ArcGIS Web- based Rapid Application Development for Presenting Urban Street Trees on Sidewalks

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Abstract

One goal of Nakhonratchasima City Municipality (NCM) development plan year 2018-2022 specifies to trees' increasing and caring for developing environmental quality. Thus, this paper requires developing ArcGIS web-based Rapid Application Development (RAD) for presenting urban street trees on sidewalks. This ArcGIS web is developed by using concept of Web Development Life Cycle (WDLC) with 4 steps: (1) building prototype model of ArcGIS web with requirement of the 3 focused groups (the 4-NCM official, the 2-academic expert, and the random sampling of 160 of 400 NCM resident (response back), (2) developing ArcGIS web-based RAD, (3) testing and evaluating, and (4) implementing and maintaining. The result of ArcGIS web development comprises of non-spatial and spatial data. This ArcGIS web can access with 2 levels: administration and users. This ArcGIS web was evaluated by acceptance with 3 focused groups who were evaluated by questionnaires; they accepted high level as same. Consequently, this ArcGIS web will be able to implement for presenting urban street trees on sidewalks and promoting a good image and environmental quality and the beautiful urban forest landscape for NCM area (where is developing as the smart city further).

Keywords: ArcGIS web, Rapid Application Development, Urban street tree, Sidewalk

1. Introduction

According to the National Strategy 20 Years (2018-2037), there is strategy about the growth building with friendly environmental quality of life for a sustainable green economy society (NSCR, 2021). This national strategy includes (1) enhancing the value of a bio-based economy, (2) conserving and restoring biodiversity including studying, surveying and creating a database, (3) conserving and restoring rivers, canals and water bodies, (4) maintaining and increasing green areas to become environmental friendly, and (4) promoting sustainable consumption and production. In addition, this national strategy has influenced office of Nakhonratchasima City Municipality (NCM) to plan the NCM Development year 2018-2022 (Office of NCM, 2019) in term of the natural resource and environmental management for the management of environmental quality at the appropriate level. This mentioned NCM development consists of (1) promoting well-being; (2) accelerating urban landscape improvement with ecological concept; (3) development and management of environmental quality; and (4) enhancing capacity in natural resource management. These issues are determined as the approach of green city development in NCM area.

At the present time, office of NCM improves trees' landscape where locates both in and out the old moat in accordance with the Cleanliness and Orderliness of the Country Act, B.E. 1992 (Office of the Council of State, 1992). Therefore, the aim of this study would like to help developing ArcGIS web- based Rapid Application Development (RAD) for presenting urban street trees on sidewalks. This research will play an important role for supporting and developing green infrastructure to prepare a smart city with developing high-resolution digital maps. This helps to promote for a good image and environment through the beautiful urban forest landscape. Moreover, this will encourage more tourists to travel within NCM and help stimulate tourism in the NCM area. In air quality, it has environmental benefit for reducing air pollution which is hot issue in NCM.

2. Literature review

2.1 ArcGIS web application for urban trees

ArcGIS capabilities allows users to train a dozen deep learning models on geospatial datasets and derive information products using the ArcGIS API for Python or ArcGIS Pro, and scale up processing using ArcGIS Image Server (Novum Intelligence, 2020). Moreover, there is model to classify points representing trees in point cloud datasets (ESRI, 2020a). ArcGIS online is a powerful tool that allows you to easily create, store, and share data, interactive maps, custom applications, and other geospatial content across your organization for the public (Stone Environmental Inc., 2021a). For using ArcGIS online for presenting urban trees, this study has recently reviewed relevant to websites and papers as Table 1.

