Investigating the potential of water supply system for environmental sustainability

Asmalia Che Ahmad1*, Asniza Hamimi Abdul Tharim1, Mohamad Haizam Mohamed Saraf1, Mohamad Quzami An-Nuur Ahmad Radzi2, Meor Abdullah Zaidi Meor Razali3, Zubir Ahmad Muhammad Ismail4

1Department of Built Environment Studies and Technology, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Perak Branch, Malaysia
2Department of Graphic, Faculty of Art and Design, Universiti Teknologi MARA, Perak Branch, Malaysia
3Landscape Department, Majlis Bandaraya Ipoh, Malaysia
4Royal Belum State Park, Perak State Park Corporation, Malaysia

*Email: asmalia809@uitm.edu.my

Abstract. The Royal Belum State Park (RBSP) is gazette as a reserve area in Malaysia is covered by 90% of forest and inhabited by mostly the Jahai tribes. One of the hardships of these indigenous Jahai is to retrieve drinkable water from clean water resource. Due to the constraint of development in the rural area of forest reserve RBSP, a sustainable water supply system project needs to ease the tribe. Hence, this study investigates the potential for a water supply system towards environmental sustainability as a starting point for an environmentally sustainable water supply project at RBSP. The investigation is conducted using the Systematic Literature Review (SLR) on the existing literature with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The statement review method from Scopus and Web of Science databases have recognized 12 out of 84 related research articles searched worldwide on a topic related to the rural sustainable water supply. Findings from the 12 sustainable water supply research articles reveal two main considerations in determining the water supply which are the local context and water sources availability. Hence, a site visit to RBSP is recommended to further investigate the potential water supply system towards environmental sustainability at the research location.

1. Introduction
The Royal Belum State Park (RBSP) located in Malaysia is gazette under the Perak State Parks Corporation Enactment 2001 as a reserve area. This area is managed by local agency, Perak State Parks Corporation to facilitate biodiversity ecotourism research, and education. The total area of the park is 117,500 hectares of undisturbed forest [1]. There is one river system named Sungai Perak with hundreds of streams and tributaries feeding the Temenggor Lake. The main access route is the public jetty at Pulau Banding for boat transportation. The Jahai tribe is largest group of indigenous people who inhabits the RBSP. One of the hardships of this indigenous Jahai tribe is to retrieve drinkable water. The clean water resource in which the nearest waterfall located a few kilometers away from their settlement. Typically, they make trips to the water resource by walking or taking boats, which is costly due to the required diesel.
Based on Sustainable Development Goals (SDG) Report in 2020, there are 785 million people with no basic drinking water [2]. Aligning this global agenda, Malaysia focused on rural communities in establishing sustainable water supply according to the nature of rural development projects towards the National Priority Area for water security in 12th Malaysia Plan 2020-2025. Since RBSP is a national park serving as rural ecotourism attractions, the balance between environment conservation and tourism management should be maintained [3]. The design, process, and management of constructing and maintaining the water supply system should be environmentally sustainable.

Water supply systems for environmental sustainability include the blends of modern and traditional mechanisms that work with nature, protects human safety and health, as well as restore natural landscapes [4]. Design and planning of the new water supply should consider the location close to water treatment facilities, minimize potentially adverse, less environmental risks, and easily accessible for monitoring and maintenance [5]. Source of water management, contaminants, and technology are also crucial in dealing with sustainable water issues in Malaysia [6].

Attributable to this issue of obtaining clean water for drinking, there is a need for an action research project to propose the design and construction of a clean water supply system. An action research project is proposed in collaboration between Universiti Teknologi MARA (UiTM), Majlis Bandaraya Ipoh (MBI), and Perak State Parks Corporation (PSPC). This project aims to provide an environmentally sustainable water supply system as drinking water to the Jahai indigenous tribe of RBSP. In order to achieve the aim, three objectives have been planned with different methods. The first objective, which is the first phase of the project, is to investigate the water supply system's potential for environmental sustainability. The next objective is to innovate, design, and construct a sustainable water supply system. The last objective is to transfer knowledge to indigenous people on the construction and maintenance of the system. However, this article only focuses on the first objective which is investigating the water supply system's potential for environmental sustainability at RBSP using Systematic Literature Review (SLR) method.

