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AN EXPERIMENTAL BATHYMETRY SURVEY USING A SMART IoT PONTOON IN THAILAND

Passapong Tanpaibool [1], Kritsada Anantakarn [1*], Rerkchai Fooprateepsiri [2], Wunchock Kroehong [1], Boonsap Witchayangkoon [3*]

[1] *Department of Civil Engineering, Faculty of Engineering and Architecture, Uthenthawai Campus. Rajamongala University of Technology Tawan-ok, THAILAND.*
[2] *Department of Information Technology, Faculty of Business and Information Technology, Rajamongala University of Technology Tawan-ok, THAILAND.*
[3] *Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, THAILAND.*

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ABSTRACT

Water resource management is a very important matter from several points of view such as water availability, quality monitoring, and distribution. The traditional bathymetric method with man on-board operation makes it difficult to collect bathymetric data in polluted water and bad weather condition. To produce the bathymetric and topographic map of the river, the research works use a pontoon made by polyethylene (PE) with echo-sounder equipment and high-end Global Navigation Satellite System (GNSS) device. Wireless communication such as local mobile 4G/3G is employed to collect geographic positioning and bathymetric data from the Thachin rivers. The integrated smart IoT pontoon system is developed and an accuracy test is conducted in this research. The advantage of this system is an unmanned on-board operated boat that can safely work in polluted water and all-weather conditions. Geographic positioning coordinate is measured by using GNSS Real-Time Kinematic (RTK) networks from the Department of Land (DOL) of Thailand and bathymetric data is collected with echo sounder. The research result, the bathymetric and topographic map of the river has Root Mean Square Error (RMS) 22cm. The outcome of an accuracy assessment of the Smart IoT Pontoon can become an effective tool for a bathymetric survey for water resource management.

Disciplinary: Multidisciplinary (River Engineering, Navigation Engineering, Civil Engineering, Information Technology).

1. INTRODUCTION

Water resource management is a very important matter from several points of view such as water availability, quality monitoring, and distribution. Water resource systems have profited both

*Corresponding author (Kritsada Annatakarn). Email: singut51@gmail.com

living conditions and social economies all the time. Lack of water supply systems causes drought and expose failures in planning, management, and decision-making. In reverse, the water supply causes floods and natural disasters. Water resources management, planning, and development to ensure adequate, effective, and balanced supplies and demand. The bathymetric map of river water depth for both agricultural crop and environmental management can be achieved by the integrated GNSS system and echo-sounder for collect environmental data and process socio-economic data. The objectives of the project are two main parts as followings:

This study develops an unman-operated device for hydrological surveying in dangerous and polluted conditions with 24 hours of operation. This solution contributes many benefits to hydrological surveyors who work on river and ocean in bad weather and water polluted sites.

To provide an IoT Smart technology for hydrological surveying by Real-time data monitoring. This objective will bring great profit for all hydrological surveyors who use pontoon for natural disaster monitoring such as flood warning systems or hydro-power dam risk monitoring.

2. LITERATURE REVIEW

Many kinds of research in hydrological surveys require bathymetrical data and geographic coordinate for topographic mapping. Water depth, river profile and features distributed in the reverbed are measured and recorded in the form of latitude (North), longitude (East), water surface (Height) and water depth (-Z) (Jawak et. al., 2015). For the hydrographic river model, it is required a smooth Digital Elevation Model (DEM) at the connection land and water area by using an integration of terrain elevation and bathymetric data (Karim et. Al, 2017). Echo sounders with a single beam generate a single line of depth points, directly beneath the equipment. The measurements are made when a vessel moves to give riverbed or seafloor patterns.

The riverboat carrying out the echo-sounder bathymetric survey has limited capacity in working under dangerous and harmful conditions such as polluted water and strong wind or storm. An aqua bulb is suitable in shallow water with safety conditions because it is not required humans to operate or control it. In some sharp curves of rivers or streams, a survey boat is too large to pass and makes the survey impossible. Water volume and bathymetry information are applied for the river, reservoir monitoring (Hassan et al., 2012). The data collection also required for water resource management such as agricultural crop and industrial water demand area (Romano et al., 2012).

