DEVELOPMENT OF REAL-TIME SMART WEATHER STATION AND WEB PROCESSING SERVICE FOR MONITORING AND EVALUATION OF FIELD ENVIRONMENTAL DATA BASED ON IOT AND FOSS4G

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ABSTRACT

Real-time environments monitoring such as temperature and humidity has become a crucial thing especially in the era of climate change that results in global warming. The problem of global warming has resulted in a number of illnesses, including illnesses such as heat stoke which, if we have a robust climate observation system. This will allow us to protect and be harmless from these hazards.

The aim of this study is to develop the low cost weather station to monitor specific environmental elements. A number of Inter of Things (IoT) technologies have been used to form the proposed system. Wireless Sensor Network (WSN) and Ethernet are the main technologies that are utilized with the propose station. The design of the weather station consists of three parts: Hardware using arduino, wemos-d1, software using arduino IDE, QGIS and Web application. Web application has designed using FOSS4G such as JavaScript, PostgreSQL/PostGIS, Geoserver, Openlayers, AJAX, PHP, HTML, CSS. The automate measuring process of the data from weather station has implemented using ZOO WPS. This web app has been shared on the public server to be accessed and monitoring the Heat Stress Index (HIS) in real-times.

***Keywords:** GIS, Internet of Things, Web Processing Service, Wireless Sensor Network*

1. INTRODUCTION

The accurate assessment of the quality of temperature can support the effective decision making on the effects from the surrounding environment in which continues to change its conditions. Therefore, the assessment process to verify the temperature conditions is aimed to be activated in order to notify human or other living things who will be affected (Zeqiang *et al.*, 2016). In order to support decision making in a real-time situation, the current sensor system technology has been applied and more accepted because of its ability to collect data. The monitoring data such as temperature, humidity, etc. can be automatically collected through a programming language and sends data to the database. It has been further integrated with sensor system technology and Geographic Information System (GIS) using Free and Open Source Software for Geospatial (FOSS4G) which is free of charge. The integration aimed to develop the process spatial analysis so the environmental data analysis will be more effective.

The analysis of weather applies GIS, web processing service(WPS) , and spatial interpolation. This technique can present the data in a graphical and spatial format and the result of the analysis through internet system which can access the real-time data. The data have been managed by various kinds of sensor system integrating together through a web interface which can verify monitor the information received at all times from the records of the sensor system called Sensor Observation Service (SOS) (Devaraju *et al.,* 2015) . The researcher has investigated the data management of a sensor system in istSOS Project, the project offering the measured data from the sensor system through a website accredited from Sensor Web Enablement (SWE). Each set of the sensor can send data across each other via ad-hoc format Wireless Sensor Network (WSN) (Vaibhavraj *et al.,* 2015). The data will be later sent to be collected in the database through the internet network and then presented through a web interface.

2. CONCEPTUAL FRAMEWORK AND METHODOLOGY

The conceptual framework by applying Internet of Things technology which is accessible through internet network from the sensor system to verify and analyze those factors that result in the weather in the study area. The data processing that accesses the spatial analysis from a web interface to warning the data can analyze the data that users can check the results of the weather. (Choosumrong *et al.,*2016).

The workflow of the sensor system that consists of the weather measuring sensor consists of air temperature, relative humidity, and light intensity measurements. The sensor receives the commands from the written instruction integrated with Arduino wemos D1 Wi-Fi board controller which transfers the data through Wi-Fi Internet.

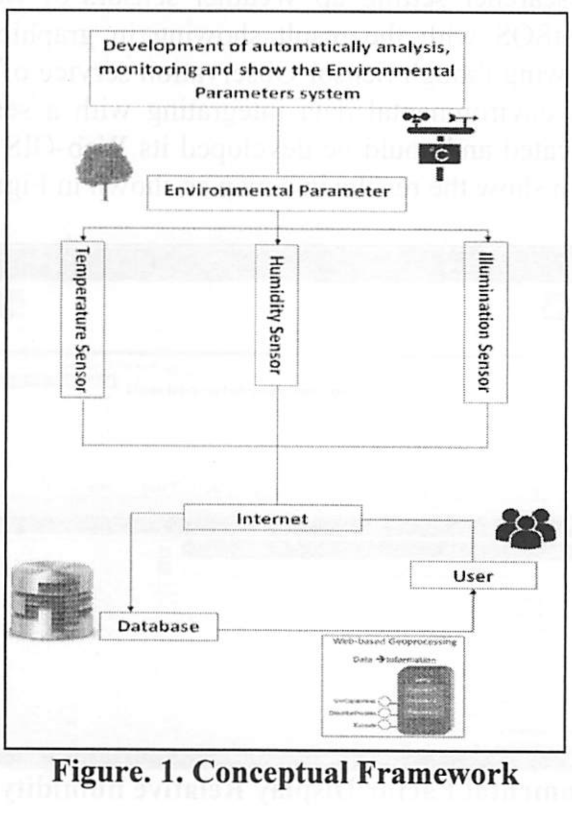

Figure. 1. Conceptual Framework

3. THE DEVELOPMENT OF DATA PRESENTATION RECEIVED FROM SENSOR MONITORING STATIONS ON A WEBPAGE

The presentation of the data received from temperature measurement is from the record of sensor monitoring stations. Those data were stored in the database without the process of spatial analysis. So, this was the process of getting data to show the real-time data in graphs from the sensor monitoring station that has recorded the database through the use of websites on the Internet, as shown in Figure 2.

