green areas as community boundaries and proper pathways along the canal's edges for adequate access to the community. The new walkways, which are, "built partly on the swampy edges where houses used to perch and partly on land reclaimed by the District Authorities in the canal" (Wungpatcharapon and Tovivich), will allow bikes and fire vehicles access to the community. Other facilities include playgrounds, open space and community centers.

1.3.4 Baan Man Kong and Community Development

The Bang Bua Canal Development Network (BCDN) was established in 1999 by the 12 communities of Bang Bua Canal to participate in environmental issues in the community (BCDN). Since the communities along the Bang Bua Canal have experienced contaminated waterways

and other related issues since 1994 (BCDN), they participated in the canal cleaning activities that later led to the establishment of the community network. As a network collaborating with the districts authorities, educational sectors and CODI, the community established a cooperative and small groups for their savings, community and environmental development. In 2003 (2546 B.E.), CODI started the development project for Bang Bua Community Network (BCDN) with its first community in December 2004 (Wungpatcharapon and Tovivich). According to BCDN, the work process of community development starts from public meetings and finding the regulations (BCDN). Then, people start saving, while they do surveying and hold public hearing (BCDN).

Today, Bang Bua Community Network has expanded to adjacent inland neighborhoods and is a part of the city canal revitalization group (Wungpatcharapon and Tovivich).The network expands horizontally, creating more effective advocacy as a bigger community.

According to BCDN, the cost of construction of each new house varies from 100,000 - 250,000 Baht (USD $3,000-6,500) with approximately 50-80 square meters per house (BCDN). CODI provides government funds as housing loans and infrastructure subsidies for the development (BCDN). The rates of the funds are different according to the conditions of each house (BCDN). For the infrastructure, 35,000 Baht will be paid to the house owner for the new development infrastructure and 25,000 Baht is for improving the old infrastructure (BCDN). The loan for the new built house is not more than 300,000 Baht with a 4% interest rate per year (BCDN). For house renovation, the owner will get 20,000 Baht to improve the living conditions (BCDN).

Each household pays for monthly housing loans approximately 590-1,187 Baht (USD $18-36) (BCDN). The regulations for the new development are that the maximum residents for each unit should not be more than 8 people, and people from the same household can build a new house when it exceeds this number (BCDN). The saving for each house is 5 Baht per day and 15,000 Baht is the minimum saving amount as a guarantee for the loan (BCDN).

CHAPTER 2. LITERATURE REVIEW

This thesis is about the landscape system along the densely populated Bang Bua canal. Since the site still lacks municipal facilities, this interdisciplinary research aims to investigate possible solutions for sanitary development, water treatment and purification in limited landscape areas. The areas of study overlap with a multitude of different disciplines beyond landscape architecture. This literature review focuses on three different approaches; urban morphology of Bangkok, community upgrading and on-site water and sanitary treatment systems with many sources found in books, online articles, and journals to site surveys.

2.1 The Urban Morphology of Bangkok and Traffic Issues

For a better understanding of the site, this study will illustrate how Bangkok and its communities were formed. Bangkok has been constructed and expanded according to the structures of the canal network. According to information in "*Physical Elements of Krung Rattanakosin*" published by researchers from Chulalongkorn University in Thailand, when Bangkok was founded in 1782 on the east bank of Chaophraya River, two canals were built as city moats for security purposes. Then, more canals were constructed to reduce the risk of flooding because Bangkok is in a flood plain. The canals are also used as a means of transportation that connect parts of the city together. In this period, the city expanded in a linear fashion along the canal network (Chulalongkorn University qtd. in Chansiri).

Under western influence and as a result of the industrial revolution in Europe, the road system was built in Bangkok in 1851 (Chulalongkorn University qtd. in Chansiri), causing the primacy of water to shift to land. Thais started to build houses along the roads while the rural areas were urbanized (Suthiranart qtd. in Rujopakarn 3304). The new streets were built according to the existing canals (Chulalongkorn University qtd. in Chansiri). The city isolated the canals and altered their primary purpose to be a source of drainage, resulting in shallower and more contaminated canals.

Other land-based transportation was set up in Bangkok after this significant transformation. The rickshaw started 1871, followed by the horse-drawn tram in 1888, railway in 1891 and electric tramway in 1894 (Rujopakarn 3304).

According to Wiroj Rujopakarn, The expansion of the road system in Bangkok was caused by the introduction of motorcars in 1902. The canal system has not further been expanded since 1915 (Beek qtd. in Rujopakarn 3304). The city developed linearly along the new roads without any planning; therefore turning Bangkok into a car-dependent city (Rujopakarn 3304). This linear development affected urban issues in Bangkok even to the present day (Rujopakarn, 3304).

In the beginning of the road system's expansion and Bangkok's development inspired by western influence, there was no adequate city planning in Bangkok. This was because of unstable political conditions since 1932. The lack of preliminary studies and ill-advised development policies can all be attributed to this poor urban planning (Rujopakarn 3305).

When the first National Economic and Social Development Plan (NESDP) was launched in 1962, it focused on economic growth and the infrastructure development of the country without any land use policies (Rujopakarn 3305). Even though there was an attempt to institute a city development plan in the 1960's, it was "never formally approved and only serving as informal working guidance" (Rujopakarn 3305-6). According to the study by Rujopakarn, the first three of the NESDP had turned Bangkok into a car-based city, resulting in severe traffic issues that continue to the present day (Bongsadadt qtd. in Rujopakarn 3305).

The failures of the planning policies turned into the failure of the development of the city. Official town planning was first launched in 1975, but it was not successful (Rujopakarn, 3306). The first Land Use Plan of Bangkok was issued in 1992 during the 7th NESDP (DTCP, qtd. in Rujopakarn 3307), followed by the second one in 1999 with the the 8th Transport Plan, effective from 1997 to 2001 (Rujopakarn 3307). All the plans however failed due to the lack of fundamental research studies and the development plans were not incorporated with each other (Rujopakarn 3307-8).

Therefore, Bangkok suffers severe environmental issues, such as air pollution and contaminated waterways. It is also facing many social issues resulting from development without the proper planning.

Another significant reason that has caused the failure of city planning and of Thailand's development is the unstable political situation and widespread corruption. Since the country turned into a democracy in 1932, Thailand has had several coups (Farrelly) that have delayed the development projects in the country.

2.2 Slum Upgrading

The approximate number of people living in slums globally is 1 billion, which is one sixth of the world's population (UN-HABITAT, "2009 SUF" 1). It is estimated that 3 billion people or 40 percent of humanity will be in need of proper dwellings as well as basic infrastructure and services by 2030 (UN-HABITAT, "Housing").

Many organizations have been helping these slum dwellers to deal with this issue. One of the important organizations is UN-HABITAT, which started the "Slum Upgrading Facility Pilot Program" (UN-HABITAT, "2009 SUF" 1) in 2004 to investigate how to improve this situation. The program has been exploring new methods to find the proper financial system and cooperation with other organizations on the bigger scale (UN-HABITAT, "2009 SUF" 1).

The UN-HABITAT Slum Upgrading Program emphasizes community involvement and collaboration with other related sectors for the upgrading projects in order to gain the financial success and bring more support to the communities (UN-HABITAT, "2009 SUF" 1).