Digital elevation models (DEMs) are one of the popular sources for topographic mapping, land survey and rural-urban development (Debella-Gilo and Kaab 2011), Nowadays, there are some free sources data of DEM can be provided as free-of-charge from the Internet. Therefore, there is an increase in the need for information about its quality and improvement of the accuracy of the DEM for various modeling and mapping applications (Mukherjee et al. 2013). Shuttle Radar Topography Mission (SRTM) elevation data produced from a C-band (at 5.6cm wavelength) interferometric ScanSAR is available from USGS website at, 1 arc-second (or 1sec × 1sec) resolution that is 30m x 30m on earth.

The Global Navigation Satellite System (GNSS) provides a positioning location for land surveying and navigation technology (Witchayangkoon, 2000). With the purpose to achieve high accuracy, Real-Time Kinematic (RTK) differential correction method is mainly applied for

Differential GNSS measurement. Department of Land (DOL) and Royal Thai Survey Department (RTSD) have established many local Continuously Operating Reference Station (CORS) is a form of RTK differential correction that is done through the use of mobile internet connection to these local CORS (Anantakarn et al., 2019).

3. METHODOLOGY

The study methodology includes the system integration of pontoon design with echo-sounder and GNSS receiver. The survey data were collected from the echo-sounder and the GNSS RTK in synchronization with elevation data from SRTM data. GIS software for the topographic and bathymetric map was generated with accuracy assessment as presented in Figure 1.