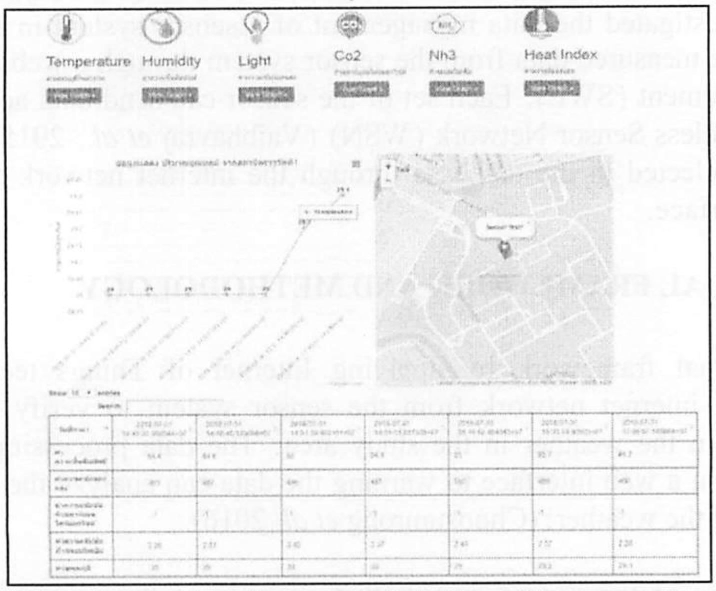

Figure. 2. Examples of environmental factors. Measured temperature Show information on website

In addition, the researcher setting up Weather sensors of weather measuring sensor within the process of istSOS with the result showing in graphical format, as shown in Figure 3. The results showing though Sensor Observation service of the istSOS. This system manages and broadcasts environmental data integrating with a sensor system. The result showing was not complicated and could be developed its Web-GIS in Open Layers3 (Open source Mapping Client) to show the results in a map as shown in Figure 4.

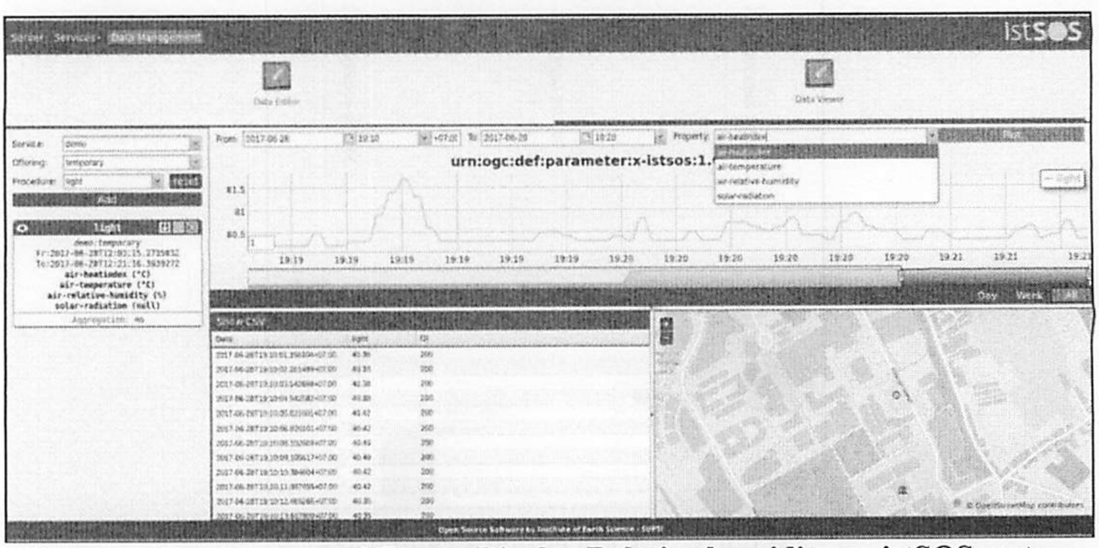

Figure. 3. Environmental Factor Display Relative humidity on istSOS system

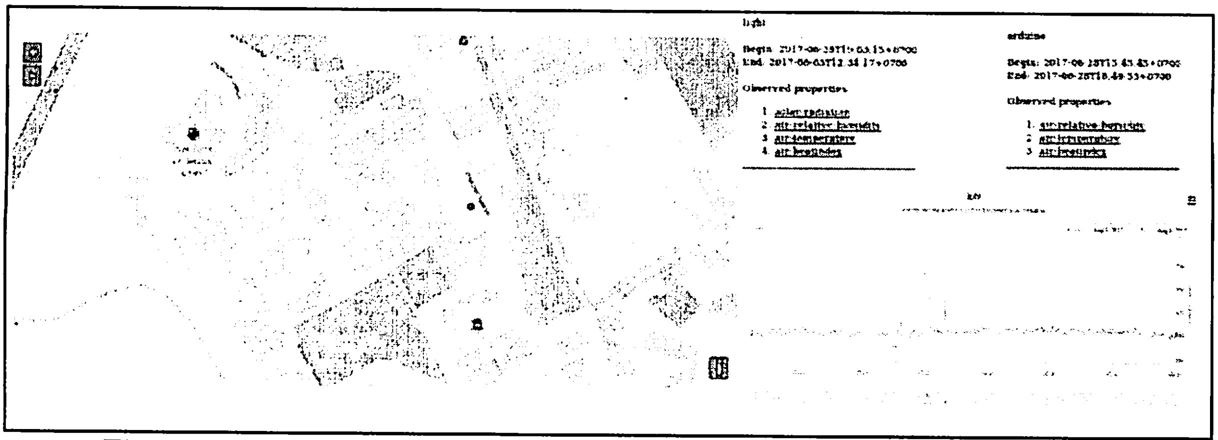

Figure. 4. Web GIS Development using Openlayers3 in Relative Humidity Measurement Display

