



Title:

**3D Modeling of Evolved Urban Fabric around Farm Ponds**

Authors:

Naai-Jung Shih, [shihnj@mail.ntust.edu.tw](mailto:shihnj@mail.ntust.edu.tw), National Taiwan University of Science and Technology  
 Yi-Ting Qiu, [chooi0215@gmail.com](mailto:chooi0215@gmail.com), National Taiwan University of Science and Technology  
 Yun-Ting Tasi, [troycar306@gmail.com](mailto:troycar306@gmail.com), National Taiwan University of Science and Technology

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Introduction:

Farm ponds in Taoyuan, Taiwan, were engineered to fulfill irrigation demand under the specific regional topographic features, soil, hydrology, and river types. Ponds planned by early people had created an irrigation system for agriculture by taking advantage of rain water and topographic features. The slope is changed from 1/40 to 1/120 which was sufficient to excavate pond and irrigate land in lower area. Extra water was caught by lower ponds consequently. Farm pond system was developed in three stages: Quin Dynasty (before 1904), during Japanese Colonial Rule (between 1904 and 1945), and the completion of Shimen Canal (1963) and Shimen Reservoir (1964) (Fig. 1, left) after 1945 [1-3].

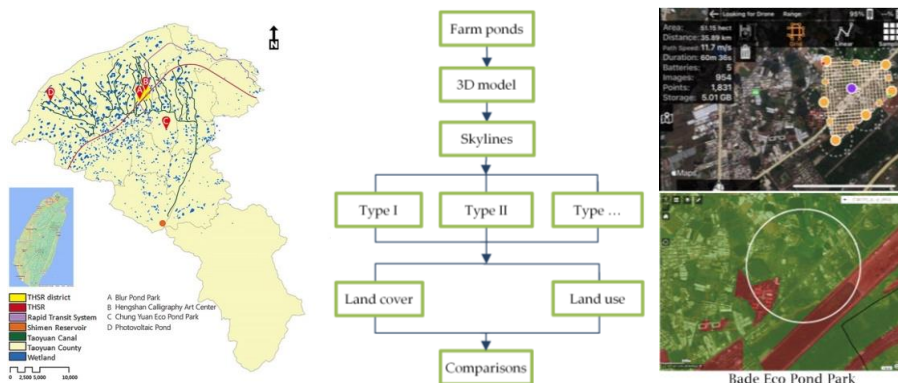


Fig. 1: Pond distribution (left); flowchart (middle); UAV plan and restricted area (right).

Farm ponds have been developed as an irrigation system and, in the meantime recognized as a culture icon in Taoyuan. Its role has been gradually replaced by reservoir and canal system. Many ponds were obsolete. The erosion of resilience in an old ecosystem is an ecological crisis [4]. As part of wetland [5], pond-related concerns lead to the initialization of wetland act and the developing pattern for pond resilience [6]. Related studies were also conducted by central and local governments for the planning of database, activation patterns, and demonstrations by the Water Resources Agency, Ministry of Economic Affairs [7]. Recently developed canals have created links and revitalized local ecology system. The revitalization was specified in detail urban plan as part of the developing strategy. Two

pond parks, the Blue Pond Park and Calligraphy Art Center, were planned specifically with strong connection to the future development of specific district near the Taiwan High Speed Rail (THSR) station in Taoyuan [8].

The maximum number of pond reached over 10,000, and was reduced to 8,845 after the completion of Shimen Reservoir [9]. Currently only less than 3,000 ponds exist. Based on the data released from Taoyuan City Government, survey made by National Wetland Conservation Project in 2011 concluded 2,851 ponds and 2,599.73 hectare in Taoyuan [10]. Some were filled and leveled up for the construction sites of new communities, parks, schools, or government agencies.

#### Research Goal:

This research aims to study the land use and skyline of farm ponds based on the UAV-assisted photogrammetric 3D modeling of evolved urban fabric in neighborhood. Based on the development occurred to peripheral region and the conversation made between urban fabric and pond, case studies were made to conclude developing patterns.

#### Case Studies of Developing Patterns:

Eight ponds were selected for individual history, designated role, and major developing type of building around them. Each pond is surrounded by specific urban fabric and thus creates distinguishing pattern of development (Fig. 2). Selections were mainly made to ponds located near the Green Line of Taoyuan Rapid Transit System and apart from it, in order to explore their potential relationship to the concept of Transit-Oriented Development (TOD): whether ponds are developed and influenced by urban context and mass transportation system.



Fig. 2: Facilities around Chung Yuan Eco Pond Park.

#### *Blue Pond Park*

Blue Pond Park was the first Eco Park in Taoyuan (Fig. 3), since 2007. It went through the second renovation in 2014 with new tourist center constructed in 2016. It was one of the sightseeing locations promoted by government, the first demonstration park for new development, and the jointed lantern site during 2016 Taiwan Lantern Festival. During the cultural event, water show was deployed and surrounded by lotus lanterns next to the stages and cable-stayed bridge in the center of the pond. Within the boundary of 250 m in semi diameter, residential building is the main type of construction added around the park. The mix-used areas, which were increased mostly in 2014, were large-scaled residential buildings with ground floor for commercial use. The area of commercial buildings remained the same, and most of them were allocated within residential areas.



Fig. 3: Building types in 2020 (left) and the area of modifications highlighted on 2010, 2012, 2014, 2016, and 2018 around Blue Pond Park (right).