2. Systematic Literature Review
A systematic literature review (SLR) utilizes formulated keywords using structured and systematic review process to identify, select, assemble, and analyse data on published research database [7]. Hence, the identification of gaps can be justified and the research directions can be determined. In the area of water supply system studies, the publication on sustainable water supply system for inhabitants at isolated and protected rural area is very limited. Thus, this research article aims to make the gap smaller by investigating and understanding the water supply system for environmental sustainability implementation at rural and reserved area. This review study looked into the existing sustainable water supply research, issues, water sources, method to solve the issues and related findings.

3. Methodology
This segment explains SLR as the method used to investigate the potential water supply system for environmental sustainability from published sources. The method is referred from review of published sources using an approach called Preferred Reporting Items Systematic Reviews and Meta-Analysis (PRISMA). This approach consists of a search string process from prominent published databases. The purpose of this approach is to reviews and synthesise existing literature systematically. For this research, PRISMA approach embraces prominent academic databases. There are four main phases in conducting this SLR procedures [7]. The advantages of using this approach are it defines clear selection criteria on research published articles by identifying exclusion as well as inclusion criteria, systematic and structures steps, utilizing prominent research databases and determination of time range [8].

3.1 SLR procedure
The SLR procedure is divided into four (4) phases as per Figure 1. The first phase is the Identification Phase, in which keywords are used in the search process in determined databases. This phase was performed in January 2021 in Scopus and WoS databases. The keywords related to water, supply,
system, rural areas, humans, sustainable, resource, and construction were being utilised (Table 1). 74 articles from Scopus and 10 articles from WoS that total 84 articles were identified. Next, the second phase in this process which is Screening Phase. From the screening process, it is found that 2 articles have been duplicated at both databases. These 2 articles are then being removed leaving 82 articles in this process. From these 82 articles which were eligible to be reviewed, 57 articles were excluded due to they are review articles, books, book chapter, conference proceedings and non-English type of the published material. Only journal articles published in English are taken into account in this Screening Phase. The third phase is the Eligibility Phase where 25 full-text articles were accessed (Table 2). Upon examining those articles, 13 articles were excluded because unrelated to water supply system at rural reserve area. Finally, the Included Phase which is forth phase were resulted in 12 articles are selected for this analysis review.

![Systematic literature review procedure of water supply for environmental sustainability](image)

**Figure 1.** Systematic literature review procedure of water supply for environmental sustainability

### 3.2 Identification Phase and database
There are many academic research databases for literature and research findings. Scopus, Web of Science (WoS), PubMed, IEEE Xplore and Science Direct are some of the examples for these databases. For this Identification Phase, the top two database which are Scopus and WoS was selected with
keywords as per Table 1. Both database Scopus and WoS consist of 23,000 and 33,000 peer-reviewed journals from almost varies discipline [7]. This database also covers more than 100 years bibliographic, conference proceedings, books, book chapters, authors profile and journal rankings.

**Table 1. Identification Phase of water supply for environmental sustainability**

| Databases   | Keywords of water supply for environmental sustainability |
|-------------|----------------------------------------------------------|
| Scopus      | TITLE – ABS- KEY ( water AND supply AND system AND in AND rural ) AND ( LIMIT -TO ( EXACTKEYWORD , "Drinking Water") OR LIMIT- TO ( EXACTKEYWORD , "Water Management") OR LIMIT- TO ( EXACTKEYWORD , "Potable Water") OR LIMIT-TO ( EXACTKEYWORD , "Water Supply") OR LIMIT- TO ( EXACTKEYWORD , "Article") OR LIMIT-TO ( EXACTKEYWORD , "Rural Area") OR LIMIT- TO ( EXACTKEYWORD , "Rural Areas") OR LIMIT- TO ( EXACTKEYWORD , "Water Quality") ) OR LIMIT -TO ( EXACTKEYWORD , "Human") OR LIMIT-TO ( EXACTKEYWORD , "Humans") OR LIMIT- TO ( EXACTKEYWORD , "Rural Population") OR LIMIT- TO ( EXACTKEYWORD , "Water Supply Systems") OR LIMIT- TO ( EXACTKEYWORD , "Water Resources") OR LIMIT- TO ( EXACTKEYWORD , "Rural Water Supply") OR LIMIT- TO ( EXACTKEYWORD , "Ground Water" ) ) AND ( LIMIT- TO ( OA , "all" ) ) |
| Web of Science | TOPIC: (sustainable water supply) AND TOPIC: (water resources) AND TOPIC: (groundwater) AND TOPIC: (construction method) Refined by: DOCUMENT TYPES: (ARTICLE) Year: All Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI. |