4. DEPLOY WEATHER MONITORING TO WEB PROCESSING TO WEB PROCESSING SERVICE

The development of online weather monitoring is the process of WPS. It is a requirement of OGC for data processing using the Internet. An important part of the development of web based processing. (Hempelmann *et al.*,2017) Using ZOO-Project to work with open source software

Real-time data were taken to the database, analyzed, and showed results of the interpolation. Level of weather intensity was measured by Grass GIS software. Grass GIS works as a library to connect with ZOO-Kernel and ZOO Service. ZOO-Kernel is the WPS server and the main part of ZOO-Project working similarly to the programs in Common Gateway Interface (CGI) which is used to identify the method of data management among web server and web browser, the standard method for the web service to transfer demands of users.

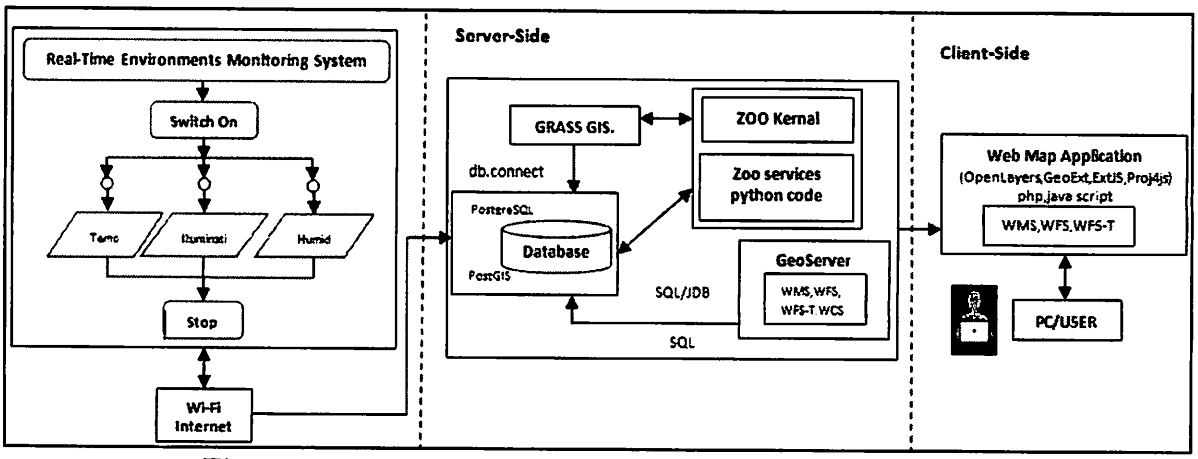

Figure. 5. The development Web based processing system

Figure 5. shows the server-side workflow which is the data analysis part. The data will be transferred to the store at PostgreSQL/PostGIS database and analyzed by using Grass GIS (Bergenheim *et al.*, 2009). The module within the program was used to process the data by applying *v. surf. idw* to evaluate spatial analysis value through Inverse Distance Weighted (IDW) interpolation. The major qualification of Grass GIS is that it works like a library connecting ZOO-Kernel with ZOO Service through ZOO Service Configuration File

(ZCFG). The analyzed data from ZOO Kernel and Grass GIS will be employed to develop the data showing on the webpage in Web Map Service (WMS), Web Feature Service (WFS), and Web Coverage Service (WCS) formats by online service of GeoServer. Then, the Client-side will be developed its format by using JavaScript Library Map Framework from Heron-MC, OpenLayers, GeoExt, ExtJS, and Proj4js, to activate Web Map Service from MapServer.