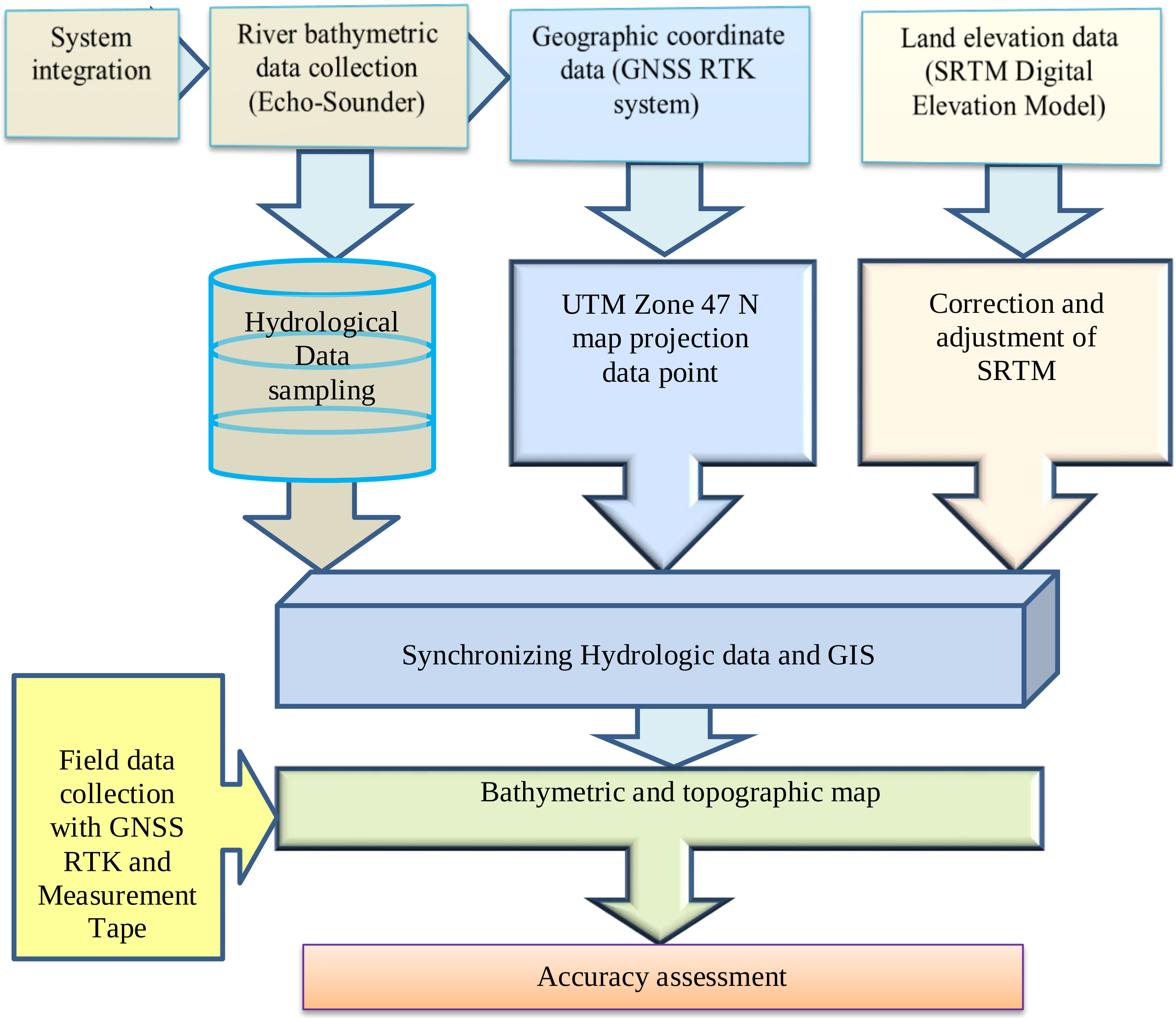

Figure 1: Methodology for data collection and processing

3.1 SYSTEM INTEGRATION

The research provides a system integration that is an alternative way to replace the traditional hydrographic survey. This work is associated with the report of Sripakorn et al. (2020).

3.1.1 FLOATING SURVEY TANK DESIGN

A high-quality thermoplastic is an excellent physical and chemical strike resistance. Polyethylene (PE) has toughness and good chemical resistance to a wide range of wet and dry products, depending on wall thickness and type with ultraviolet light stabilizers. This study applies the bulb-shape rigid plastic PE tank with 50 cm diameter and height 80 cm, see Figure 2.

3.1.2 ECHO SOUNDER EQUIPMENT

Echo-sounding accuracy is ± (0.02 m + 0.1% D) where D is the water depth). The device has 0.3-200m in the detection range. It is perfect for shallow and deep-water surveying by the minimum 0.3 m range. The modular user-friendly design of the echo-sounder makes it easy to use, repair and upgrade while it can operate in all-weather condition.

The hydrological software has advanced water depth analysis and automatically filters out the secondary echo. The main parameters as gain, power, and range are adjusted manually and automatically. The software provides a professional depth-keeping configuration ensuring accurate results by removing interference noise.

3.1.3 GPS EQUIPMENT

This study uses a palm-sized cheap GNSS receiver designed for land and water surveying applications (Anantakarn and Witchayangkoon, 2019). Using an external GNSS antenna, the free Land Survey App and post-processing software, it is possible to conduct a real-time kinematic (RTK) positioning (Witchayangkoon, 2000; Anantakarn et al., 2019).

3.1.4 EQUIPMENT INSTALLATION

Echosounder and GPS equipment is integrated and install as in Figure 2. Sounder equipment and RTCM via Internet Protocol (NTRIP) Modem and GNSS receiver are integrated and installed in the pontoon. In order to make the pontoon floating properly for movement, the weighting material is filled and adjusted for optimal surface movement conditions.

3.2 THE STUDY AREA

Thachin river has a record of poor to very poor water quality for a prolonged period (Pollution Control Department, 2015), where the river water flows into the upper Gulf of Thailand The report indicated the Thachin estuary contains bacteria and nutrient pollution from phosphates, phosphorus, and nitrogen. Nutrient pollution harms water quality, food resources for aquatic animals, marine habitats, and algae to grow faster than ecosystems can handle. Some study findings stated that large amounts of wastewater discharged into the river are from households as well as industry, and agriculture sectors. Thachin river area is selected in Nakhon Pathom province for this study. The site is located about 40 km West of Bangkok on the Thachin river as shown in Figure 3.

The survey area is estimated at 15,484,304 square meters that defined by a buffer zone with 500 meters from the river centerline. This zone shows a black line in Figure 3 with dynamic land use as residential, aquaculture farm, agricultural crop, fruit garden, and industrial zone.