### 3.3 Screening Phase, Eligibility Phase and exclusion

In the Screening Phase, the identified records from Scopus and WoS were screened for duplication and articles published in English. The duplicated and non-English publications were excluded to avoid difficulties in translating other languages. For the period of the previous study, it was set to longer period all years since there was a lack of related publication in the field. Next, peer reviewed academic journal research articles are selected. Publication in review articles, books, book chapters, conference proceedings are excluded in this phase. In the Eligibility Phase, only full-text articles are selected for suitability of the literature content analysis. These full text articles are carefully chosen base on the research area of social science, art and humanities. The non-full text articles and area of hard science that comprise physics, chemistry and biology which is unrelated to this research were excluded. The screening, eligibility and exclusion are shown in Table 2.

**Table 2. Screening, eligibility and exclusion in SLR procedures**

| Item               | Screening & Eligibility | Exclusion                                      |
|--------------------|-------------------------|------------------------------------------------|
| Database           | Scopus & WoS            | Duplicated articles                            |
| Language           | English articles        | Non-English articles                           |
| Period             | All years               | -                                              |
| Published material | Peer reviewed academic journal | Review articles, books, book chapters, conference proceedings |
| Type               | Full text articles      | Abstract and non-full text articles            |
| Research area      | Social science, art & humanities | Hard science                                   |

### 3.4 Included Phase and analysis

The Included Phase has systematically resulted 12 articles for the analysis. The content analysis of these articles is being conducted by reading in depth and extracting from the full-text articles. The issues, water sources, and solutions related to the sustainable water supply system in various countries are highlighted in order to investigate the existing scenarios. Table 3 shows...
the summary of the content analysis. The 12 articles represented the worldwide search on indexed publication on sustainable water supply at rural areas. Three articles addressed sustainable water supply in different China provinces (Xinjiang, Beijing, and Yunnan). Meanwhile, other articles covered Europe (Romania, Ireland), South America (Mexico, Brazil), Middle Eastern (Egypt) and the African continent (Namibia, Angola, Algeria, Tanzania, and whole Africa countries). It is interesting to note that different country has its sustainable water supply issues due to global climate change, water sources, and human activities.