2.2 Methodology for web development

Recently, Web Development Life Cycle (WDLC) is used for a new methodology of web development (Signity Software Solutions, 2019; French, 2010). Traditionally, web development uses System Development Life Cycle (SDLC). However, SDLC cannot be used for web development and proposed web development life cycle model, a hybrid model for web development while WDLC is able to use and decrease the time of development, add structure to an unstructured problem, and keep the users involved throughout the entire development life cycle (French, 2010). Generally, the SDLC are designed and established for application development includes Joint Application Development (JAD), Rapid Application Development (RAD), and Prototyping. Prototyping is an adjustment to the SDLC used to speed up development and delivery of applications (Kendall and Kendall, 2010; French, 2010; Turban et al, 2004). In this study, we chose WDLC based on RAD process. RAD allows developers who can make adjustments quickly during the development process, enhancing flexibility and adaptability and encouragement of code reuse, which means less manual coding, less room for errors, and shorter testing times (Singh, 2019). RAD processes consist of 4 steps: (1) define project requirements; (2) prototype; (3) rapid construction and feedback gathering; and (4) finalize product and implementation (Lucichart, 2021; CODEBOTS, 2020).

2.2 Web evaluation-based acceptance of information technology

In this study, the Technology Acceptance Model (TAM) -mainly based of Davis et al., (1989), has been used for evaluating this ArcGIS web application. TAM is one of most influential theories of information system. It was theorized for the aim of modelling the information system' acceptance by potential users, that is to predict Information system (IS)/ Information Technology (IT) acceptance and diagnose any design problems before the systems are actually used (Chandio, 2011). The basic constructs of TAM, were based on perceived usefulness and perceived ease of use constructs, were the factors most commonly referred, and were important for TAM

Table 1. Using ArcGIS online for presenting urban trees

No.	Titles and Authors	Details
1	Tree preservation by DDOT (2021)	This web provides ArcGIS online for following the steps to responsibly manage the trees on property throughout development project.
2	VERMONT Youth Resources by Stone Environmental Inc. (2021)	This ArcGIS web presents urban trees in many Vermont communities.
3	the urban tree canopy by ESRI (2020b)	This web offers the urban tree canopy in other US cities.
4	Presenting the trees to view pop-ups containing in Montgomery Botanical Center by ESRI (2019)	The ArcGIS web application, created by ESRI to demonstrate how organizations can quickly get an application like this up and running, offers users a way to explore the center virtually. Just click the trees to view pop-ups containing more information such as the scientific and common names of the trees and photographs of each one.
4	GIS tree inventory by City of Chanpaign (2021).	This web shows to know type of tree is growing in front of house.

Remark: DDOT is The District Department of Transportation and US is the United State.

as a simple, predictive, and robust tool to assess the acceptance of IT by users (Tella & Olasina, 2014; Venkatesh & Davis, 2000). In addition, TAM suggests was presented to the users, the users decide when and how they used the technology based on a number of factors as (Davies & Venkatesh, 1995):

- Perceived Usefulness (PU): which is defined as "the degree to which an individual believes that using a specific system would improve his job performance?"
- Perceived ease-of-use (PEOU): which is defined as "the degree to which an individual believes that using a specific system would be free from effort"?

3. Materials and methodology

3.1 The NCM roads

This study concentrated on 2 NCM-roads: Phoklang and Jomsuratyat where are in administration of NCM area where establishes from 14°56'-15°00'N to 102°01'-102°08'E (Figure 1). Such 2 roads are selected as study case because there are the high density communities and many importantly govern places (e.g., office of NCM, Sukanaree school) and cultural tourism (e.g., Thao Suranaree monument and the ancient temples). The general characteristics of such 2 roads can explain as follows:

1) The Phoklang road is long 1.53 km where origin point starts from five intersections of Nakhonratchsima train station to location of Thao Suranaree Monument (destination point). This Phoklang road is the second of fifth intersections of Nakhonratchsima train station. Phoklang road cuts through Tedsabarn, Kaset (or Kaset alley), Yotha and Buarong roads. Some block segments of Phoklang road have only two lanes which cannot handle rush hour traffic. In addition, Phoklang road is the main road on the west-east line where cuts through the high density community and the important places (e.g. office of NCM, Sukanaree school and Thao Suranaree monument) in NCM.