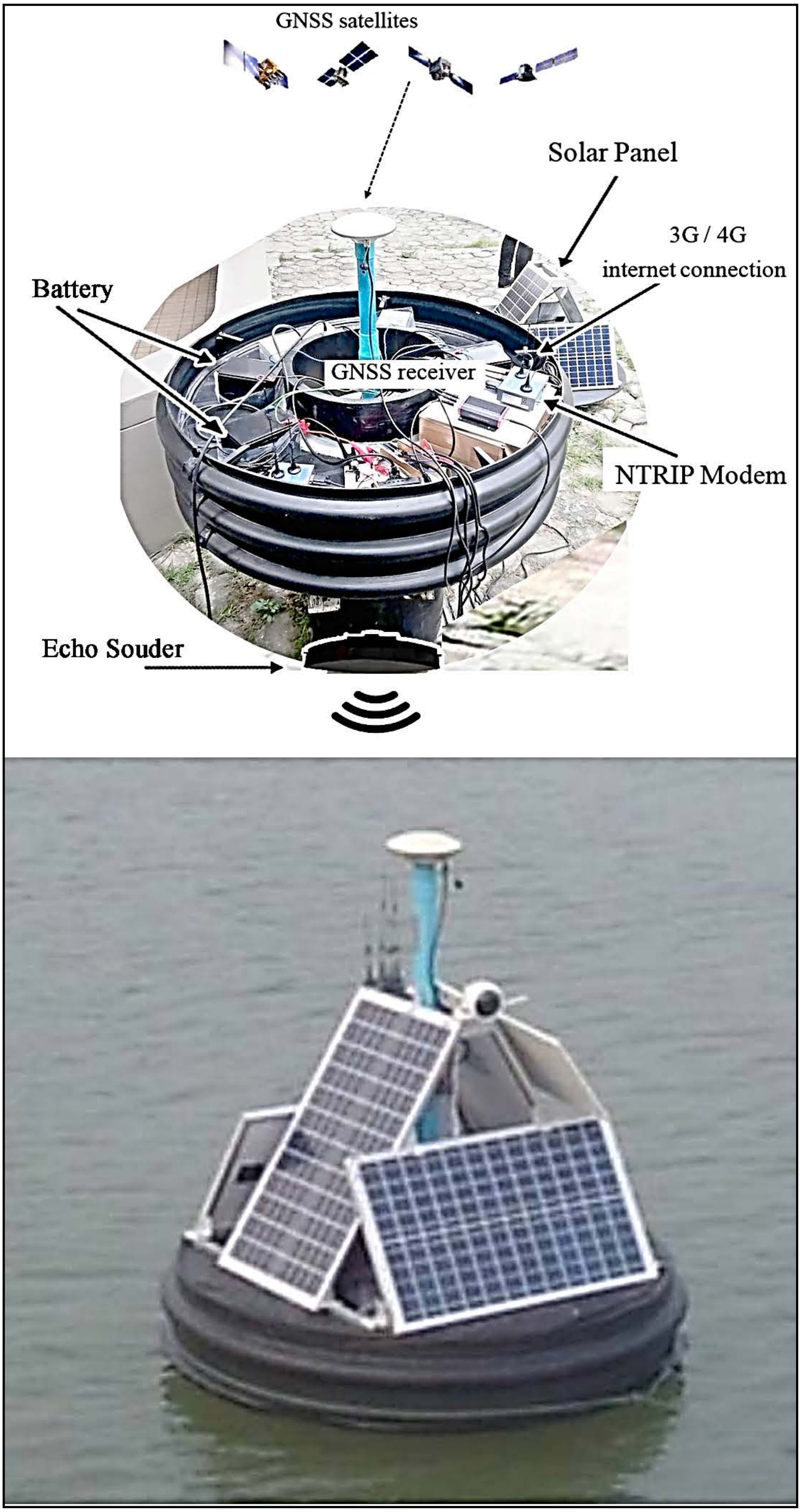

Figure 2: A description of Smart IoT Pontoon

3.3 DATA COLLECTION AND DATA PROCESSING

The field survey has been conducted during 09-12 January 2020 and the point data collection of river depth data is estimated at 21,814 surveyed points. The surveyed data has been processed by using open source free GIS software Quantum GIS Ver. 3.10 as presented in Figure 3.

3.3.1 ECHO-SOUNDER DATA COLLECTION

The Smart IoT pontoon was towed by a simple boat at the average speed of 2.5 km/h along the river with approximately 13 kilometers. In order to get better bathymetric data, the data collection is arranged for the three paths such as center, right side and left side of the river and showed as pink color points in Figure 3. The echo-sounder measured point was recorded in 2 meters interval as water depth. Each point of water depth measurement was stamped with a geographic coordinate and time of data measurement.

