REBUILDING LAKE CHINI TELEMETRY SYSTEM FOR WATER QUALITY MONITORING

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ABSTRACT*: Tasik Chini Research Centre (TCRC) has been using sensors to monitor water quality at Lake Chini since 2010. TCRC complements the works of the Department of Environment (DoE) in monitoring the water quality by collecting readings of parameters used to calculate the Water Quality Index. Water Quality Index is used to measure cleanliness and the quality of water to sustain the rich and diverse biodiversity of flora and fauna. For the last 10 years, the telemetry system built-in 2010 is adequate for such purpose. However, the rampant logging, mining and plantation activities in the last five years discharged waste such as sediment, fertilizer and toxic into the lake and threaten the lake biodiversity. The big flood of 2014/2015 further destroyed most equipment of telemetry stations and rendered them inoperable. We present the challenge of rebuilding the collapsed infrastructure to resume the measurement of water quality parameters. The new telemetry system incorporated two new features to ensure accessibility: A dashboard and early warning system, and moving data and application into the cloud.*

KEYWORDS: Lake Chini, water quality index, sensors, telemetry systems

1. INTRODUCTION

Tasik Chini, a UNESCO Biosphere Reserve, is the second-largest natural lake in Malaysia. It is formed from a combination of 12 open bodies of water known as "Laut" or "sea" by the native Jakun tribe living within the vicinity of the lake. The 200 hectares lake surrounded by 5000 hectares of swamp forests and freshwater swamps forming an area known as Tasik Chini Forest Reserves [1-2].

The lentic ecosystem is home to a rich and diverse biodiversity of flora and fauna, many endemic or unique to Lake Chini. It has been reported that the reserve is home to 87 species of freshwater fish, 189 species of birds, 51 low forest species, 15 freshwater swamp forest species, and 25 aquatic plants [2]. The surface of the lake is covered with thousands of pink lotus flowers, Nelumbo Nucifera, in June and September each year. About 800 indigenous people from the Jakun tribe made their homes there [3].

The natural environment in Lake Chini that includes the flora and fauna, rivers, swamps, lowland, and hill forests, as well as the indigenous people, form a unique ecosystem. This ecosystem depends on the lake for their survival and water supply.

Ensuring healthy water quality is vital for the survival of the ecosystem. We present, here, our work in restoring the infrastructure for the monitoring of water quality of the lake in the aftermath of the big flood of 2014/2015 which decimated all our monitoring stations as well as from years of waste discharged into the lake. We presented a new architecture of our telemetry stations.

2. MATERIALS AND METHODS

Malaysian Department of Environment (DOE) is the agency entrusted by the government to consolidate surveillance and rehabilitation programs at Lake Chini to ensure water its water quality meets the established standards. They have been collecting parameters from sensors at their 23 telemetry stations periodically since 1978.

In addition to DOE, Tasik Chini Research Centre (TCRC) of Universiti Kebangsaan Malaysia also involved in monitoring water quality at the lake. In 2010, TCRC constructed seven telemetry stations to measure and record water quality parameters at seven different rivers that formed the inflow and outflow streams of the lake. Every telemetry station consists of a tower block which houses solar cell and battery for power supply, a data logger to record readings from sensors, a GSM modem and antenna to transmit the data from the data logger to a server at TCRC. Figure 1 shows the actual tower (left) and the water quality sensors used (right). The architecture of the telemetry system used is shown in Figure 2. The tower also houses climatology and hydrology sensors.

Readings were taken every 15 minutes. The measurement of water quality taken are Temperature (^oC), Conductivity (uS/cm), Total Dissolved Solids (mg/l), pH (unit), Turbidity (NTU) and Optical Dissolved Oxygen (mg/l). These readings will be used to determine the Water Quality Index (WQI) and classify according to the Interim National Water Quality Standard (INWQS). Details of the parameters and methods of water analysis can be found in [4].

Figure 1. The telemetry tower and water quality sensors.

The almost real-time updating of data into a centralized database has been an invaluable task. However, the telemetry station that was constructed in the last decade is already due for a technological upgrade. The big flood that began in late December 2014 until early 2015 has totally decimated the telemetry stations and its components and rendered them inoperable [5]. Since the flood may happen again, a new system that can mitigate the risk is required.

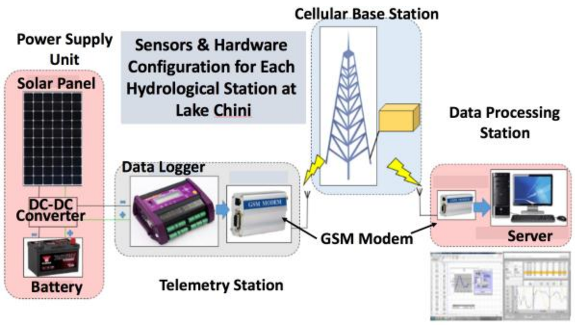

Figure 2. The architecture of original telemetry station at Lake Chini.

The record-setting “tsunami-like” flood of 2014 was summed up by [6] as “the most significant and largest recorded flood in the history of Kelantan. The big flood completely destroyed the IT infrastructure. Some of the stations were submerged and unreachable for more than a week. Due to the flood, devices vital to our samplings such as data loggers, power supplies and routers were unserviceable. Vital data for the next few months were not logged in the data logger and not transmitted to the server.