2.3 Slum Upgrading in Thailand

Tracing the history of slum upgrading in Thailand, its starting point was during 1948–1958, when 3462 urban dwelling units were built as government aid for people (UN-Habitat, "2003 The Challenge" 202). Then, in 1973, the National Housing Authority or NHA was established as a government authority to work on house and flat construction (UN-HABITAT, "2009 SUF" 3). Instead of relocation, the "sites and service development program", from 1977 to

the 1980’s, made NHA to allow slum residents to stay in their area (UN-HABITAT, “2009 SUF” 3). Slum upgrading program under NHA officially started in 1977 (UN-HABITAT, “2009 SUF” 3). In 1992, NHA set up the new authority, Urban Community Development Organization, to operate loans and assist the communities for their upgrading and development (UN-HABITAT, “2009 SUF” 3). It was funded USD$50 million by Thailand Government (UN-HABITAT, “2009 SUF” 3) and other foreign funds (UN-Habitat, “2003 The Challenge” 202). However, the outcomes were unfruitful due to its limited scope of works that could not reach the more expanded community networks (UN-HABITAT, “2009 SUF” 4).

In 1992, the Urban Community Development Office founded the Community Development Fund as an agent to connect fund sources and support from the organizations to the community networks (UN-HABITAT, “2009 SUF” 4). Nationwide, Community Organization Development Institute (CODI) developed from the Community Development Fund, combining the Urban Community Development Organization and the Rural Development Fund in 2000 (UN-HABITAT, “2009 SUF” 3). The new organization board equally comes from three groups; community members, governmental officials and other related organizations (UN-HABITAT, “2009 SUF” 4).

This collaboration was successful in establishing the Baan Mankong Program in early 2003 to upgrade the informal settlements countrywide, aiming for the goal of “cities without slums” (UN-HABITAT, “2009 SUF” 4). As of 2009, CODI works in an interdisciplinary fashion, collaborating with other related organizations as the networks, operating the national community upgrading programs based on “community based savings and loan groups” in more than 200 cities (UN-HABITAT, “2009 SUF” 4). The financial support for each project relies on the community savings for at least 10 percent of all the finance, the rest coming from different sources such as the government and other private sectors (UN-HABITAT, “2009 SUF” 4).

Somsook Boonyabancha, Managing Director of CODI describes the community based saving system as “a horizontal system that brings people together” (Boonyabancha, qtd. in UN-HABITAT, “2009 SUF” 4) and “a political vehicle that helps poor people to create change” (Boonyabancha, qtd. in UN-HABITAT, “2009 SUF” 4).

2.4 Ecological Engineering for Landscape Architecture

This research aims to seek sustainable methods for water treatment technology in the highly dense area. As the ecological values of the communities are deteriorating, this study will investigate the appropriate methods to revitalize the natural features of the site in terms of ecological and economical approaches.

2.4.1 Phytoremediation

According to Encyclopedia Britannica, phytoremediation is the method that "uses plants to treat contamination from soil" (Britannica). Bangkok is located in the tropical zone. Therefore, the native plants which are low-cost and easily to provide are tropical plants. In this study, types of vegetation will be grouped according to their habitats.

2.4.1.1 Trees and Woody Plants

Trees and woody plants provide larger biomass for phytoremediation. Therefore, they can collect more toxicity from the soil and the water. This section studies the potentials of the existing trees and woody plants that are native or commonly found on site.

Existing tree species on site are usually flood-tolerant plants. The most common species are Ficus species (*Ficus spp.*), Rain Tree (*Samanea saman*), Sacred Garlic Pear (*Crateva religiosa*), and *Barringtonia acutangula*. A study from National University of Singapore in 2011 shows that *Ficus benjamina, Ficus microcarpa, Ficus virens , and Melastoma malabathricum are* potential species for phytoremediation in tropical countries (Yeo and Tan 213-26). The experiment proves that these fast-growing species help reduce cadmium and needs to be study further on their absorption of lead, copper, and zinc in the soil (Yeo and Tan 225). These plants are native to Bangkok and Ficus species an easily found on site. Ficus species, in Thailand, are sacred trees and usually left undisturbed.

While, *Samanea saman* or Rain Tree, a leguminous species, is the dominant species found on site. The study in 2012 shows that leguminous trees and "its symbiotic association with nitrogen-fixing bacteria and arbuscular mycorrhizal fungi (AMF)" could aid in phytoremediation of

petroleum-contaminated areas (Bento et al.) Therefore, *Samanea saman* and other native leguminous trees have a very high potential for phytoremediation in the areas contaminated with petroleum products. Another native leguminous tree found on site is *Erythrina variegata* or the Indian Coral Tree which has a high potential for soil remediation.

Barringtonia acutangula and *Crateva religiosa* are also commonly found on site. The research published in 2013 from the University of Allahabad, India, shows that *Barringtonia acutangula* could absorb Chromium and collects in the root and shoot tissues. Since *Barringtonia acutangula* can grow in the swampy area, it is effective for both soil and water treatment. For *Crateva religiosa,* the plant study published in 2014, from Ahmadu Bello University and Michael Okpara University of Agriculture in Nigeria, shows heavy metals as the trace elements in *Crateva religiosa*. The research shows significant numbers of copper, iron and chromium collected in the trees. Therefore, *Crateva religiosa* has a potential for phytoremediation for the site.

2.4.1.2 Wetland plants

This study will investigate the possibility of using tropical wetland plants to clean the water in the canal. Today, Bang Bua Canal communities use several types of aquatic plants to treat the water in the canal. The water quality in the canal changes seasonally. Therefore, there is no record provided for the contaminated substances in the water. The potential plant to use for water treatment is Water Hyacinth (*Eichhornia crassipes*), *Typha latifolia* and *Ipomoea aquatica*.

Following the King of Thailand's pilot project using Water Hyacinth to clean the water in the reservoir in the central part of Bangkok, the most significant and widely use plant that the locals use for cleaning water in the canal is Water Hyacinth (*Eichhornia crassipes*). Bang Bua Canal dwellers use local and recycled materials such as bamboo sticks, plastic containers and fishing nets to control the spread of the Water Hyacinth. In a study from Kanazawa University in Japan in 2011, Water Hyacinth help to absorb arsenic, iron, copper, zinc, lead, cadmium, chromium, nitrogen and mercury from the water (Rahman and Hasegawa 636).

Other two common aquatic plants found on site are *Typha latifolia* that collects chromium, arsenic, zinc, lead, cadmium, copper and nitrogen, and *Ipomoea aquatica which can find* arsenic, zinc, lead, cadmium, copper and mercury as trace elements (Rahman and Hasegawa 636).

2.4.2 On-site Wastewater Treatment Technologies

There are several new wastewater treatment technologies that are based on ecological approach and many wastewater treatment technology providers in the market. However, the goal of this study is to develop adequate technologies to help cleaning the water in the area that has limited land supply. Therefore, this study will focus on an approach based on the technology first developed by John Todd in his Living Machines®, which uses an aquaculture system of greenhouses with plants to treat wastewater.

2.4.2.1 Organica Water

A study from the Royal Institute of Technology in Sweden by Jesse Anderson , "*Localized Sustainable Water Management in Practice*" (2012) compares three different methods of on-site wastewater treatment technologies: Living Machines®, Organica Water and Solar Aquatics™. The research shows that Organica Water has the smallest footprint for the wastewater treatment plant. Due to limited information from other wastewater treatment technology providers, this thesis will be based on the academic sources that are available, where Organica Water is proven to use the smallest area.