2) Jomsuratyat road is long and 1.57 km where origin point starts from five intersections of Nakhonratchsima train station to location of Thao Suranaree Monument (destination point). This Jomsuratyard road is the third of fifth intersections of Nakhonratchsima train station. This road cuts through Buarong, Yotha and Tedsabarn roads along western direction and rail routes of northern east region (start from Jira train station to Suranaree road). Some block segments of this road have only two lanes which cannot handle rush hour traffic. In addition, there is importantly governing places such as behind side of NCM office, Nakhonratchasima forest office, Sukanaree school and history temples etc.

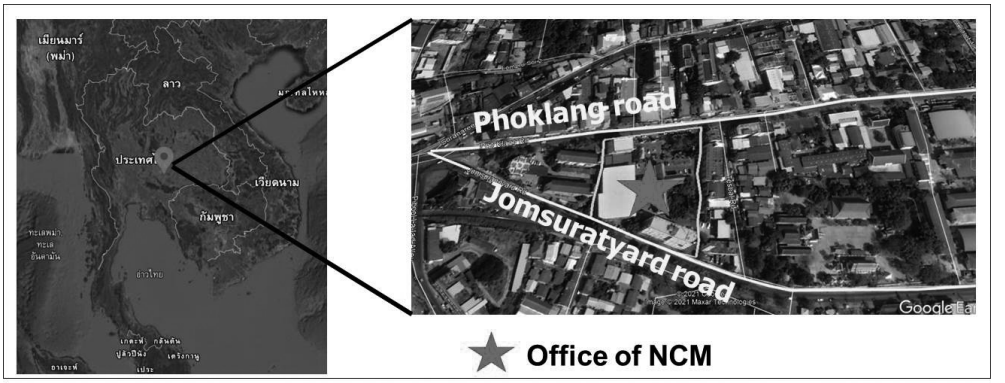


Figure 1. Phoklang and Jomsuratyat roads in NCM

3.2 Developing ArcGIS web application-

This study explores characteristics of trees along sidewalk of such 2 NCM streets above. These are presented on development of ArcGIS online with WDLC-based RAD process includes the main 4-step and more details as follows:

3.2.1 Building a prototype modeling of ArcGIS online with requirements of the particularly focused groups

The particularly focused users consisted of 3 groups: (1) the 4-NCM official, (2) the 2-concerned academic expert, and (3) the 160 (back responding) of 400-NCM resident-based random sampling. They were interviewed by questionnaires for suggesting development of ArcGIS online for presenting urban street trees on each studied sidewalk. The prototype modeling was designed by work flow-based composition of ArcGIS web development as shown as Figure 2. This framework consisted of main and sub processes as follows:

1) Data sources include field collection, Development Plan of Nakhon Ratchasima Municipality (2018 - 2022), and literature reviews in topic 2. These data can be taken to design questionnaires for asking specially focus group.

2) Layers for trees on sidewalks along NCM roads were transformed from UTM-based GPS equipment to point layers-based ArcGIS program.

3) Layers for NCM roads were extracted from google map to line layers-based ArcGIS program.

4) Thematic maps were built from 2) and 3) with using ArcGIS program.

5) Geodatabase on web was developed by using Microsoft SQL and PostgreSQL.

6) Developing ArcGIS online-based RAD process (more details in 3.2.2) includes (1) designing context diagram and data flow diagram with requirements of the focused groups, (2) developing ArcGIS web application on ArcGIS online, (3) testing and evaluating ArcGIS web application and (4) implementing and maintaining of ArcGIS web application.

7) Evaluating ArcGIS web application used TAM.

8) Representing urban street trees on sidewalks was shown by ArcGIS web application.

9) Servicing map and information were requested via ArcGIS server.

3.2.2 Development of ArcGIS web application-based RAD process

This study is looking for a faster method of ArcGIS web application development that RAD process can continuously allow iterations. On the other words, this RAD helps to end up restarting the development from the beginning every time the client suggests changes. This ArcGIS web application was developed by requirements of the 3 specially focused groups (as 3.2.1). In this development of ArcGIS web application, there were 4 processes as follows:

1) ArcGIS web application was designed by context diagram and data flow diagram (as Figure 3.).