The flood was not the main reason for the complete overhaul of the decade-old telemetry system. However, it was the catalyst for a revamp since the event demonstrates that the IT infrastructure at Lake Chini is unprepared for any eventuality. An IT Risk Management exercise study was carried out by **[7]** on at TCRC as a consequence of the flood. She observed that TCRC needs to promote some aspects of IT risk management policies such as developing a special risk management system or a special model for risk registration and data storage.

The current infrastructure served the purposes defined a decade ago and used the technology available during the period. However, the economic activities (logging, mining, and plantations) around the lake present a new challenges. In particular, wastes from these activities such as sediment, fertilizer and toxic that flow into the lake gave a lasting effect to the flora and fauna, and threaten the lake biodiversity.

Since its inception, network coverage was a dismal 2G. There were little incentives for the telco to upgrade to 3G or 4G since the area is unpopulated. Transmitting data using 2G is expensive since the charging structure is based on per connection rather than volume. The exorbitant charge prevents TCRC from having true real-time monitoring. Readings from the sensor were taken in a fixed time interval and cached in the data logger before transmitting it to the server. In our case, data from sensors were logged every fifteen minutes, stored in the data logger and transmitted to the server once every eight hours. This process was chosen purely for economic reasons.

There is also an issue of having an offline, centralized and proprietary system. There is a difficulty for TCRC to disseminate their findings to interested researchers, communities, and agencies. It is essential for the recipients to transform the digital footprint into something meaningful and practical. In order to provide this initiative, current and future data must be made accessible. A physical server currently being deployed is not particularly apt for such purpose.

The current dashboard is limited to graphically display the readings of all sensors from every station. There is no warnings or alerts when some readings went beyond the acceptable threshold.

3. RESULTS AND DISCUSSION

Revamping current stations is not a matter of replacing all available devices and tools. TCRC needs a network of systems capable of providing accurate and speedy information to enable the environment to be monitored and able to benefit users of local communities and relevant agencies. The latest and real-time data needs will assist stakeholders in preserving and conserving the river environment in Lake Chini in particular and the lake catchment area in general. This environmental information also helps researchers and government agencies in assessing environmental conditions as well as providing early steps to relevant agencies to take appropriate action to help conserve and preserve the environment of Lake Chini. The risk in this study refers to any potential, positive and negative impacts of natural disasters or water quality in Lake Chini according to Malaysia classification of river and lake water quality status. In addition, the development of a risk management system can be used as a medium for the delivery of water quality information to the aborigine community using popular apps in their mobile devices **[8]**.

These are new requirements that were requested by researchers, agencies and community. These provisions need to be incorporated within the new telemetry system. The new improved architecture of the new telemetry system incorporates:

1. A dashboard and early warning system are needed. The dashboard should be able to:
   - display raw data and the Water Quality Index periodically.
   - visualize parameters taken from the sensors.
   - display interactive maps showing the location of all seven sampling stations and the parameters.
   - access data anytime and anywhere using various devices.
2. A flexible early warning system allows TCRC to set a threshold for certain parameters and warn the communities and agencies for further action if sensor readings are beyond the threshold range. This is necessary for TCRC to detect any event that demands immediate mitigation such as flood and pollution.
3. Current and future data must be stored in a cloud. Moving data into the public cloud will ensure public accessibility as well as discharge TCRC from daily operations of maintaining a physical server such as security and backup. The cloud will also be hosting the dashboard and early warning system. This public repository will make it easier for real-time data from the data logger to be accessed by the dashboard and early warning system as well as the in-situ calculation of WQI.

4. Integrate the new system into the recently upgraded 4G network in the area and with enough room to future upgrade to a modern mobile network.

Figure 3 shows the architecture of a new sampling station. A solar panel and battery will provide power supply to a data logger which will accept readings from water quality, hydrology and climatology sensors. The readings will be pushed to a router for data transfer to the cloud via a mobile network. Each monitoring station is equipped with a mobile/wireless network technology that has high reliability with no interruptions and security issues. All monitoring stations form a separate network infrastructure and operate on the data plan allocated to it. Data transfer will be regular and continuous.

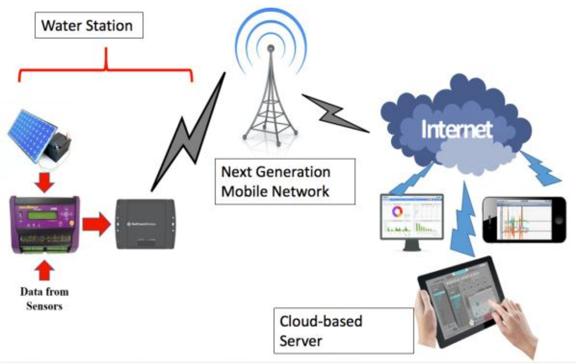

Figure 3. New architecture for telemetry station.

4. CONCLUSIONS

This study focused on restoring the telemetry stations at Lake Chini so that processes and activities to acquire valuable data from sensors that were halted due to the damage caused by the great flood of 2014/2015 can resume. There are lots of improvements to the systems. The cloud enables the sharing of data among researchers, government agencies and local communities with relative ease. It also allows access to the data anytime, anywhere and on many different device platforms. The dashboard gives a better visualization of parameters for users. With the integration of an early warning system, researchers will be able to pinpoint the location of disaster so that immediate mitigation can be carried out. Faster and improved network coverage will ensure real-time data can be read, stored and acted upon.

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