Organica Water is a wastewater treatment technology company from Hungary. It is renowned for its Fixed-Bed Biofilm Activated Sludge (FBAS) technology. FBAS was described as "the integration between Fixed Film Activated Sludge (IFAS) system that leverages the use of various natural and engineered media to provide a habitat for a diverse fixed-film bacterial culture which metabolizes the contaminants in wastewater" ("Organica FBAS"). Unlike the "constant motion" ("Organica FBAS") used in an Activated Sludge system or MBBR, FBAS is conducted in a fixed bed media that acts like a habitat for organisms in the reactor ("Organica FBAS"). The organisms in this biofilm help to clean the water. Organica uses this effective natural system as a

proven solution for wastewater treatment while only requiring a small area according to the study from Anderson in 2012. There are two developed FBAS systems from Organica that have been use to treat the wastewater in the “odourless, botanical-like” glasshouse: Organica Bluehouse (“Organica Bluehouse”).

Organica Food Chain Reactor (FCR)

Organica Water describes Organica Food Chain Reactor (FCR) as an all-inclusive wastewater treatment system that “incorporate solids removal, biological treatment/nutrient removal, phase separation, and final treatment for reuse quality into a compact, single structure” (“Organica FCR”). In details, the *FCR* system is a biological treatment system operates by a series of reactors that reduce nutrients and dissolve contaminants in the water. The water flows into this FCR system through a pre-treatment, which connects to the biological reactors (“Organica FCR”). These reactors, according to Organica, are cascade structures with customized Biomodules that create specialized ecosystems based on the treatment sequence (“Organica FCR”). The water continuously flows through the reactors while plant roots and biofiber media absorb the undesirable nutrients in the water (“Organica FCR”).

Organica Fed Batch Reactor (FBR)

Organica describes this system as the combination between sequential feeding from conventional batch processes and simultaneous nitrification and denitrification from continuous-flow wastewater treatment technologies. The system also combines natural plant roots as a biofilm carrier to increase the ability to transfer treated oxygen (“Organica FBR”). Organica states that this combination saves energy and improves overall operating efficiency (“Organica FBR”).

The FBR system operates through four phases. First, the water is pumped into an anaerobic reactor from an equalization basin and flows into an aerated reactor through a recirculation pipeline. While the wastewater and sludge continuously recirculates between the anoxic and aerobic phases, the compartments have nitrification controls in place, as well as denitrification and microbiological decomposition of organic matter (“Organica FBR”).

Then, the system stops operating and lets the sludge settle at the bottom of the reactor. The water on top is then pumped to an effluent tank, while sludge is pumped out as a solid waste at the processing line (“Organica FBR”).

Footprints and Sizes

Based on the information from the Organica website, the sizes and numbers of the reactors in both FCR and FBR systems vary to many factors (i.e. water quality of the influent and effluent, temperature, and the capacity of the treatment plant). The study from Royal Institute of Technology in Sweden, by Jesse Anderson, shows the footprint comparison between two Organica FCR systems (Szarvas treatment plant for a poultry processor and Budapest Harbor Park Industrial Complex in Hungary) that use the area from 0.3 to 1.2 square meters for 1 cubic meter of water, while the footprint of Organica FBR systems in Telki, Hungary use the area only 0.4 square meters for 1 cubic meter of water (Anderson, 20 and 32)

CHAPTER 3. METHODS

This research investigates the possibility of informal communities upgrading the areas adjacent to the waterways in Bangkok. This design thesis uses Bang Bua Canal communities as a case study because they are the pilot project for the community-upgrading program in Bangkok. The study focuses on landscape systems and new technologies that help to improve ecological values for the communities and bring beneficial impacts to the people and the city within limited budgets and lands. This design project will utilize and emphasize the use of local resources and cost-efficient technologies to establish a proposed landscape strategy for multi-functional infrastructure for the canal-side informal community. This proposal aims to create a network of public spaces along Bang Bua Canal which can help to improve ecological values and the quality of life for people in the community.

3.1 Goals

Goal 1. Propose a landscape design strategy as a multi-functional infrastructure for the community, focusing mainly on the water facilities

Goal 2. Develop accessibility of the community and reconnect the community to the city

Goal 3. Improve physical dwelling place for people in the community

3.2 Precedents

This thesis aims to investigate different perspectives to solve the issues in the informal settlements. Therefore, the study of the precedents will be divided into 2 parts. The first section focuses on the public space systems in the informal settlements. The second section will investigates the biological treatment systems for water.

3.2.1 Public Space Systems and Development Approaches

3.2.1.1 Favela Bairro

Based on the information from "*The Favela-Bairro Project: Jorge Mario Jáuregui Architects",* the Favela Bairro project is one of the important precedents to study about slum

upgrading in the city scale. The program focused on connecting the informal settlements in Rio de Janeiro into the city system. The Favela Bairro project had created changes to approximately 105 shantytowns in the city, containing 450000 dwellers.

The program aims toward the possibility for changes in the city as a whole, accepting the Favelas and the people as a part of the city. The scope of works for the program starts from the formal parts of the city in the formal grid system and connect them to the informal part. Then, it focuses on infrastructure and public space improvement in the informal community, such as new streets, community cores, sewage and other infrastructures. The successful strategies of this project can be applied to slum upgrading programs elsewhere in terms of the ambitious scale. First, the project is based on what locals need and customized the design based on their needs. Hence, the residents have right to choose what they want. Next, the development is based on to the cultural identity of each community. The construction of soccer fields and salsa places in the communities illustrates what residents like to do. These sport complexes become places for social interaction.

To provide more public spaces and infrastructure, the relocations of housing could not be more than 5 percent. Therefore, the residents have options to stay on the existing locations, relocate or accept the funds and move out from the community.

Topography is also the significant part of the development. Unlike the other parts of the world, the informal settlements which occupied part of the city are generally located in the steep and hilly areas, and the formal city is on the flat land. The architects used vegetation to stabilize the slope as they are the cheapest form of the erosion control methods. The locals plant their gardens and provide plant materials for the project. To blend the informal city and the formal city together, the architects put the roads and facilities at the edge to the territories to break down the edges and connect the two parts with recreational space.

The construction of the project provided job opportunities for the people in the community. This helps to solve social issues as they hire labors from the community and these workers gain knowledge and skills from training.

3.2.1.2 Villa Tranquila, Argentina

According to the book "*Interrelaciones urbanas Urban interrelations*", Villa Tranquila is a 40-year-old settlement, located near the abandoned industrial area in the south of Buenos Aires, Argentina. Before the upgrading in 2004, the site contained 7,000 people from 1,900 families living in 1,700 units on 25 hectares. Half of the populations was unemployed and 80 percent of all the households were below the poverty line (Janches and Rohm). The site is 10 blocks away from one of the most populated parts of the city (Janches and Rohm 49). The population in the community is only about 1 percent of the informal settlement population in Buenos Aires Metropolitan Area.

The upgrading program for Villa Tranquila aimed to solve the issues of ownership status and census population in the community (Janches and Rohm 24). The strategies also focused on securing financing for the community and studying the settlement situation (Janches and Rohm 24). The development approach considers respecting existing conditions, being child centered and integrating interior and exterior space (Janches and Rohm 64). The program started its development where help was most needed and where access was easiest, and then it continued to the related areas (Janches and Rohm 73-75).