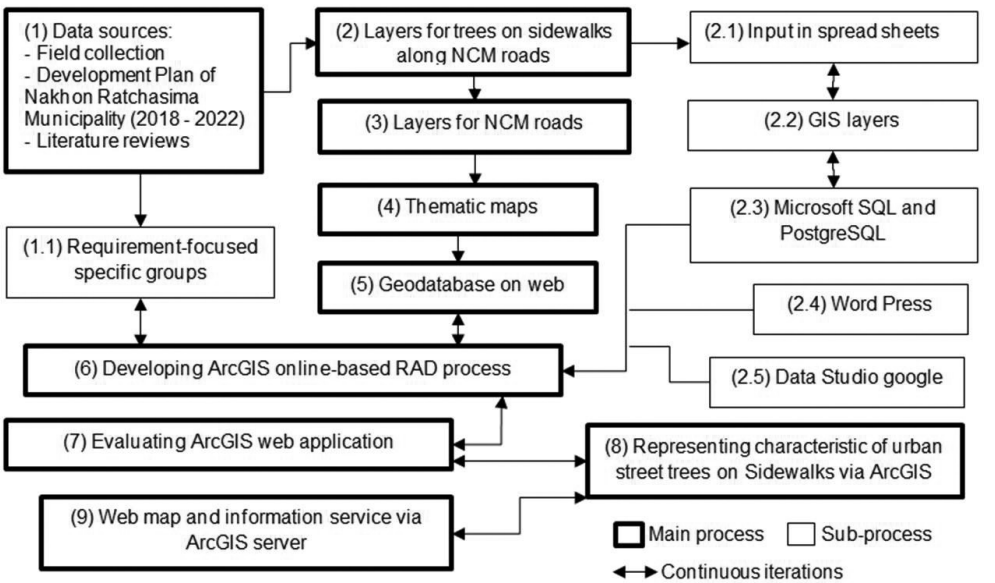


Figure 2. Model work flow for developing ArcGIS web- based RAD process

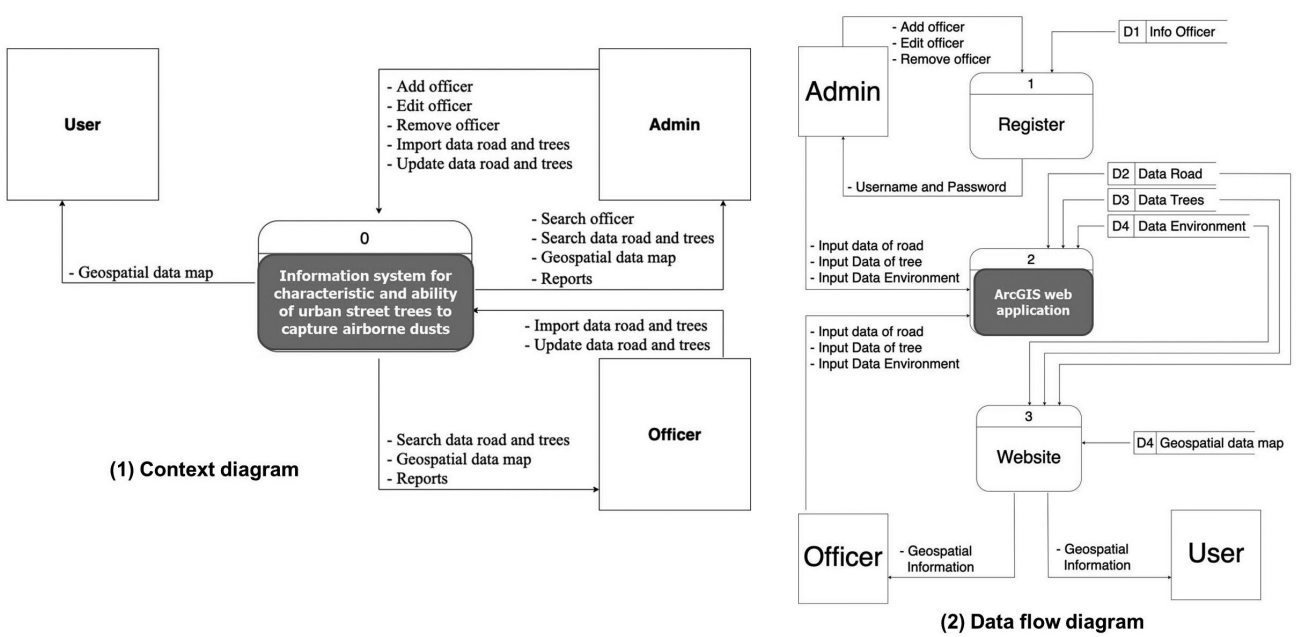


Figure 3. (1) Context diagram and (2) Data flow diagram for developing ArcGIS web application

2) ArcGIS web application was developed by ArcGIS online, integrated to Microsoft SQL and PostgreSQL, Word Press and Data Studio Google. Such mentioned programs can download and study working as Table 2.

Table 2. Programs for developing ArcGIS web application

No.	Programs	Sources
1	ArcGIS online	https://www.arcgis.com/index.html and https://www.esrith.com/products/arcgis-online/ https://www.esri.com/news/arcwatch/0712/create-customized-mapping-applications-using-esris-web-map-and-application-templates-in-arcgis-online.html
2	Word Press	https://wordpress.com/ and https://my.studiopress.com/documentation/usage/wordpress-features/how-to-update-wordpress/
3	Data Studio Google	https://datastudio.google.com/u/0/navigation/reporting and https://supermetrics.com/product/
4	Microsoft SQL	https://www.microsoft.com/en-us/sql-server/sql-server-downloads
5	PostgreSQL	https://www.postgresql.org/

3.2.3 Test and evaluation of ArcGIS web application

This ArcGIS web application was simultaneously tested and evaluated by researcher and the 3-focused groups (the 4-NCM official, the 6-concerned academic expert, and the sampling size of NCM residents. Research team generally tested functionality of this ArcGIS web application. The 3-focused groups concentrated on evaluating this ArcGIS web application in details of functionality, usability, interface, the spatial data and information, and compatibility etc. Critically, this ArcGIS web application was tested and evaluated until they satisfied or at least error about 90% before this ArcGIS web application will be implemented in NCM web. Essentially, in method of RAD process, developer can make adjustments quickly during the development process especially encouragement of code reuse, which means less manual coding, less room for errors, and shorter testing times.