| Authors (year) | Country                | Sustainable Water Supply Issues                                                                 | Water Sources       | Research Objective                                  | Research Method                                                                 | Research Findings                                                                                                                                                    |
|---------------|------------------------|-------------------------------------------------------------------------------------------------|---------------------|----------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9]           | Namibia and Angola     | Rainfall variations and semiarid environment caused life-threatening flood and droughts.          | Natural pans and rivers | To quantify the potential water supply and storage |
|               |                        |                                                                                                 |                     |                                                    | Digital model utilizing high-resolution TanDEM-X to analyse blue spot.           | Identification of more than 2200 pans. These pans are potential in in managing flood and water supply.                                                                    |
| [10]          | Romania                | Climate change and intensive hydropower plant (HPP) development affecting the water supply systems | River               | To measure the effect of HPP and climate changes to river flows | Comparative analysis performed before and after the HPP development and climate global warming situations | The HPP operation has no significant impact on the river flows. The climate impacts, directly and indirectly, the transformations of the river flows. |
| [11]          | Africa continent       | Poor quality of borehole design and drilling process leading to failure of the water supply      | Drilled boreholes   | To initiate competency practices of borehole drilling | Mixed-method of online besides direct meetings and analysis documentation       | Identification of initiatives for the Rural Water Supply Network (RWSN).                                                                                                   |
| [12]          | Egypt                  | The extreme shortage of water and water pressure                                                | Dam                 | To provide an easy-to-read guideline to facilitate sustainable water management | A discussion on sustainable water management of schools worldwide              | The guidance criteria for sustainable water management.                                                                                                                  |
| Country      | Problem                                                                 | Solution                                                                 | Methodology                                                                 |
|-------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|
| China (Xinjiang) | Serious water crisis at agricultural planting zone due to climate change | To develop a system dynamics (SD) model for a decision support system (DSS) for sustainability | Simulation operation of system dynamics (SD) model proposed adjustments of planting structure and implementation of water-saving irrigation. |
| Mexico       | The need for alternatives water supply due to restrictions on groundwater extraction, which is the main water sources | Rainwater                                                                  | To assess the rural community’s perception on alternate water supply of rainwater harvesting (RWH). Questionnaires distributed to rural community. |
| Ireland      | Issues on water distribution networks, such as leakages, and electricity usage, increasing the cost | Water supply network                                                      | To determine the value for money and sustainability of water supply networks device. | A comparative study between Pressure Reducing Valves (PRV) and Pump as Turbines (PAT). PRV reduces leakage but consumes more energy or less sustainable. PAT reduces electricity costs, thus more sustainable. |
| Brazil       | The need for water consumption assessment to encourage water conservation | Water reservoirs                                                          | To identify factors influencing water consumption in single-family households | Questionnaires distributed to 108 households. The identification of significant variables affecting households water consumption. |
| Algeria      | The need to benchmark the service management and performance of the drinking water supply | Various sources, such as rainwater, dam, borehole drillings, and seawater desalination | To develop a decision support tool for drinking water supply management Consultation with stakeholders and performance perception | Development of Drinking Water Supply Service (DWSS) as a tool for the government to improve sustainable water management policy. |
### Tanzania
- **The necessity for improvement on water distribution at rural area.**
- **Distribution Points (DP)** within piped water distribution systems (PWS) from the borehole (with solar-powered motorized pump).
- To examine water collection patterns using Smart Meter Data from piped water distribution system (PWS).
- Data from Smart Meter Data, surveys, and interviews of communities.
- Data on drinking water collection patterns from DP to improve the sustainability of rural water supply.

### China (Beijing)
- **Failure of rainwater control at green roof of China International Airport of Beijing.**
- **Rainwater**
- To identify problems of rainwater at green roof.
- A self-organize design approach of neural network model.
- Rainwater control map neural network model for controlling rainwater for sustainable system at the green roof.

### China (Yunnan)
- **Climate change causing drought, which affects great loss in agriculture production and the national economy.**
- **Rainwater**
- To propose a framework for the agricultural drought vulnerability model.
- The factor analysis method used to determine the main indicators driving the system.
- The evaluation system developed to guide drought mitigation.

### Findings
There were three articles on sustainable water supply issues at different locations in China. Two of the articles highlighted the water crisis at the agricultural zone located in Xinjiang and Yunnan. These two areas have different water sources, which has been badly affected by global climate change. Xinjiang’s water sources are from precipitation and glacier snow meltwater from the mountains, whereas Yunnan depends on rainwater to water the crops. In Xinjiang, research was conducted for a Decision Support System (DSS) using technology development. The System Dynamics (SD) Model was developed to regulate the planting routine and irrigation structure towards water saving [13]. However, in Yunnan, research was conducted by developing the evaluation system on Agricultural Drought Vulnerability Model to mitigate drought [20]. This model highlights agriculture land, rainfall, irrigation, water supply, and population as the driving factors. The other article highlighted rainwater overflow at the green roof of China International Airport. The solution was based on the technology in which Rainwater Control Map Neural Network Model was established to control rainwater, creating a sustainable drainage system for the green roof [19].