The public space system of Villa Tranquila is one of the most significant strategies of this project. The architects created public spaces near the important community nodes, and spaces along the paths that people use daily (Janches and Rohm 67-68). The public space system supports a wide rage of functions and maximizing the use of the available spaces in the community (Janches and Rohm 68).

The design develops three levels of public space from the larger scale to the smaller scale (Janches and Rohm 68). The first level is urban scale, which is the space between the edges of the settlement and the city (Janches and Rohm 68). This strategy is to integrate the informal settlements to the city (Janches and Rohm 68). The second level is institutional scale (Janches and Rohm 68). The institutional scale focuses on the existing socio-cultural institutions (Janches and Rohm 68), such as schools and community centers. The development of this scale leads to the improvement of the space in the settlement and creates functional space for people

(Janches and Rohm 69). Last, the developments of small-scale for family space provides semipublic spaces between domestic and public spaces, which are low maintenance (Janches and Rohm 69).

The three levels of public spaces are linked by routes and streets, which are related to the existing circulation (Janches and Rohm 69). These spaces develop relationships between programs, functions and spaces (Janches and Rohm 69). They also create social integration in the society as these public spaces attract more people (Janches and Rohm 69). The spaces support educational activities for kids, who always use outdoor space as their play areas (Janches and Rohm 69). Also, the public spaces provide gathering space for everyone.

3.2.2 Water Treatment Technologies

To prove that the water treatment facilities could be set up in the small area available, this section will study precedents that have similar conditions.

3.2.2.1 Municipal Wastewater Treatment, Etyek, Hungary

The municipal treatment plant at Etyek started to operated in 2007 (Organica, “2014 Etyek”). The treatment system, which served 10,000 people, occupied 570 sq.m. (6,135 sq.ft.), and the hydraulic Capacity Per Day is 1,000 cu.m. (264,000 Gallons) (Organica, 2014). Therefore, the footprint per 1 Cubic Meter is only 0.325 square Meter.

Footprint per 1 Cubic Meter: 0.57 sq.m.

Based on the information from Organica website, Etyek is the town near Budapest, Hungary. It upgraded the wastewater treatment plant as the old facility exceeded its limit from the tourism industry and the new development. Due to the limitation of land in the old city, Organica constructed the new water treatment facility on the site of existing water treatment facility, while the original system is still in use (Organica, “2014 Etyek”). The new treatment facility is FBR system (Anderson 2011,P.20).

According to Organica website, the new wastewater treatment facility reduces Capital expenditures (CAPEX) by 30 percent because of land values and reduces operating expense

(OPEX) by 28 percent (Organica, “2014 Etyek”). The reduction of OPEX is according to less energy consumption and less sludge production (Organica, “2014 Etyek”).

3.2.2.2 Foxconn Technology Group Treatment Plant, Shenzhen, China

The treatment system at Foxconn Group started its operation in since 2010 (Organica, “2014 Shenzhen”). The treatment system, which served 18,000 people, occupied 975 sq.m. (10,500 sq.ft.) and the hydraulic Capacity Per Day is 3,000 cu.m. (792,500 Gallons) (Organica, “2014 Shenzhen”). Therefore, the footprint per 1 Cubic Meter is only 0.325 square Meter.

Organica website states that the site is an electronic manufacturing plant in Shenzhen in China, one of the most populated city approximately 10 million people (Organica, “2014 Shenzhen”). The factory constructed the wastewater treatment to clean the water in its system before release to the natural waterway or bring the water back to use. Prior to this, the wastewater from the factory was drained directly into the waterway.

Organica built the new water treatment facility on the site as a glasshouse where people can use it as recreational area.

The wastewater treatment facility at Foxconn factory reduces Capital expenditures (CAPEX) by 16 percent because of land values and reduces operating expense (OPEX) by 28 percent (“2014 Organica, Shenzhen”). The reduction of OPEX is according to less energy consumption and less sludge production (“2014 Organica, Shenzhen”).

3.2.2.3 Urban Municipal Canal Restorer, Fuzhou, China

This precedent has some similarities to the Bang Bua Canal development project in terms of its water purification purpose. The city of Fuzhou in China contains a population of 6 million and encounters polluted waterways throughout (John Todd Ecological Design). The Baima Canal is one of the most polluted canals in the city. The pollution in the Baima Canal cause by “750,000 gallons per day of untreated domestic sewage” and the canal had bad odor and a lot of floating solids (John Todd Ecological Design). To solve this issue, the city chose a cost-efficient and low maintenance restoration system (John Todd Ecological Design).

The development was started in 2002 by John Todd Ecological Design and Ocean Arks International by using vegetation and fabric media as the Restorer for the canal to create biodiverse surface areas for biological treatment for wastewater (John Todd Ecological Design). The Restorer was 500 meter long and used 12,000 plants from of 20 native species which were planted adjacent to the newly constructed walkway in the center of the canal (John Todd Ecological Design).

The water entered the treatment system at the top of the canal, which was an anoxic area for denitrification (John Todd Ecological Design). Then, the aeration system added air to the water by the floating aeration system blowers and forced the water to go through the biologically diverse areas (John Todd Ecological Design). The Restorer cleaned the water by several bacteria species that lived in the plant roots and fabric media (John Todd Ecological Design). These bacteria species digested sludge and grease, as well as removed nitrogen (John Todd Ecological Design).

The Restorer helped to improve water quality in the canal and reduce the odor. The clarity of water was increased to several feet from less than 6 inches in the beginning, while passing the effluent standard (John Todd Ecological Design). The canal became a recreation area for the community (John Todd Ecological Design). The result shows 92 percent reduction of COD and BOD (John Todd Ecological Design).

CHAPTER 4. RESULTS AND DISCUSSIONS

4.1 Design Concept

- Proposed landscape architecture as the water treatment facilities
- Addressing the informal communities as a part of the city
- Public space system for the communities that connect to the city
- Providing potentials for more urban infrastructures

4.2 Comparison and Design Diagrams

The infrastructure systems of Bangkok are not strategically planned. Therefore, they cause many negative impacts for the society and lead to informal settlement around the city. The diagram shows how the city has been constructed along with the informal communities in the city. The map shows that seven water treatment facilities in Bangkok are unable to serve the whole city. The canal and road systems of Bangkok

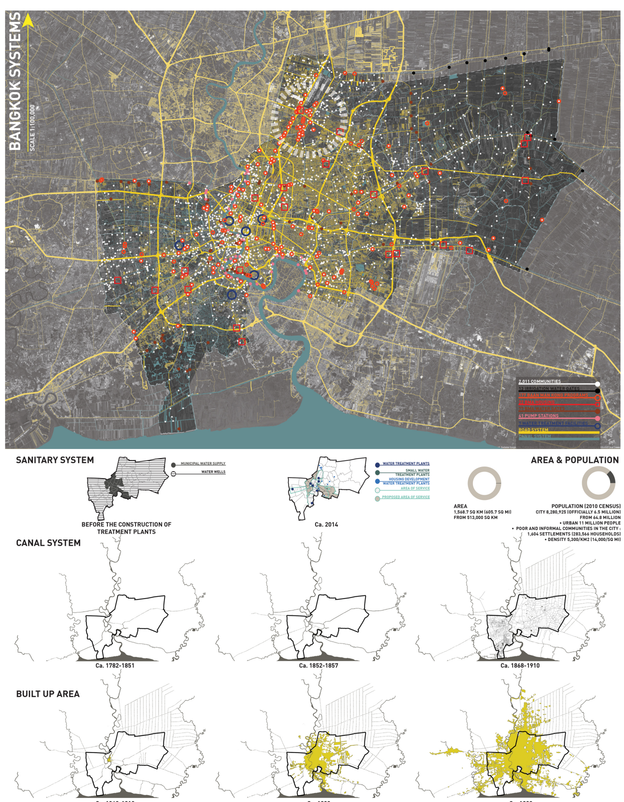

Fig. 1 The map shows the overall infrastructure systems of Bangkok relating to the informal communities.