Acceptance of this ArcGIS web application used TAM that was mentioned in work of Davis (1989) for evaluating group of NCM residents. Presently, NCM office reported all NCM population in February 2021 about 122,323 people (male 56,986 people and female 65,337 people). Therefore, sampling size-based reference of National Statistical Office (2012) was calculated by 398 people who was asked by questionnaires. In this questionnaire, there was 3 parts:

- Part 1 provided general data (i.e. gender, age, frequency),
- Part 2 provided acceptance of this ArcGIS web application for studying NCM street trees and dust capturing (e.g., providing data and information, accessing, interesting and attraction etc.), and (3) suggestions. This technology acceptance was designed in form of rating scale as: 5 means the highest agree; 4 means the high agree; 3 means the middle agree; 2 means the low agree; 1 means the lowest agree. Then such rating scale was interpreted by score range, 4.20-5.00 mean the highest acceptance; 3.40-4.19 mean the high acceptance; 2.60-3.39 mean the middle acceptance; 1.80-2.59 mean the low acceptance; 1.00-1.79 mean the lowest acceptance.
- Part 3 provided suggestions from NCM residents.

3.2.4 Implementing and maintaining of ArcGIS web application

This ArcGIS web application already has been operated domain registration named, www.gis-streettreets.ibuddyweb.com that is posted in web of NCM. For maintenance, Rajamangala University of Technology Isan (RMUTI) and NCM office will help each other to maintain this ArcGIS web that comprises of input data, delete data, update data, and upgrading ArcGIS online.