3.3.2 GNSS RTK DATA COLLECTION

The GNSS receiver with dual-frequency L1/L2 was set in RTK mode in connection with DOL Virtual Reference Station (VRS) service. The fixed mode with horizontal and vertical Root Mean Square (RSM) error at 3cm and5cm respectively. The map data projection is selected as WGS 1984/UTM zone 47N with the elevation model of EGM 96. The geographic coordinate was synchronized with the river depth measurement point in the standard text comma-separated values (CSV) format for further processing and analysis.

3.3.3 SRTM ELEVATION DATA PROCESSING

Shuttle Radar Topography Mission (SRTM) elevation data is available at a resolution approximately 30m x 30m was downloaded from the USGS website in raster geo-TIFF format. Ten Ground Control Points (GCP) were collected by using GNSS RTK during the field survey that was applied for SRTD data correction and adjustment. The correlation was conducted and the strength of an association between two variables and is completely symmetrical (Li et al., 2013).

The SRTM data was filtered by median-filtered digital value and extracted from the co-registered with ten GNSS surveyed points for correction and adjustment SRTM data (Anantakarn et al., 2019). The adjusted SRTM data for land elevation information was then combined with river water depth data collected by echo-sounder to produce the bathymetric and topographic map of the river.

3.3.4 FIELD SURVEY DATA FOR GCP AND CHECKPOINT

The land survey data was conducted for the collection of ten Ground Control Points (GCP) by using the GNSS receiver with dual-frequency L1/L2 was set in RTK mode in connection with DOL Virtual Reference Station (VRS) service. These GCPs were applied for correction and adjustment of the SRTM data for improving the quality of land elevation data.

The water surveyed data was applied for the collection of 27 Checkpoints (CP) by using the measurement tape for river water depth. These CPs were selected for every 500m distance and were then compared with the bathymetric and topographic map results for accuracy assessment.