Bang Bua Communities are in northern Bangkok. The map shows that there are many informal communities in this area. The land use of this area is mainly residential and governmental land. The site location is near a military base, the international airport, universities and an air force base. However, the site is at the canal edges, cut off from the rest of the city.

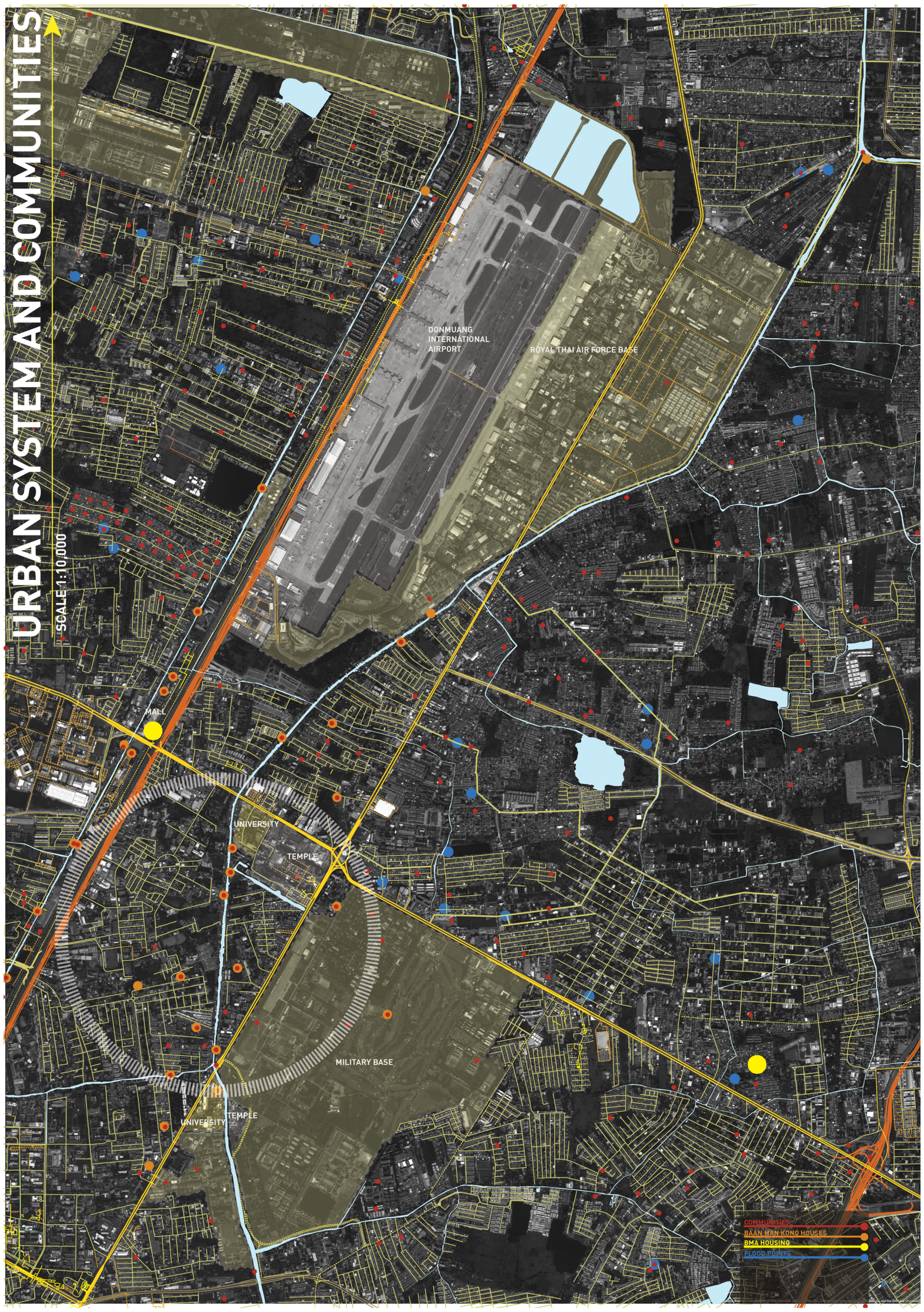

Fig. 2 The map shows the urban systems of the area near the site. The land use pattern is unclear.

The existing water and sanitary treatment systems on site are divided into two systems, before improvement and the new development. The old treatment system uses conventional sewage system along with cost-efficient D.I.Y. grease traps for each house to treat the water. However, the conventional sewage system is always failing in the high-density areas and the D.I.Y. grease trap is unable to control the amount of water that drains into the canal. The new development comes with septic aeration tanks, which provide better operation, and newly installed pipes that connect the water from the households to the municipal drains. In the new system, the water that drains into the canal is still not clean. Therefore, the people from the communities are using floating plantings of Water Hyacinth to help in cleaning the water.

Fig. 3 The drawing shows the existing treatment systems of Bang Bua communities.

Since the water treatment facilities in Bangkok are not enough to serve the whole city, the proposed ecological treatment systems in the program aim to develop on-site treatment and improve water quality in the canal. According to the study, the on-site system with smallest footprint that can find in the market is Organica Water. Due to the limited size of land, the proposed development will use Organica Water system as a treatment system on site for water from the communities, along with phytoremediation methods for water in the canal.