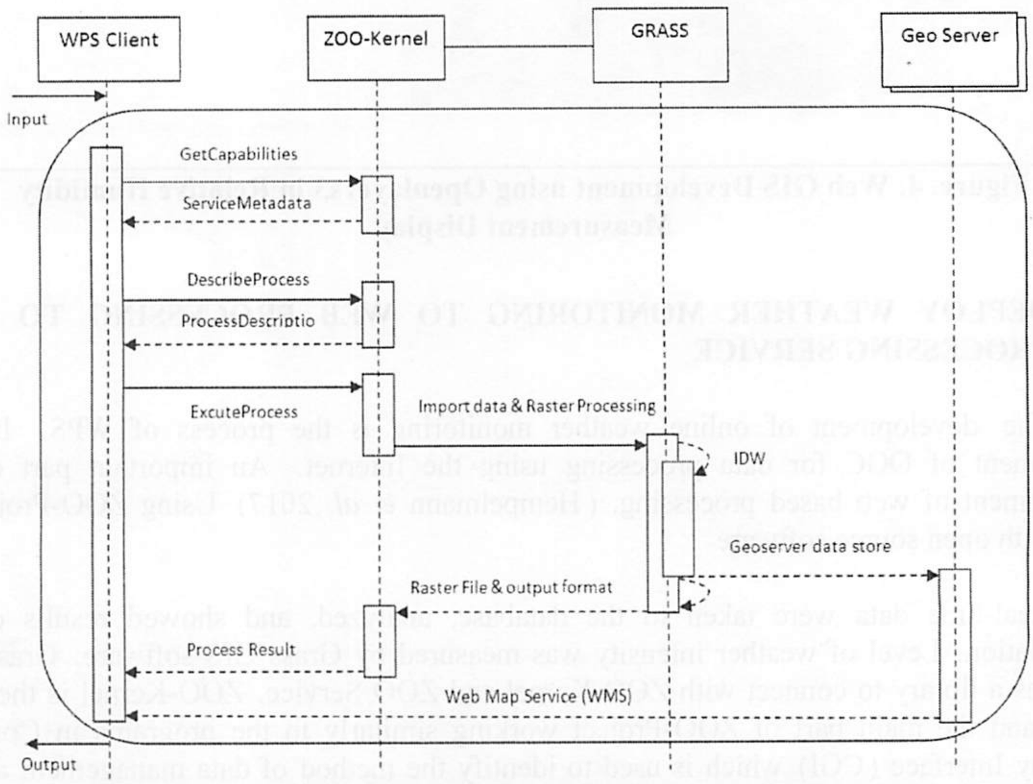

Figure. 6. Uml sequence diagram The WPS and GRASS GIS

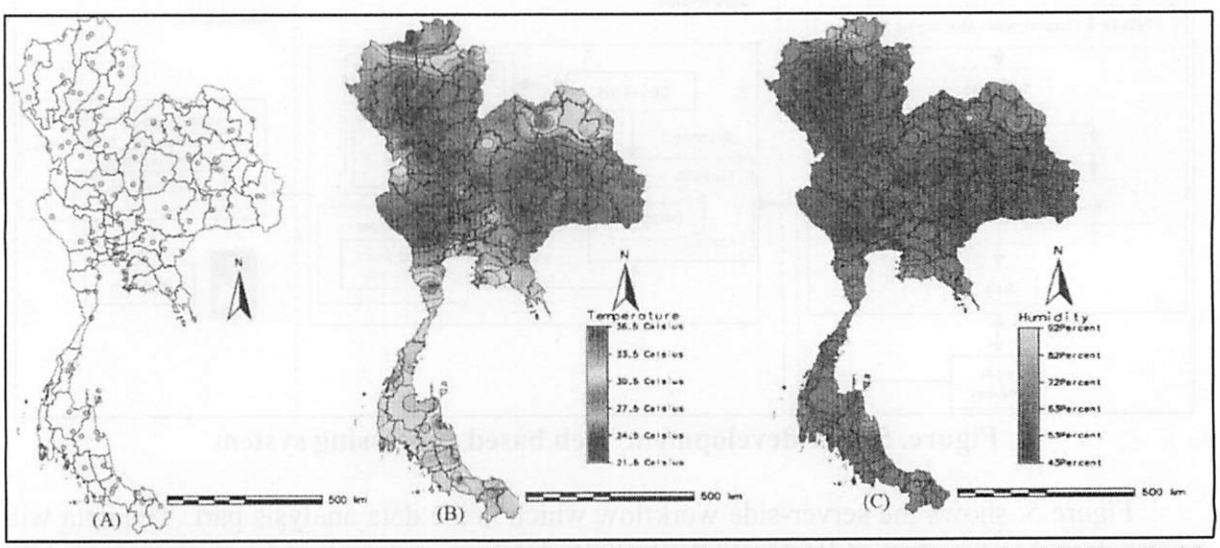

Figure 7. Results example instruction v.surf.idw The collected data is on 28/09/61; 13.00 from Thailand Methodological Department (A) and used in the process Inverse Distance Weighted (IDW) process shows the temperature density (B) And relative humidity (C)

5. RESULT AND DISCUSSION

Measuring real-time weather is the measurement of the air temperature. Relative humidity is the main factor in this study. the development of the system with an ability to follow up the increasing or decreasing value of the weather can help monitoring, warning, and showing the level of danger effecting on human livings. The system works and shows the results of the analysis for the intensity of the environmental factors within the study area. The development of the system applied ZOO and WPS systems and the user network connection was later developed within the Web application that connected with the database system. Users can check the data and show the results of the measured air environment from the calculation of real-time through Web Application.

6. CONCLUSIONS

The development of the online system to automatically analyze the real-time weather data, users can check the weather data from the system that measures the environmental factors and analyzes with spatial data by using interpolation. The analysis also applied the intensity of environmental factors to be integrated into the analysis; The results will be shown on the web application. As a result, users can check for accurate data which is shown in real time. The system has been developed via the low-cost software in which can be developed in open source free software. The developers can also develop the system through the low-cost hardware and software. It is convenient for many users because of its easy function and the results shown in a graphical format which are easy to read.

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ORIENTATION PLANNING FOR DEVELOPING URBAN GREEN SPACE BY INTEGRATING GIS AND AHP: A CASE STUDY IN HUE CITY

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ABSTRACT

Urban green space, an important component of urban ecosystems, plays a pivotal role in preserving biodiversity in urban area. Recently, there is no balance between green spaces and construction land within urban land patterns. This paper aims to analyze the suitability of developing urban green space in Hue city by utilizing GIS and AHP. Nine suitability factors/criteria of urban green space expansion were selected as: Slope, distance form water network, land use/Land cover, Population density, Distance from Main Street, House density, Distance from historical place, Distance from park, and Land price. By overlaying layers with weighting of those suitability factors, the suitable locations for developing urban green space of Hue was obtained and classified into 5 levels: no suitable, less suitable, suitable, relative suitable, and very suitable. The results show that the area of green space in accordance with all criteria in a high suitable level is 7.29 ha (accounting for 0.10% of the total area), relatively suitable area is 369.19 ha (occupying 5.52%), suitable area occupies the largest area of 3723.59 hectares (corresponding to 51.88%), less suitable level is 2889.96 hectares (occupying 40.28% of the area), and no suitable is 159.43 ha (making up 2.22% area). These research findings will be used as a foundation for development plan for urban green spaces in backdrop of climate change challenges in Hue City.