#### *Photovoltaic Pond*

No. 12-14 Photovoltaic Pond was located in Xinwu District, Taoyuan City. It was the first farm pond covered by 5,000 m<sup>2</sup> photovoltaic panels with the capacity increased from 481.44 kw in the first stage

to 2,000 kw in the second stage. Annual power generation will be 0.6 GWh (Gigawatt hour) which is enough to support 170 families annually [12]. Since 2019, Taoyuan Agriculture Expo was held in the park and the dry farmland next to the pond. Large scaled exterior installations were left for long-term education and demonstration purpose of leisure agriculture. The public facilities increased significantly in 2019.

#### Active Segmentation of Skylines:

Skylines were applied to illustrate the interface between a pond and peripherals. UAV imagery presented the most updated fabric of constructions, circulation system, and landscape around a farm pond. The layout can tell how close a building was located to a pond. Two methods were applied to the UAV-based 3D model by creating sections and contrast projections of a specific region. The former made linear or zigzagged sections to highlight the diversified land use and land cover (LULC). The latter illustrated the impact of a specific region by turning on/off new constructions from the model. Both methods took the advantage of skyline as an indicator of urbanization, in which the context was contributed by profile and repetitive patterns of buildings and landscape.

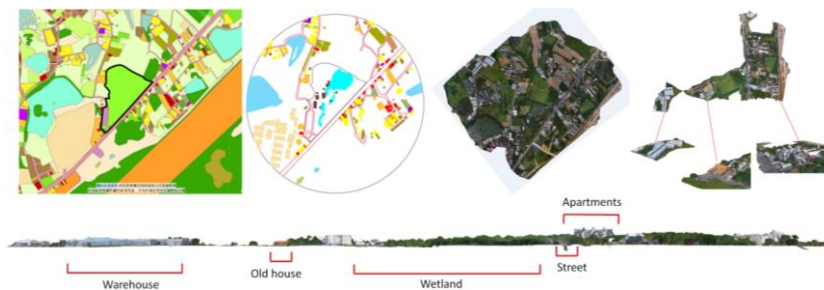


Fig. 4: Bade Eco Pond Park: land use, building types, and cross-site section.

The volumetric comparison of Bade Eco Pond Park revealed the type of development from an old low-rise community with inconsistent roof construction cover to a well-planned layout of apartments (Fig. 4). The skyline evidenced a possibly long-term development from an irrigation-based farm layout, an ecology park, to a landscape-oriented real estate planning strategy. Selected sections were made around Chung Yuan Eco Pond Park (Fig. 5) along a local main street and viewed from either side. The skyline illustrated lower profile with mainly factory-like façade. In contrast, the area next to the pond illustrated a mixed low and high combinations of residential and apartments or university buildings. This case illustrated dramatically different fabric from a green space filled with factories to the pond surrounded by a university and old communities. It was originally presumed that the farm pond contributed to part of the green space. However, the long-term developing community had created a special pattern of urbanization in a preferable pond-centered distribution which even crossed the main street to the other side.

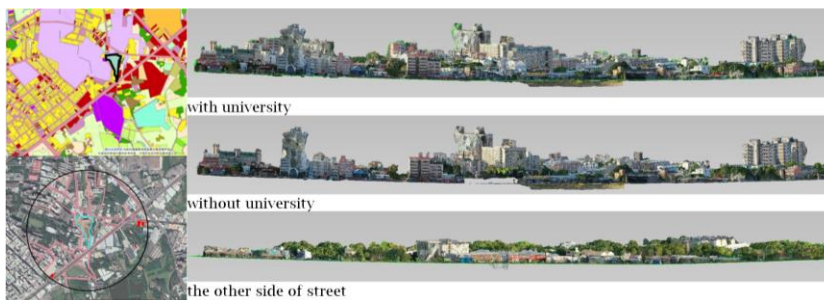


Fig. 5: Chung Yuan Eco Pond Park: land use (2019), building types, and cross-site sections.

The interrelationship between the pond and peripherals has been changed from a farm pond to a retention pond to alleviate long-term flooding problem. This pond was excavated and re-designed with scenic overlook as part of the landscape connecting campus. The campus buildings also reshaped the skyline as gradually evolved from where the pond was located.

#### Discussions:

Three-dimensional scan can be applied to integrate with GIS data for analysis purpose [13]. This study showed each pond represented a specific diversity with different developing pattern. Active skyline led to a likeness of higher overall living quality in creating the relation with THSR circulation system and the specific regional development plan. A constant investment had been made to increase the future credential from the detailed development plan for THSR special district. For example, a purposely designed bridge was added to enrich pond's role of variety in urban context. A rather passive skyline of pond development was to install photovoltaic panels to create the capacity of green energy.

Active skyline was also made possible through festival event and temporary urban fabric. Typical pattern of skyline for early development but low flexibility can be seen in Chung Yuan Eco Pond Park which is located in a region with high density of residences. Pond is a wetland that cannot be developed privately. This pond has illustrated a strong advantage as a retention pond excavated deeper to create more capacity of water storage, and also a typical pattern and a lesson learned as a consequence of replotted commercial use in an over-developed neighborhood.

#### Conclusions:

The development of farm ponds and properly evolved urban fabric can be achieved from a strategy defined by special zoning specification [14]. A balanced developing strategy under the diversity of emphases can be illustrated by the skyline through historic and well-developed local character. Although local fabric was changed by the saturated area of new resident building and the mass development of office buildings, the similarity in development illustrated the potential convergence trend between increased developing area and decreased undeveloped area. Active skyline was contributed by the consistent enriches of urban fabric. Former planning has combined the pond contexts with the assistance of the skyline to illustrate the evolvement of new pond infrastructure.

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