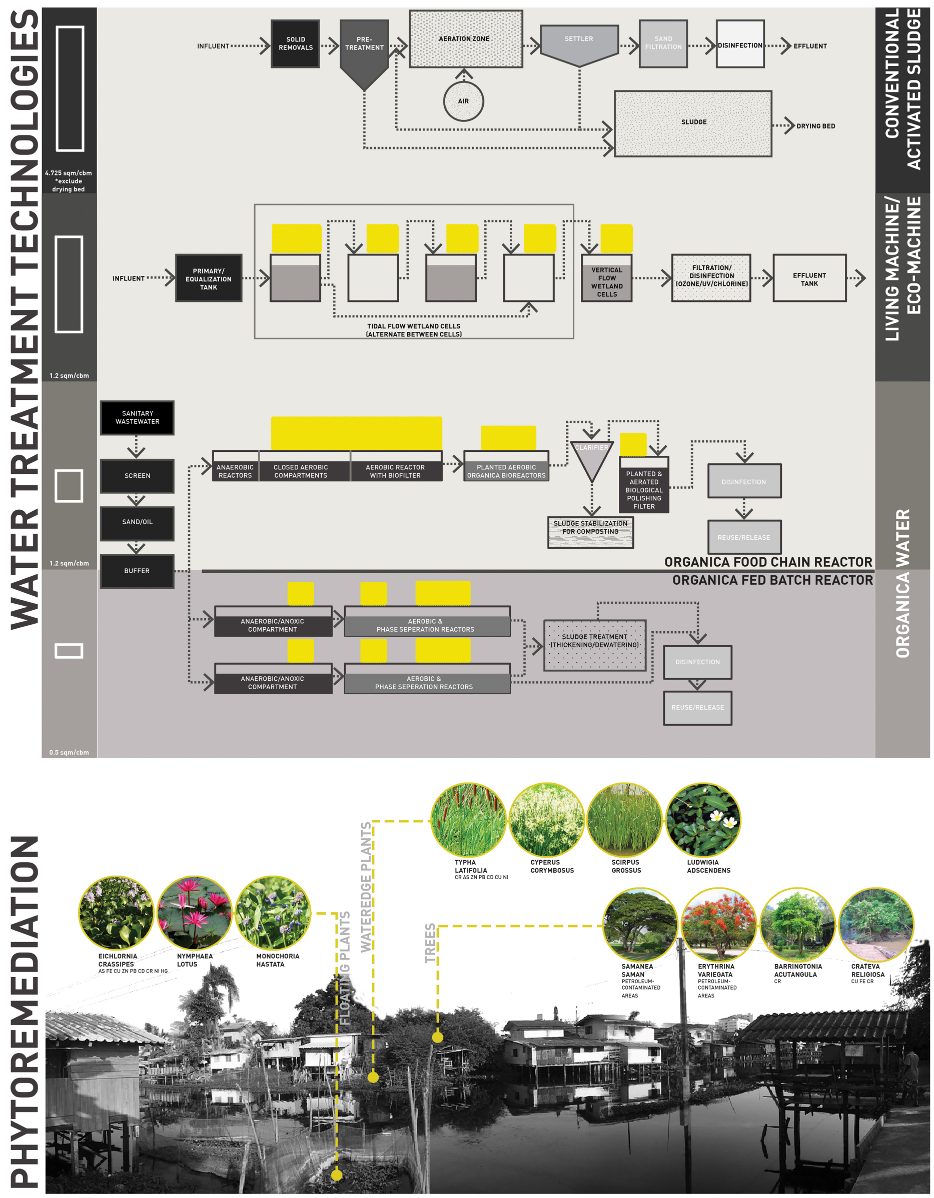

Fig. 4 The drawing shows the proposed treatment systems for Bang Bua communities.

The urban growth of Bangkok turned the agrarian society of Bang Bua into informal communities and now they are now on upgrading process. The Baan Mankong Program aims to keep every house to stay in their existing communities. There are some communities that have already been upgraded. However, most of the communities need improvement. The proposed housing units will create different water edge conditions according to the land and house sizes.

Fig. 5 The drawing shows the development of Bang Bua communities and site existings.

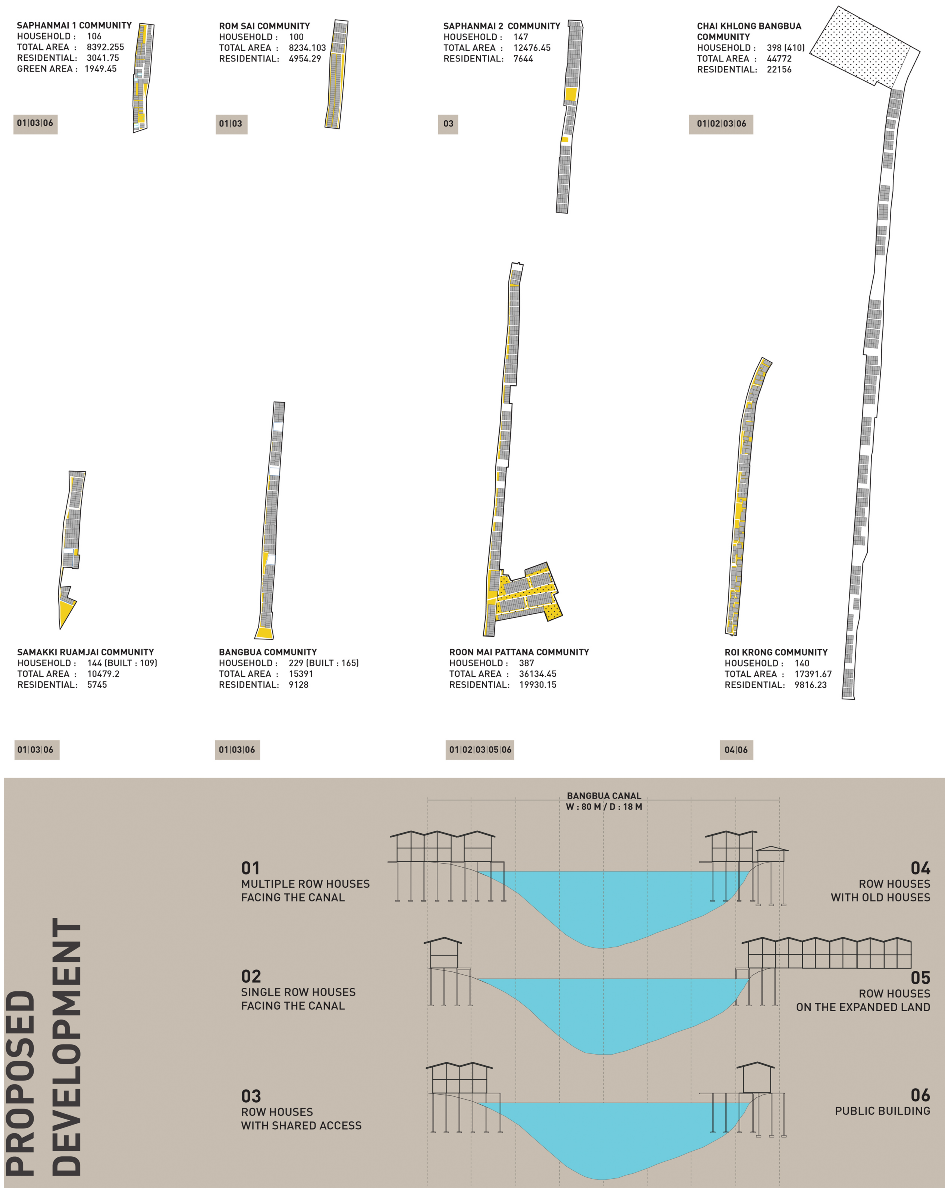

Fig. 6 The drawing shows new house types of Bang Bua communities after upgrading.

4.3 Opportunities, Constraints, Site Plan and Site Details

There is high potential for connecting the site back to the city. Small roads can connect the residential parts of the city to the site, while the vacant public lands next to the site can turn into urban infrastructure such as urban plazas and water treatment facilities. Vacant lots inside the communities become parts of the linear park system.