Keywords: *urban green space, GIS, suitability, orientation planning, Hue city.*

1. INTRODUCTION

Urban green spaces are significant aspect of urbanized ecosystem, which provide a variety of environmental and social services for enhancing life value. In urban structure, green spaces are an integral part of the natural - cultural - social characteristics and development level of each region and country in each historical stage. Worldwide, rapid urbanization has been destroying or degrading green space types for a variety of land use purposes. Natural ecosystems are being gradually replaced by urban ecosystems, which decreasing the accessibly between residents and green space. Green spaces are becoming an important measure in assessing the environmental quality and ecological sustainability of urban land use planning (Kshama Gupta et al., 2012). Hence, the provision of urban green space for highly urbanized areas in developing countries is a huge challenge for the local authorities (Z. A. Lashari, et al., 2017).

Hue city, located in the center of Vietnam, is well known as a green city. However, under the challenges of rapid urbanization and risk of climate change and natural disasters, green spaces are gradually decreasing due to the occurrence of impervious surface. Therefore, selecting suitable site for allocating optimum urban green spaces is necessary for ensuring their roles and functions as well as for responding to the city standard.

Analytic hierarchy process (AHP) approach is one of the techniques for weighting the factors that the effective criteria on the development of optimum green space. Geographic Information System (GIS), on the other hand, is well known as a beneficial technique in land suitability assessment, land use suitability mapping and spatial analysis. Combining AHP and GIS enables decision support systems by providing suitable maps (Z. Saeedavi et al., 2017).

The purpose of this research is to conduct urban green space suitable analysis (UGSA) in Hue city by employing multi-criteria analysis techniques with the support of AHP and GIS. This result may assist and provide benefit to city planner as well as government authorities in ensuring proper urban land use planning and management in general and in orienting urban green space plan in particular for sustainable development.

2. STUDY AREA

2.1 Study site

Hue is a city of Thua Thien Hue Province locating in the center of Vietnam. It has an area of 7076.28 ha with a population of 356,159 people (2017). Currently, Hue City has 23 parks, of which only one park has an area of over 10 hectares and seven parks cover an area of 2-9 hectares. According to the report of Hue Green city action plan, the ratio of green space area per person is about 6 square meters (m^2), which is slightly lower than the standard for a city of Class I to II (6 m^2-7,5 m^2/person) (Asian Development Bank, 2015). Therefore, one of the main tasks of this city is to maintain the existing green space and to allocate optimum land use to urban green space.

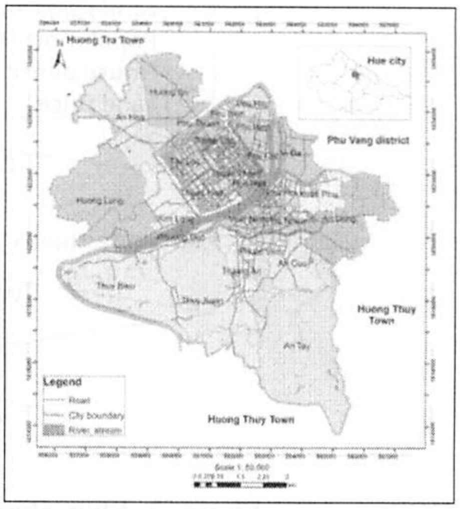


Figure 1: Study area

2.2 Materials

The spatial and non-spatial data were gathered from various Thua Thien Hue government departments and authorities as showed in table 1.

Table 1. Data collection for analysis

Data	Type	Sources	Scale
Landuse map 2017	(*.dgn) Microstation	CNRET- DONRE	1:10.000
Topographic map	Geodatabase	GISHue project, EDIC	1:10.000
Master plan and Land use planning to 2020	(*.dgn) Microstation	People's Committee	1:10.000
Population census in 2017	Figures	Statistic Department	Ward level
Historical Flood Scenario 2009	*.shp	People's Committee	1:10.000

3. RESEARCH METHODOLOGY

3.1 Framework of analysis

In this study, the GIS based land suitability analysis integrated with AHP technique was employed as the multi-criteria decision analysis for urban green space suitable analysis (UGSA) in Hue city. In this analysis, AHP technique was also used to set the criteria for having the information about various land suitability alternatives from different experts. Meanwhile, GIS was utilized in mapping the thematic map for each criteria as well as in conducting the spatial analysis (Mathias Tesfaye Abebe & Tebarek Lika Megento, 2017; Z. A. Lashari, et al., 2017). UGSA is implemented through the following steps (Figure 2).