4. Results and Discussion

4.1 Data and information for presenting on this ArcGIS web application

In this study, we used tree data on inbound and outbound sidewalks of 2-NCM road: Phoklang and Jomsuratyard as case study. Inbound sidewalk means route into NCM while outbound sidewalk means route out of NCM. These data was taken from research project titled, 'Comparison of Tree Biodiversity in Urban Streets using Application of Geo-informatics Technology Between Nakhon Ratchasima Municipality (Nakhon Ratchasima, Thailand) and Honolulu (Hawaii, USA)', funded by Thailand Science Research and Innovation (TSRI) year 2021.

4.1.1 Non-spatial data for NCM trees on sidewalks (as Figure 4)

This study provides the non-spatial GIS data (as Figure 4) for NCM trees on sidewalks as follows:

1) Dash Broad reports overall of the NCM street trees on sidewalks such as the amount of trees, the amount of stumps etc.

2) Tree data reports the characteristics of NCM street trees and leaves with attribute data and photos.

3) Road data reports data collection of NCM street trees on sidewalks in form of excel files.

4.1.2 The GIS data for NCM trees on sidewalks

This study provides the GIS data (as Figure 5) for NCM trees on sidewalks e.g., point layer of trees on sidewalk (green point shows each tree and NCM boundary etc. Moreover, there is pop-up of trees is shown in this part too.

4.2 Accessing ArcGIS web application

This ArcGIS web application is developed for representing urban street trees on sidewalks and can visit at https://www.gis-streettreets.ibuddyweb.com/?fbclid=IwAR0E-tPQ2QgE9xkpSK5_6D8aF0wWf9wWQAFtlDUrD3bhCOVxBtnCsKXOlW0. In the future, this ArcGIS web will be posted at NCM web named, https://www.koratcity.go.th/. This study has presented trees on sidewalks of the 2-NCM roads (Phoklang and Jomsuratyard roads) as case study. This ArcGIS web application has been set by 2 levels: (1) administrators and (2) users (who focus on the 3-group: NCM officers, geospatial academics, and NCM residents).

1) Administrators comprise of 1 NCM officer and 1 RMUTI Academic who are formally allowed to manage all data and information and users' accessing (e.g., NCM Officers and residents and academics) on this ArcGIS web (Figure 6).