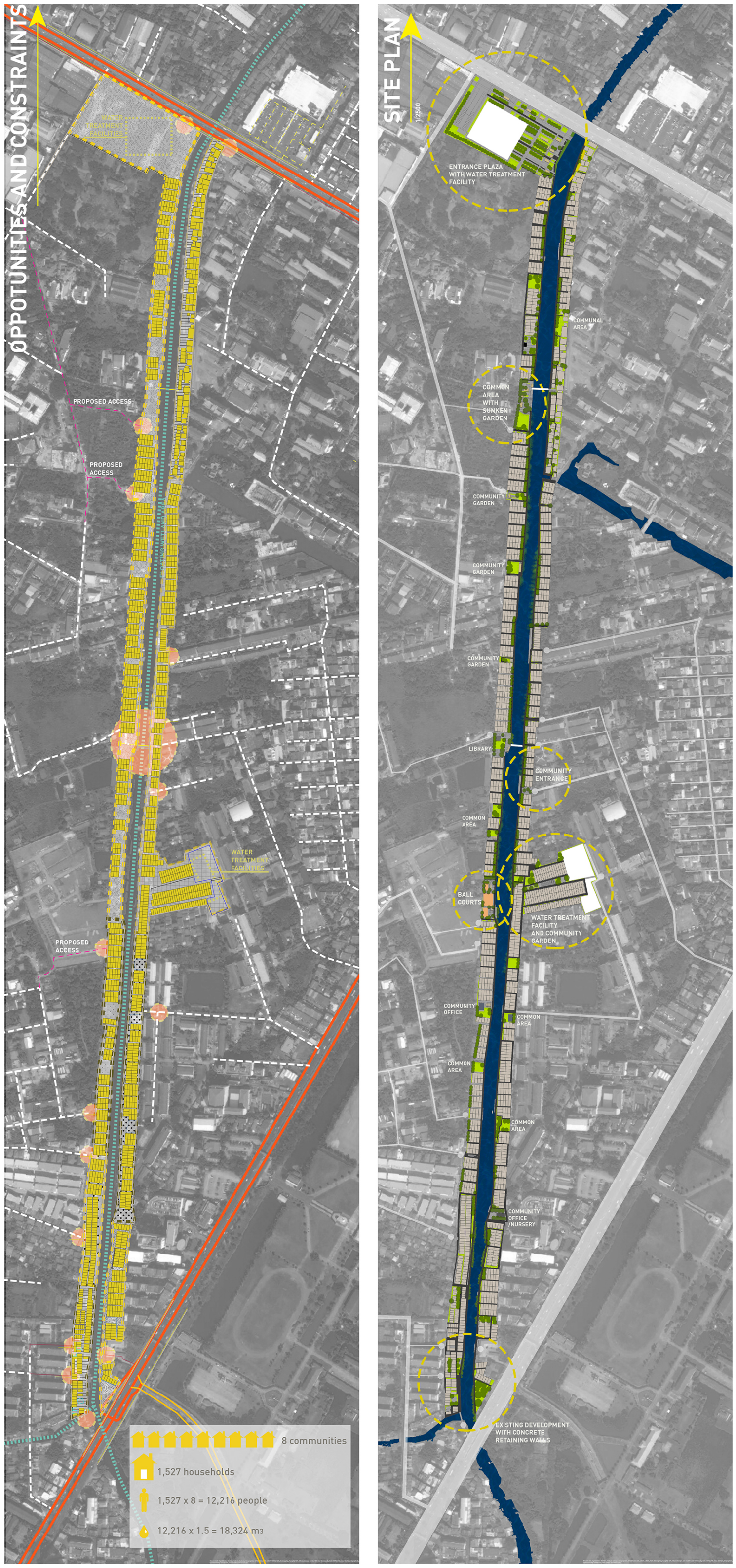

Fig. 7 and 8 The drawing shows opportunities and constraints of the community development and the site plan after upgrading.

The plan shows that the proposed development turns the vacant spaces adjacent to the site and empty lots in the communities to water treatment facilities and public open spaces. The area next to the main road becomes a public plaza where the street vendors from the communities can sell their goods to the people from the rest of the city. The plaza also supports a wide range of uses, such as social space, playground, commercial space and seating area. The canal edge is stabilized by plants and functioned for phytoremediation. The vacant lots inside the community become gathering spaces, playgrounds and community gardens. These bring opportunities for social development.

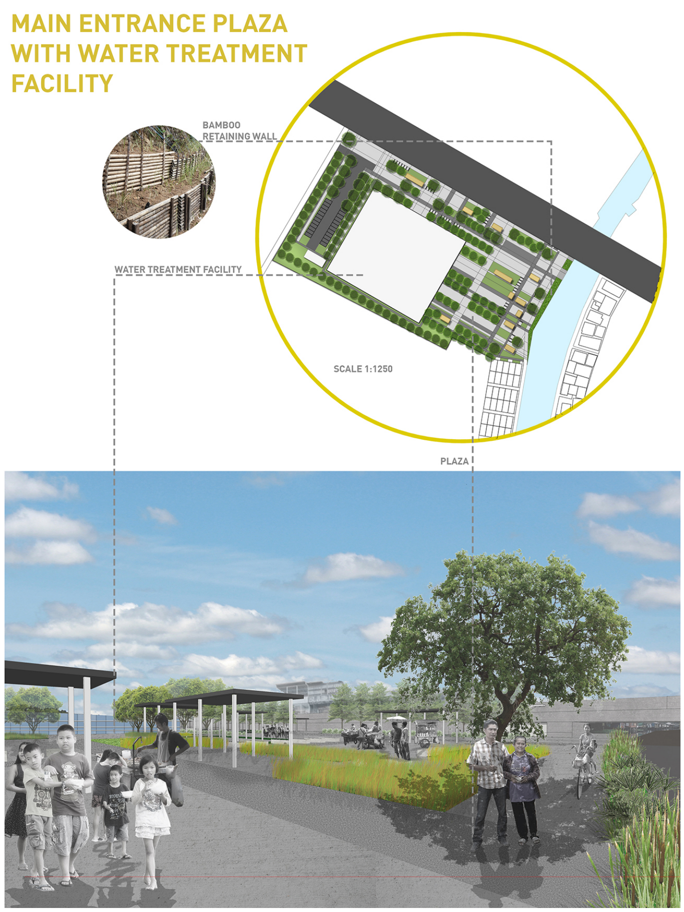

Fig. 9 The drawing shows perspective and details of the main plaza after upgrading.

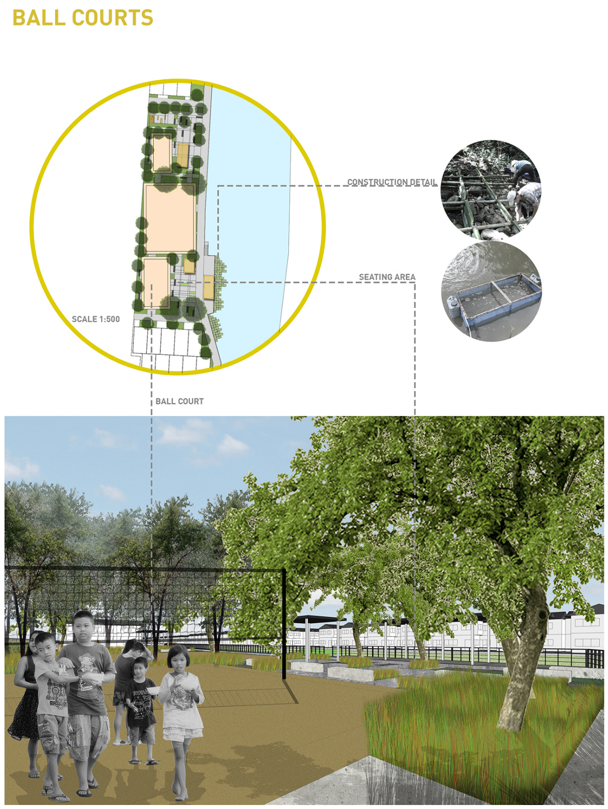

Fig. 10 The drawing shows perspective and details of ball court area after upgrading.