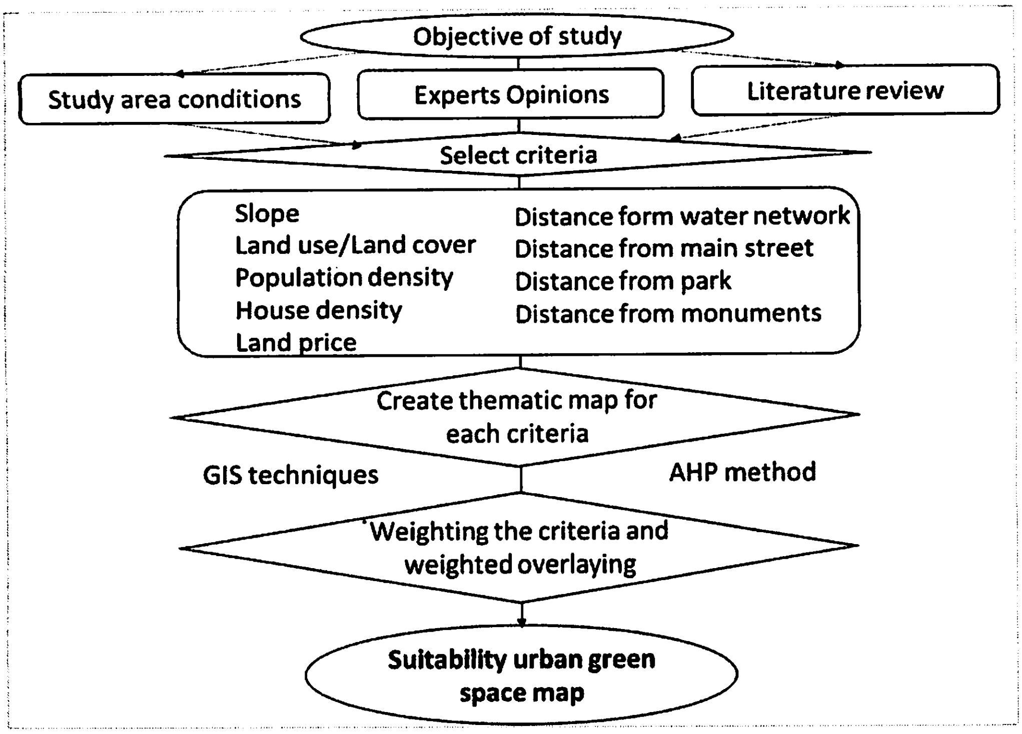


Figure 2. Flow chart of urban green space suitable analysis

3.2 The urban green space suitable analysis (UGSA)

Based on referring natural, socio and economic characteristics of the study area, literature review and expert opinions, the problem of UGSA in Hue city was defined. The criteria utilized for UGSA were appropriately selected based on literature review and prior knowledge of this particular field. A total of 9 factors used as input datasets were collected from various sources. Map preparation for each of the determined criteria was done by spatial processed (distance and proximity analysis, and weighting overlay) in ArcGIS software.

Each criteria/factor score (thematic layer in *.shp file) was standardized by converting into a raster at 30 x 30 m resolution. In each factor, the rate of suitable for green space development was defined and reclassified into: Highly suitable (S1), relatively suitable (S2), suitable (S3), less suitable (S4), and Unsuitable (N) for urban green space corresponding to the score of 5, 4, 3, 2, 1, respectively (Table 2). The weight for each criteria was determined based on its importance for the green space development with the analytical hierarchy process (AHP) technique. Questionnaires were prepared and 12 experts in urban land use planning were asked to assign a weight to each factor based on their desired priorities for this ground. After collecting data from the questionnaires, the mean of the total votes was calculated and then computated, the weight of each factor was obtained. If the consistence ratio (CR) is <0,1 the weighting score is satisfactory.

Spatial overlaying was done for urban green space development after calculating the weight of each factor and the map of suitability, by which the final fitness was obtained in ArcGIS with raster calculator (Weighted Overlay). Based on the finding of suitable site for urban green space development, this paper also takes account in the Master plan and Land use planning to 2020 as well as the historical scenario of 2009 inundation of Hue city for orienting the urban green space development.

Table 2. The criteria for site selection and suitable analysis of urban green space