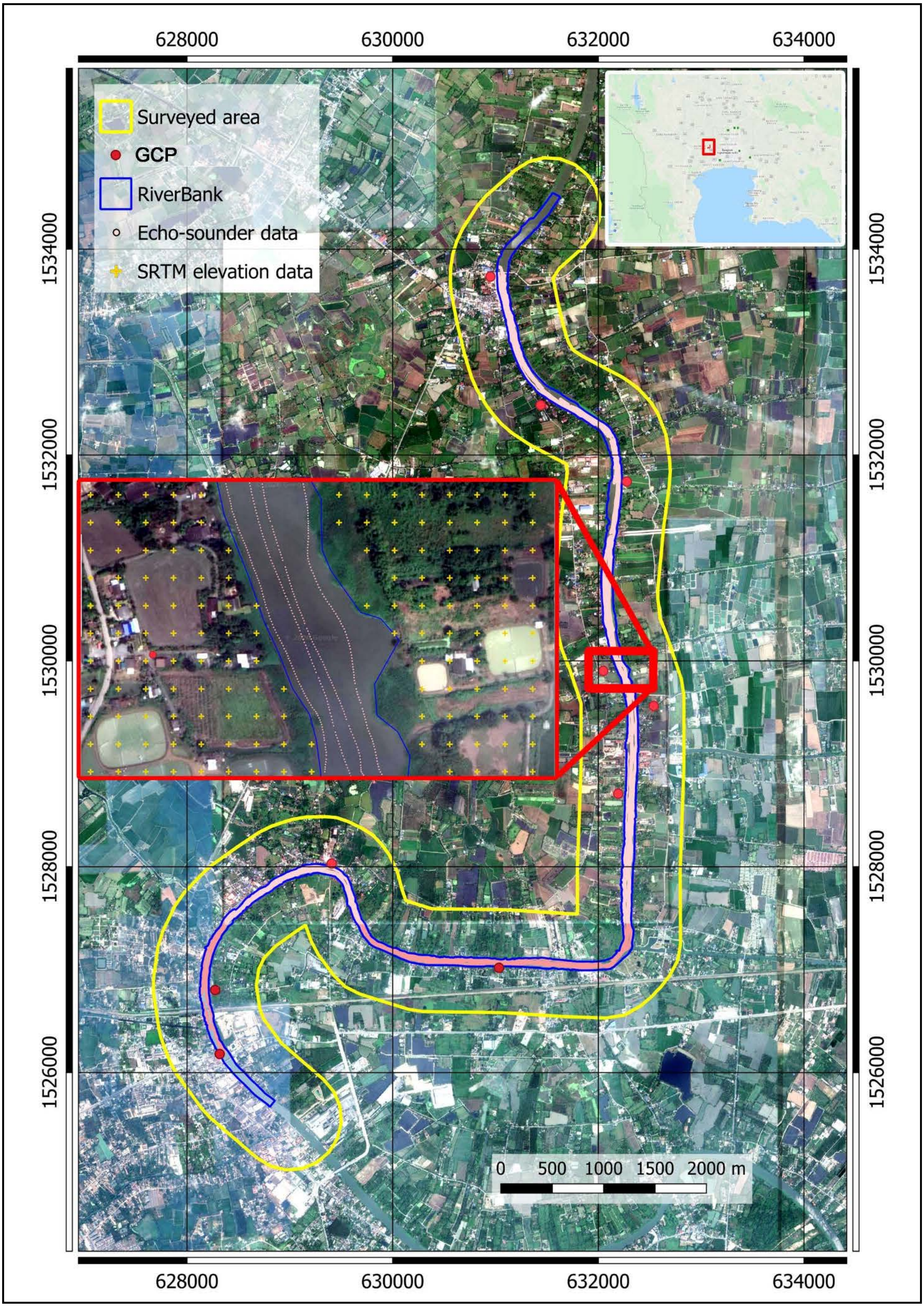

Figure 3: Survey data collection on the Thachin river, Nakhon Pathom province.