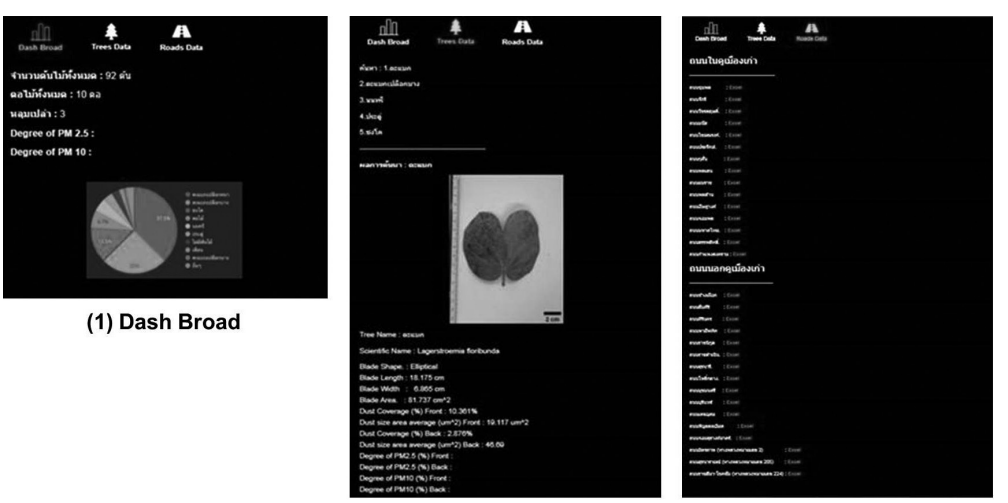
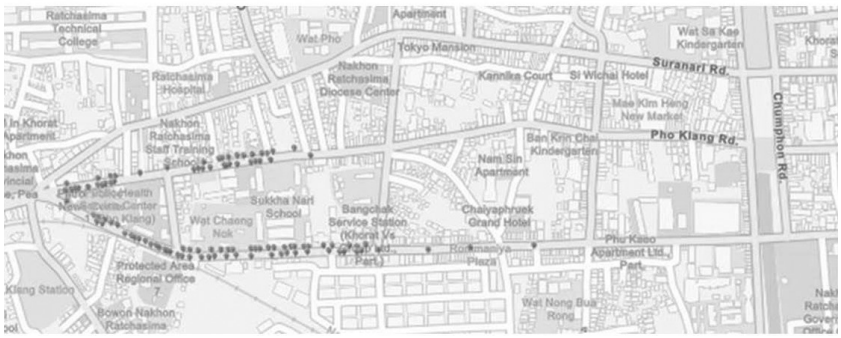
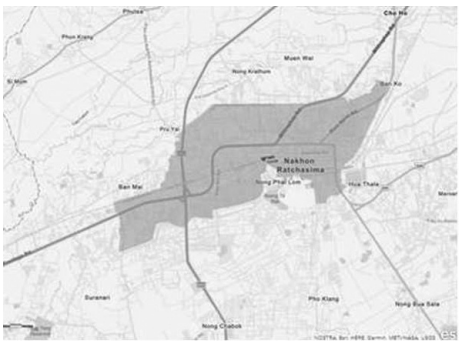


Figure 4. Non-spatial data for NCM trees on sidewalks



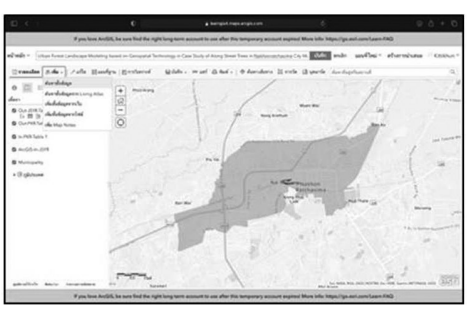
(1) GIS-point layer for trees on sidewalk (green point shows each tree)

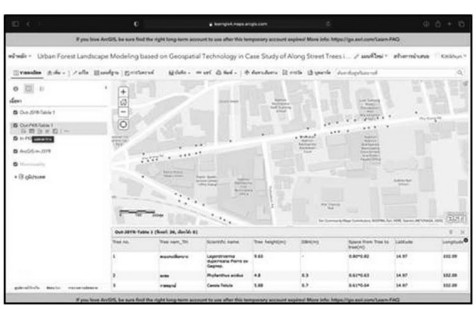


(2) GIS-polygon layer for NCM Boundary

Figure 5. This is example of GIS data for NCM trees on sidewalks

(1) Screenshot for login (Left) and managing ArcGIS web (Right)

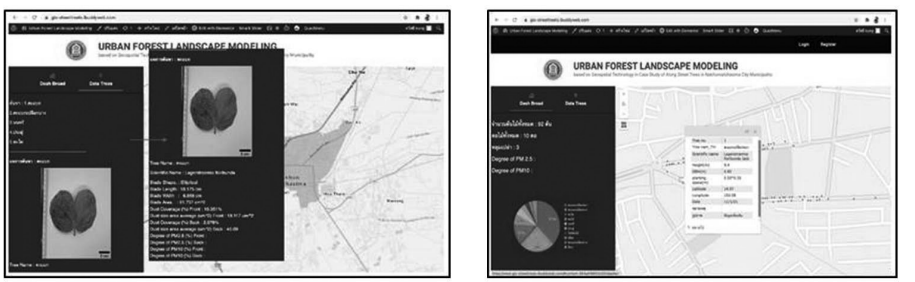




2) Screenshot for managing and organizing non-spatial and spatial data on ArcGIS web

Figure 6. Example for administrators' responsibility on ArcGIS web

(1) Screenshot for the first ArcGIS web of focus users



(2) Screenshot for presenting characteristics of urban street trees and leaves on sidewalk

Figure 7. The focus users' accessing for this ArcGIS web

2) Users who are the 3 special focus groups for using this ArcGIS web: (1) NCM Officers, (2) geospatial academics and (3) NCM residents. These focus groups can assess the user interface that comprises of contents, and non-spatial and spatial data etc. (Figure 7).