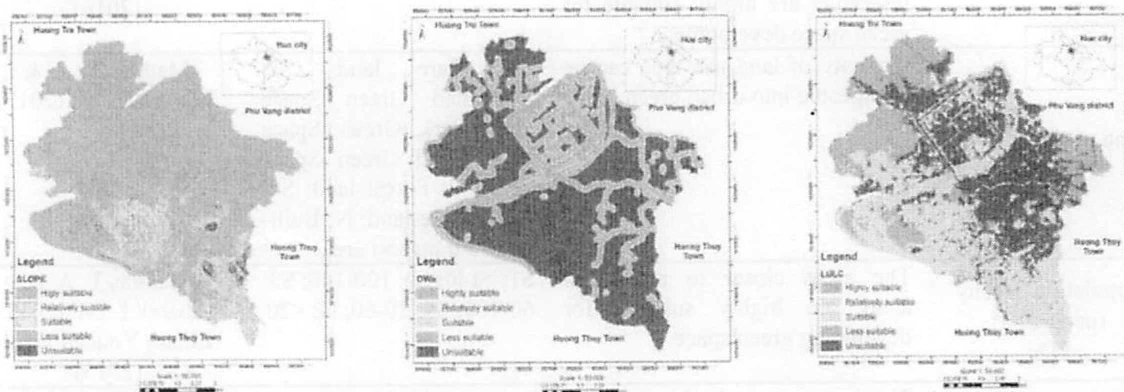
Criteria/Factors	Description	Level of suitability	References
Slope (%) SLo	The areas with low slopes are highly suitable for developing park	S1: 0-5; S2: 5-10 S3: 10-15; S4: 15-30 N: >30	Elham Yousefi et al. (2016), Mathias T. A. & Tebarek L. M. (2017)
Distance from water network DWa	The closer to stream banks get more preferences; contribute to maintain the environmental health of the area; Lands closest to water resources like rivers, lakes, and reservoirs are highly suitable for green space development.	S1: 0-30; S2: 30-60 S3: 60-90; S4: 90-120; N: >120	Vietnam Ministry of Construction (2012), Mathias T. A. & Tebarek L. M. (2017) Elham Yousefi et al. (2016)
Land use/Land cover LULC	Capacity of land use type can be changeable into urban green space	S1: Bare land; S2: Dedicated Green Space land, Park Green Space land, Road Green Space land; S3: Forest land; S4: Agriculture land; N: Built-up and transport area	Mathias T. A. & Tebarek L. M. (2017)
Population density (people/ha) PDe	The areas closer to residential areas are highly suitable for developing green space	S1: >140; S2: 100-140; S3: 60-100; S4: 20-60; N: <20	Mathias T. A. & Tebarek L. M. (2017) Elham Yousefi et al. (2016)
Distance from main street (m) DSt	The green space site is preferable when it is located at a suitable distance from roads in order to easily access transportation, enhance the possibility of monitoring and maintain their security for citizen.	S1: 0-25; S2: 25-50 S3: 50-75; S4: 75-100; N: >100	Elham Yousefi et al. (2016) Thua Thien Hue People's Committee Mathias T. A. & Tebarek L. M. (2017)
House density (%) HDe	High density of house should be priority for green space development	S1: >20; S2: 15-20; S3: 10-15; S4: 5-10; N: 0-5	Existent conditions of city
Distance from monuments (km) DMo	Hue's complex of monuments is featured on UNESCO's world Heritage, hence green space development must be not erase the monuments, contribute to maintain and preserve the cultural and historical site in ecological balancing.	S1: 0-0,5; S2: 0,5-1; S3: 1-1,5; S4: 1,5-2; N: >2 and the monuments areas	Mathias T. A. & Tebarek L. M. (2017)
Distance from park (km) DPa	The area which is farthest from the existing park highly requires the green space due to the lacks of green space or vegetation, balancing the number of green space and parks between the areas.	S1: >3; S2: 2-3; S3: 1-2; S4: 0,5-1; N: <0,5.	Mathias T. A. & Tebarek L. M. (2017)
Land price (1.0 VND/m^2) LPr	The areas with the cheaper price will be priority than those areas with the higher price for urban green space development	S1: <3.500; S2: 3.500-6.500; S3: 6.500-9.500; S4: 9500-1.600; N: > 1.600	Elham Yousefi et al. (2016); Decision number 75/2014/QĐ-UBND of Hue city people's Committee

4. RESULT AND DISCUSSION

4.1 Mapping and weighting the criteria/factors

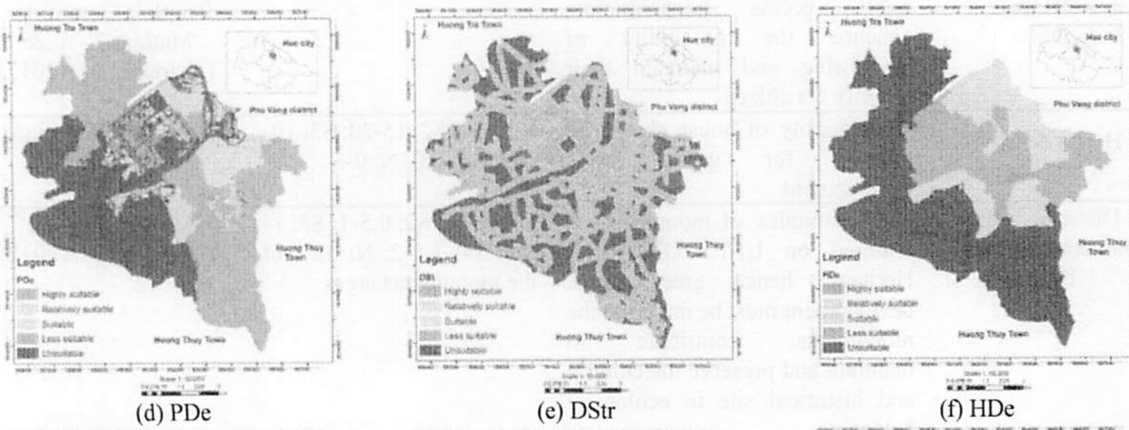
The proximity maps was prepared for each of the criteria of distance from water network (DWa), distance from main street (DSt), distance from monuments (DMo) and distance from park (DPa). The maps of slope (SLo), land use/land cover (LULC), house density (HDe) and land price (LPr) also were created and classified for the final suitability of urban green space.

AHP pairwise comparison matrix was created and criteria weights were calculated for each factor by comparing factors on a scale from 1 to 9 with 0,01 CR (acceptable for AHP analysis). The reclassified input datasets were assigned with a weight value to express the importance of each criterion to the other criteria for suitable site selection for green space. The suitable green space development was created through the formulation: Final map= SLo*0,07 +DWa*0,04+LULC*0,31+PDe*0,20+DSt*0,11+HDe*0,09+DMo*0,11+DPa*0,04+LPr*0.03 (Figure 3).