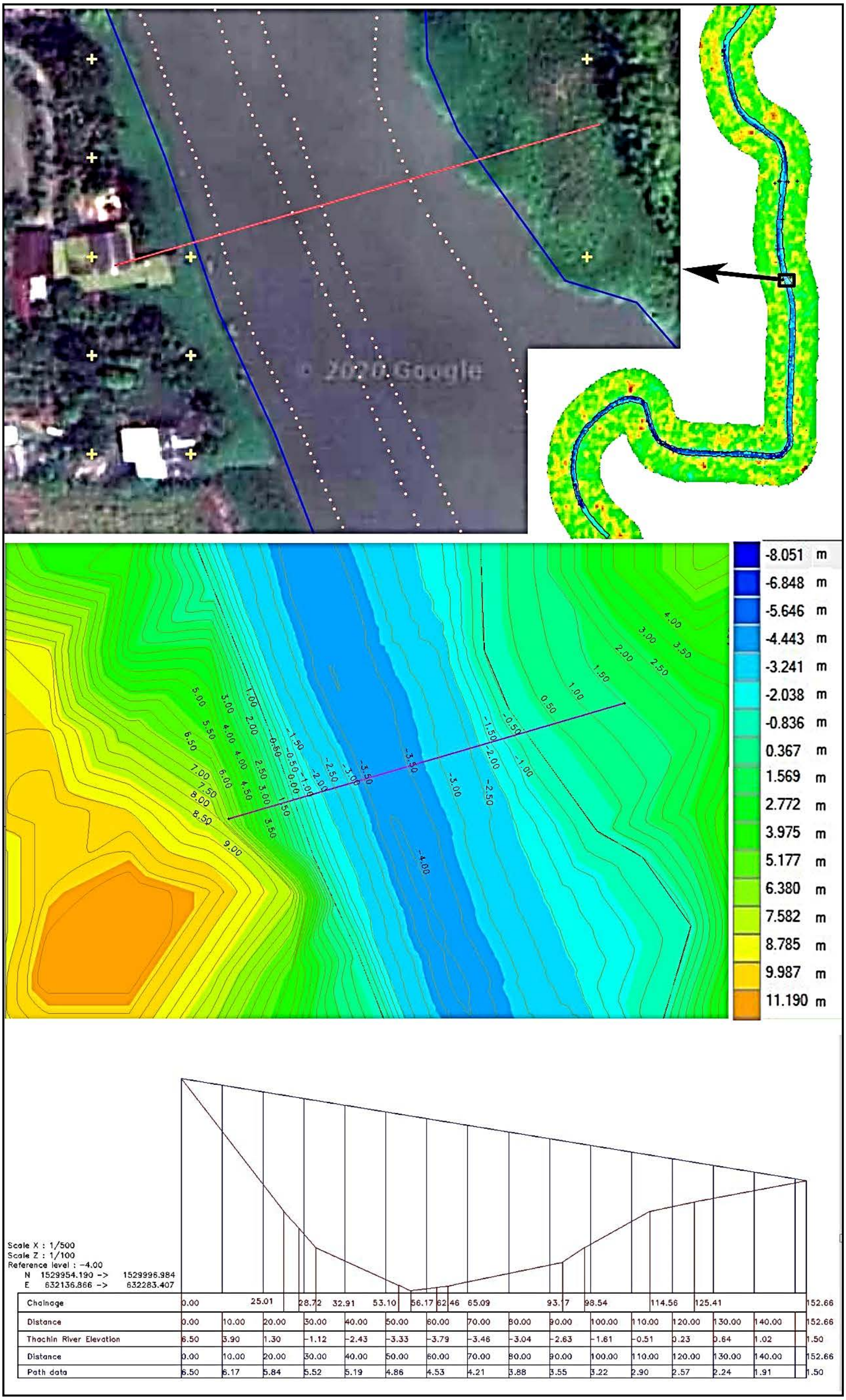

Figure 4: Analysis of bathymetric data by using GIS (Courtesy of Google®).

4. RESULT AND DISCUSSION

Topographic map was generated from the echo-sounder data and SRTM data for land and water area respectively, Figure 4. The bathymetric and topographic map with the elevation contour lines were also produced in 20 centimeters interval for the purpose of accuracy assessment.

There are 10 checkpoints collected during the field survey by using the GNSS RTK system. These points are then used to compare with the topographic map result for accuracy assessment. The results of accuracy inland area were compared between the GNSS RTK system and DEM from the SRTM data as shown in Figure 5.

There are 27 checkpoints using measurement tape and the GNSS RTK system, to compare with the topographic map result for accuracy assessment. The results of accuracy inland area were compared between the GNSS RTK system and water elevation from the echo-sounder data, Table 1.

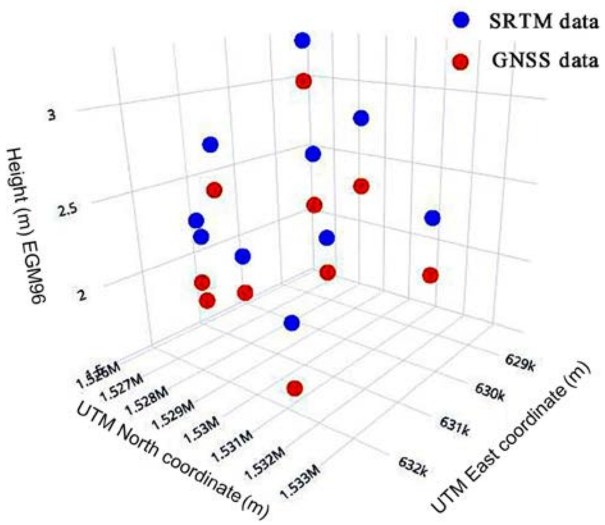

Figure 5: Results of comparison elevation from GNSS RTK measurement and SRTM data.

Table 1: Results of comparison elevation from tape measurement and echo-sounder data.

ID	UTM North	UTM East	Height measured by Tape (m)	Height measured by Echo Sounder (m)	Different height from Tape and Echo-sounder (m)
PT10	1532200.357	632060.564	-1.94	-2.17	0.23
PT12	1531720.424	632220.430	-3.54	-3.65	0.11
PT14	1531192.387	632084.563	-5.11	-5.19	0.08
PT16	1530712.664	632113.172	-4.18	-4.00	0.18
PT18	1530251.299	632081.017	-3.87	-3.51	0.36
PT19	1529781.063	632232.205	-3.30	-3.06	0.24
PT2	1533810.374	631101.314	-0.76	-0.98	0.22
PT21	1529278.713	632377.421	-2.78	-2.57	0.21
PT24	1528788.139	632359.410	-4.28	-3.82	0.46
PT25	1528283.722	632335.610	-3.89	-3.75	0.14
PT28	1527781.693	632321.162	-2.14	-1.97	0.17
PT29	1527279.928	632306.982	-5.26	-5.29	0.03
PT3	1533315.554	631172.515	-4.18	-3.97	0.21
PT32	1527015.539	631913.860	-7.11	-6.66	0.45
PT34	1527107.409	631429.465	-4.06	-3.98	0.08
PT37	1527058.481	630932.107	-4.91	-5.14	0.23
PT38	1527067.628	630411.926	-6.00	-5.78	0.22
PT41	1527198.118	629912.502	-8.20	-8.26	0.06
PT42	1527585.815	629656.128	-4.45	-4.51	0.06
PT44	1527982.991	629410.954	-8.56	-8.32	0.24
PT46	1527846.728	628934.773	-3.78	-3.45	0.33
PT49	1527574.836	628543.428	-4.15	-3.66	0.49
PT50	1527194.401	628264.069	-2.06	-1.81	0.25
PT52	1526700.040	628145.744	-5.82	-5.62	0.20
PT54	1526218.789	628370.854	-5.11	-4.79	0.32
PT6	1532843.477	631241.185	-2.48	-2.59	0.11
PT7	1532454.816	631680.688	-2.88	-3.02	0.14
				RMS	**0.22**