4.3 Evaluating acceptance of ArcGIS web application with using the 3 focus groups

This ArcGIS web application was evaluated by the 3 focus groups: the 6 geospatial experts, the 4 concerned NCM Officers and the 318 (back replying) of 400-NCM resident based on random sampling. These evaluated results (Table 3) can explore as below:

1) Overall of 6-expert evaluation was in high acceptance of ArcGIS web with 3.67 of mean (0.11 of S.D.). For suggestion, there was functionality such as geodatabase testing, security testing, client and ArcGIS server etc.

2) Overall of 4-concerned NCM Officer was in high acceptance of ArcGIS web with 3.71 of mean (0.09 of S.D.). For suggestion, there is compatibility such as checking of coding and script on running ArcGIS web etc.

3) Overall of 318-NCM resident was in high acceptance of ArcGIS web with 3.92 of mean (0.05 of S.D.). For suggestion, there is the slow requesting of web map and information service via ArcGIS server.

5. Conclusions

This study has developed ArcGIS web application on platform of ArcGIS online for presenting urban street trees on sidewalks. RAD process is used for developing ArcGIS web application because this study requires the focused users and enhances flexibility and adaptability as developers can make adjustments quickly during the development process or continuous iterations.

Table 3. Evaluating acceptance of ArcGIS web application

Questions	Geospatial experts		NCM Officers		NCM residents	
	Average	Acceptance level	Average	Acceptance level	Average	Acceptance level
1. Interface and platform (interesting and attracting)	4.65	Highest	4.43	Highest	4.52	Highest
2. Usability (value and useful data)	4.34	Highest	4.21	Highest	4.25	Highest
3. Functionality (easy and comfortable)	3.35	Middle	3.08	Middle	3.41	High
4. Compatibility (script and coding on running ArcGIS web)	2.74	Middle	2.62	Middle	2.76	Middle
5. Web map and information service	3.45	High	4.10	High	3.45	High
6. Promote to tell other people for visiting this ArcGIS web	-	-	-	-	4.76	Highest
7. Return to use this ArcGIS web again	-	-	-	-	3.49	High
8. Overall of this ArcGIS web	3.51	High	3.88	High	4.72	Highest
Total	22.04	-	22.24	-	31.36	-
Average	3.67	High	3.71	High	3.92	High

Development of ArcGIS web application provides tree data and information on sidewalk of NCM roads (Phoklang and Jomsuratyard roads are selected as case study). Accessing this ArcGIS web application, there are 2 levels: administrator and users who are focused for this study such as NCM Officers, geospatial academics and NCM residents. These focused users are evaluated acceptance of this ArcGIS web application that has overall of high acceptance level as same. In addition, the focused users recommend that should adapt compatibility, functionality and the slow requesting of web map and information service via ArcGIS server. Although this ArcGIS web application is highly accepted by the 3-focus group, we still continuously make adjustments especially encouragement of code reuse, which means less manual coding, less room for errors, and shorter testing times. Actually, this ArcGIS web application is under responsibility between NCM and RMUTI researchers who have to continuously develop because it is implemented for improving trees on sidewalk of NCM roads, is registered by domain named https://www.gis-streettreets.ibuddyweb.com/?fbclid=IwAR0E-tPQ2QgE9xkpSK5_6D8aF0wWf9wWQAFtlDUrD3bhCOVxBtnCsKXOlW0 and will be posted at NCM web (https://www.koratcity.go.th/) further.

6. Acknowledgement

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