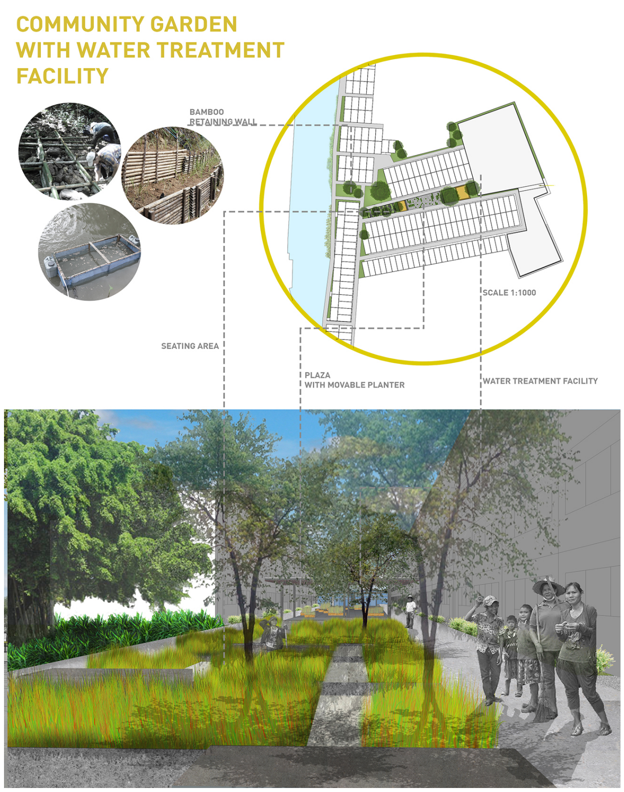

Fig. 11 The drawing shows perspective and details of community garden and water treatment plant area after upgrading.

COMMON AREA WITH SUNKEN GARDEN

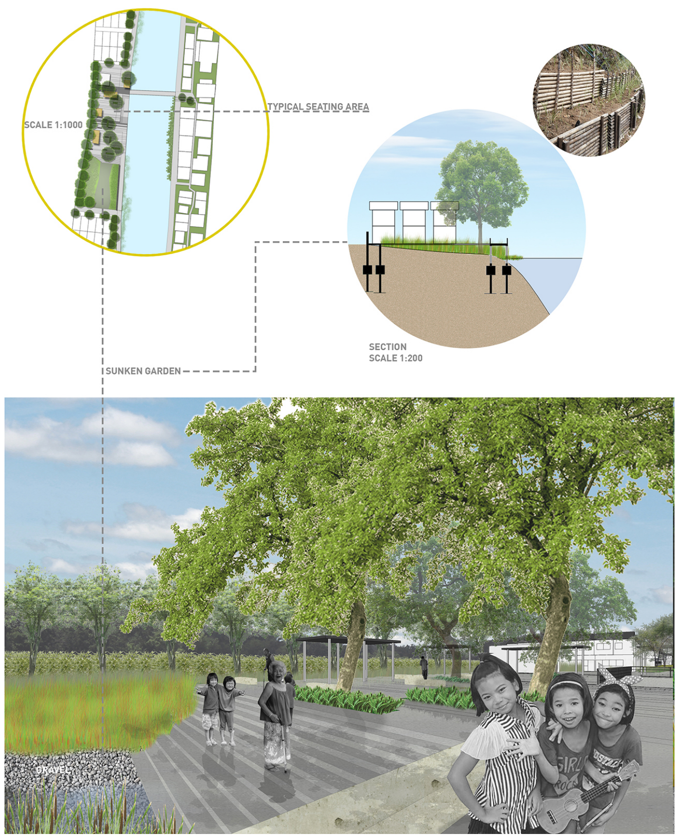

Fig. 12 The drawing shows perspective and details of common area and sunken garden after upgrading.

FLOATING WETLAND

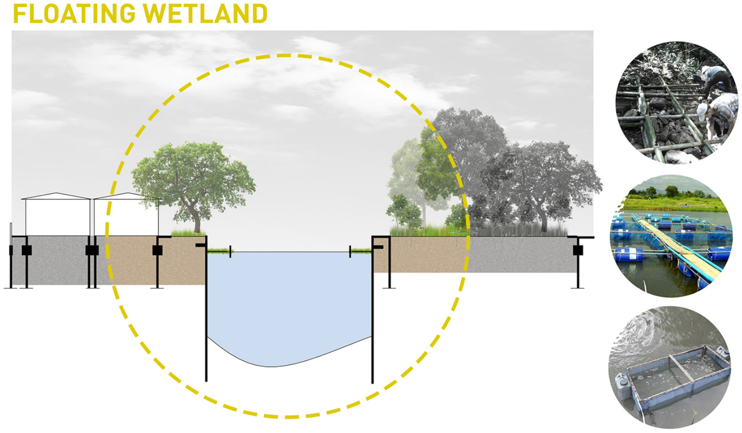

Fig. 13 The drawing shows the details of floating wetland after upgrading.

CHAPTER 5. CONCLUSIONS

5.1 Answers to the Research Questions

Informal settlements or slums are global issue. Large groups of people around the world are in need of adequate housing, proper infrastructures, clean water and basic sanitization. The living conditions of slums lead to other major issues in the societies. One-third of the world's urban population live in slums and the largest majority of slum dwellers live in developing countries (UN-Habitat, “2003 The Challenge” 2). Asia had the largest number of slum dwellers (about half of the global population of slum dwellers), which reached 554 million people in 2001, followed by 17 percent in sub-Saharan Africa (187 million people), 14 percent in Latin America (128 million people) and 6 percent in other developed countries (UN-Habitat, “2003 The Challenge”). Today, the world's urban population growth is concentrated in, and has a significant impact on, developing countries and their urban conditions (UN-Habitat, “2003 The Challenge” 5). This will results in the growth of slum population and expansion. Therefore, slum upgrading is needed to solve this urgent issue around the world.

As a pilot project for slum upgrading in Thailand, the new development for Bang Bua Canal communities will establish the connections between each community, as well as between the communities and the city. The newly constructed houses provide more safe spaces for the communities. The design utilizes the limited spaces in the community and provides proper public space facing the canal. The waterway becomes the main open space for the communities, providing vistas and making the new public spaces open to public, increasing social interaction in the public space. Therefore, the communities from both sides of the canal can help to observe each other, making safer communities.

The plaza at the main road will provide opportunities for economic activity for people from the communities, while the public spaces in the communities will be covered with more tree canopy and create more social interaction.

The new water treatment facilities will help to treat wastewater for approximately 24,000 people according to the calculation. They also provide the educational space to study how the

treatment system works and make the water system in the communities cleaner. The overall costs of operation are lower than buying big plots of land for the conventional activated sludge system. Therefore, it will be cost-effective.

The new development of Bang Bua will create more economic opportunities, better environment and more social interactions based on cultural approach. The communities will be improved for the better quality of life.

The study in this thesis investigates and develops a way to improve living conditions for people in the informal settlement of Bang Bua Canal from landscape architecture approach. This could also be developed for slum upgrading projects in the other parts of the world. As the world's population is increasing, there should be many ways to solve the living conditions issues based on different cultures and existing social conditions. This research proposes methods to help address these social issues in pursuit of a better society in the future.

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