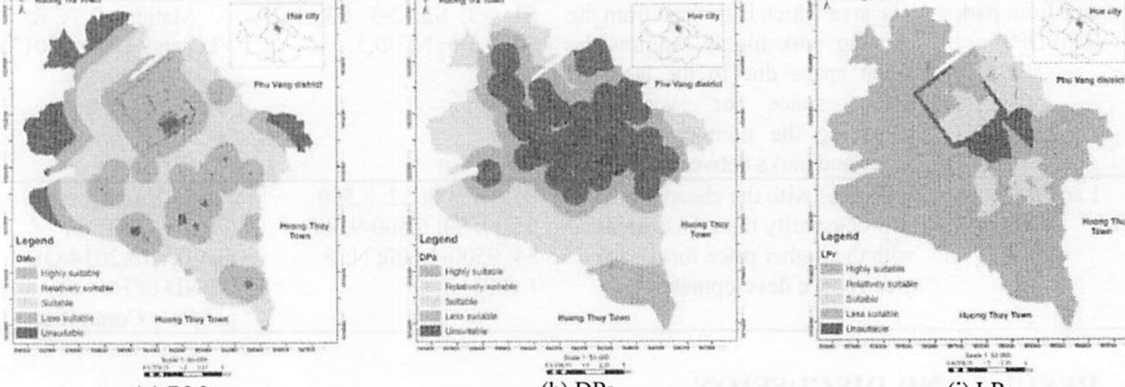


(a) Slo (b) DWa (c) LULC

Figure 3. Suitability level of each criteria for green space development



(d) PDe (e) DStr (f) HDe



(g) DMo (h) DPa (i) LPr

Figure 3. Suitability level of each criteria for green space development

4.2 *Suitability analysis* for urban green space development

In order to select suitable sites for green space development, all the reclassified input datasets were overlaid using the Weighted Overlay tool in ArcGIS. The distribution and proportion of suitability level for urban green space development were showed in Table 3 and Figure 4.

As found in GIS-base UGSA in Table 3, the result identified 7,29 and 369,19 ha area are highly suitable and relatively suitable for green space development, accounting for 0,1% and 5,52% of the total area, respectively. Those areas are situated inside the Citadel, where there are many monuments and ponds but few green space for the urban residents. The largest area suitable for green space development, which covers 51,88% (3723,59 ha) of the area, is distributed mainly in the center and the south west of the city. The existing land cover types in this area are mainly agriculture, forest and vegetation. The less suitable level is 2889.96 hectares, occupying 40.28% of the area, which is located mainly in the built-up area with high residents' density. Those areas are located mainly in the northwest, and southeast of the city. The remaining 159,43 ha (2,22%) is unsuitable for green space development.

Integrating suitability map for green space development with the master plan and land use planning to 2020 and 2009 historical flood scenario, the planning for urban green space development was conducted as follows:

In the highly suitable and relatively suitable areas for green space development, it is needed to build green parks, new green urban residential areas, green traffic and squares. These should be built on land use areas which are planned for public purposes focusing on green urbanization and ecological urbanization (such as Con Hen). As for highly suitable areas in highly flooded location (inner city), there should be plan for building regulating reservoirs. The reservoirs can function as green trees and simultaneously regulate water during rainy and flood season, which can reduce the risk of high flooding in the area. Regarding the suitable areas in the south and south west of the city, there should be good protection of the existing landscape (forest plantation, ecological agriculture, and nursery garden). With unsuitable areas (relics), it should not be planned to expand urban green space. For less suitable areas, a system of green trees or decorative flower pots should be developed along the streets, especially in high density of traffic and population areas. This can contribute to air conditioning and environmental protection.

Table 3: Proportion area of suitability level for urban green space development

Suitability level		Area (ha)	Proportion (%)
N	Unsuitable	159,43	2.22
S4	Less suitable	2889,96	40.28
S3	Suitable	3723,59	51.88
S2	Relatively suitable	396,19	5.52
S1	Highly suitable	7,29	0.10

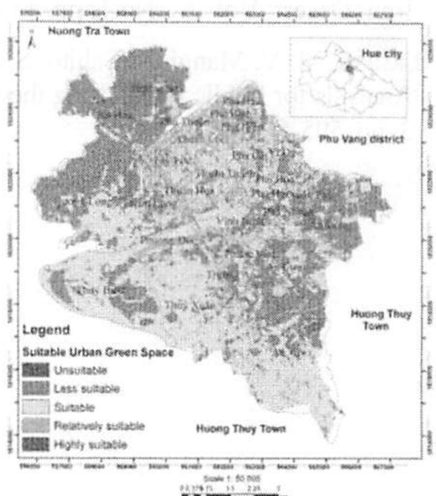


Figure 4. Final suitability map for urban green space development

5. CONCLUSION

Under the impact of urbanization, built-up area in Hue city has expanded dramatically while urban green space areas are shrinking, which leads to emerging challenges to green city goal. The paper applied an integrated multi criteria analysis, with a combination of GIS and AHP, in classifying the suitability level for urban green space development. This effective method is of low cost and can easily provide up-to-date information under the dynamics of recent urban land use/land cover change. The results show that the area of green space in accordance with all criteria in a high suitable level is 7.29 ha (accounting for 0.10% of the total area), relatively suitable area is 369.19 ha (occupying 5.52%), suitable area occupies the largest area of 3723.59 hectares (corresponding to 51.88%), less suitable level is 2889.96 hectares (occupying 40.28% of the area), and no suitable is 159.43 ha (making up 2.22% area). These research findings will be used as a foundation for development plan for urban green spaces in backdrop of climate change challenges in Hue City.

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