Geographic positioning coordinates are measured by using GNSS Real-Time Kinematic (RTK) networks from the Department of Land (DOL) of Thailand and bathymetric data is employed Echo Sounder. The research result shows that the RMS error of water depth is the average of 22cm.

5. CONCLUSION

Surface water can be affected by land use, agricultural practices, pollution, and climate change. Monitoring and treatment of surface water require significant investments in time and money. The study provides a new integrated system as a Smart IoT pontoon for bathymetric and topographic mapping. The accuracy test was conducted in the Thachin river at the length about 13 km with GNSS measurement in RTK mode in combining with echo-sounder and intensive field surveying for accuracy assessment. The GCP and Checkpoints are applied to evaluate the mapping result that shows the RMS error of water depth is the average of 22cm. The system provides an IoT Smart technology for hydrological surveying by Real-time data monitoring. This objective will bring great profit for all hydrological surveyors who use pontoon for natural disaster monitoring such as flood warning systems or hydro-power dam risk monitoring.

The built system and instruments work to provide continuous quantity and quality water records. The efficient instruments provide reliable data you need at reduced costs.

6. AVAILABILITY OF DATA AND MATERIAL

Data in this study can be provided upon contacting the corresponding author.

7. ACKNOWLEDGMENT

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PassapongTanpaibool is an M. Eng. Candidate at Department of Civil Engineering, Rajamangala University of Technology Tawan-ok. He is self-employed in Construction Business. He earned his Diploma in Construction Technology from Rajamangala Institute of Technology, Salaya Campus and a Bachelor of Engineering degree in Civil Engineering from the South-East Asia University. He is interested in Hydrology and Construction.

Dr. Kritsada Anantakarn is a Lecturer at the Department of Civil Engineering Technology, Faculty of Engineering and Architectures, Rajamongala University of Technology Tawan-ok, Uthenthawai Campus, Thailand. He earned his Bachelor of Engineering (Civil Engineering) from Faculty of Engineering Rajamangala Institute of Engineering, and a Master's degree in Urban and Environmental Planning from King Mongkut's Institute of Technology Ladkrabang, and his PhD from Thammasat University. He is interested in GPS/GNSS and Spatial Technology.

Dr. Rerkchai Fooprateepsiri is an Associate Professor and President of Rajamangala University of Technology Tawan-ok. He got his Master's degree in Computer Engineering. He earned his PhD in Information Technology both from Mahanakorn University of Technology. His research focuses on the Area of Computer Engineering, Computer Vision and Data Analysis.

Dr. Wunchock Kroehong is a Lecturer at the Department of Civil Engineering, Faculty of Engineering and Architectures, Rajamongala University of Technology Tawan-ok, Uthenthawai Campus, Thailand. He earned his Bachelor of Engineering (Civil Engineering) from Faculty of Engineering Rajamangala Institute of Engineering, and a Master's degree from the school of Civil Engineering at the Mahanakorn University of Technology, and his Ph.D. from the Suranaree University of Technology. He is interested in Concrete, Geopolymer, and Durability.

Dr. Boonsap Witchayangkoon is an Associate Professor at the Department of Civil Engineering, Thammasat University. He received his B.Eng. from the King Mongkut's University of Technology Thonburi with Honors in 1991. He continued his Ph.D. study at the University of Maine, USA, where he obtained his Ph.D. in Spatial Information Science & Engineering. His research encompasses Emerging Technology to Civil Engineering Applications.