For the European continent, there were two articles from Romania and Ireland. There has been decreasing water amount in the river flow, which is Romania’s main water supply sources. The research was conducted to determine whether the constructed hydropower plant (HPP) or the climate change has...
It was found that the HPP operation has no significant impact on the river flows. However, climate change which impacts the humidity and temperature have directly and indirectly transformations of the river flows directly due to transformations in air temperature-humidity conditions and indirectly related to the transformational flow of the river [10]. In Ireland, research has been conducted on distribution of water networks due to water leakages and electricity consumption. It aims to determine the value for money and sustainability of water supply networks devices. The result showed that Pump as Turbines (PAT) has potential in improving water distribution networks. Additionally, PAT is more sustainable because it generates energy and reduce electricity costs. The other device, Pressure Reducing Valves (PRV) could reduce leakage with electricity consumption. PRV is lack of opportunity to recover energy which shows it is less sustainable [15].

The issues highlighted in South America and Middle Eastern are water management, such as water consumption, alternative water supply, and guidelines to communities towards water conservation. Factors influencing water consumption had been studied in Brazil [16]. The significant variables affecting water usage were demographic profile that consist of number of occupants, level of education and water saving practices. Other variables were water-efficient tools and building topographies including the age of building, number of lavatory and floor area. In Mexico, studies on rain water harvesting (RWH) has been conducted as alternate of present groundwater supply. Findings shows that financial support and training were necessary action in order to apply this sustainable system for the community [14]. At Egypt, a guideline from research outcome has been circulate to community to streamline sustainable water management process [12]. In addition, it seems that sustainable water management need to focus on water preservation, behavior changes, and water efficiency techniques.

Most African countries depend on borehole for rural water supply. Other than borehole drillings, there are various water sources, such as pans, dam, wells, riverbed, seasonal rainwater, and seawater desalination. Along with UNICEF’s cooperation, a study has been conducted on the poor quality of borehole processes that lead to failure water resource and supply [11]. Rural Water Supply Network (RWSN) has been initiated to improve the competency of drilling exercise of boreholes. The initiative consists of leadership, funding agencies, investment term, training, personal development, drilling expertise and institutional environment. Other study in Namibia and Angola, has initiated an effort to quantify water’s potential storage [9]. A digital model utilizing high-resolution TanDEM-X has been design to analyze blue spot of potential water resources. The model identified 2200 potential pans to expand water supply expansion in the future.

Another water issue in Africa is clean water supply for drinking purposes. A decision support tool on sustainable water management has been developed in Algeria. Drinking Water Supply Service (DWSS) was established to take account of government policy directions towards sustainable water management [17]. In Tanzania, a water collection patterns from piped water distribution systems (PWS) at distribution points (DP) has been examined [18]. The community used smart pre-payment meters to collect water at DP since PWS was not connected to individual households. The patterns influencing water collection were collecting time, volumes collected, location, and distances to DP. These data could improve drinking water supply in terms of water capacity, water service, save queuing time and increase farming activities.
5. Conclusion
This systematic literature review has highlighted the sustainable environment issues and practice of the water supply system at rural area across the globe. The scope covers rural areas within the published articles in Scopus and WoS database. As a conclusion, the selection and implementation of the water supply towards environmental sustainability depend on the issues of the local context and water sources availability and other related factors are location, climate, climate change, topography, quality of water supply processes, water shortage, water pressure, leakage, energy consumption, alternative water source, water consumption, water conservation, water supply service, water collection patterns, effective device, overflow, drainage, sustainable technology, simulation for decision making, and water management. The action or solution for these issues shall depend on the availability of water sources. Based on this systematic literature review, authors worldwide have identified the water sources, namely water pans, river, boreholes, dam, glacier snow, rainwater, reservoir, and seawater.

In response to this investigation, issues of the Jahai tribe local context and water sources availability at RBSP are required in determining the suitable environmentally sustainable water supply. Eventually, there is a significant need for a thorough site visit to Jahai villages at RBSP. The site visit is required to obtain information on the local context such as culture and lifestyle of the Jahai tribe as well as the suitability of water sources, availability of access, site conditions, and other related constraints. Lastly, the other consideration of environmentally sustainable water supply at RBSP is the authority approval due to its status as a reserved area.

Acknowledgement
This research is supported by the Geran Lestari – SDG-Triangle @ UiTM (600 – RMC / LESTARI SDG-T 5 / 3 (100 / 2019)) managed by Universiti Teknologi MARA, Malaysia. The authors thank the research collaborators, Majlis Bandaraya Ipoh and Perak State Parks Corporation, for their partnerships and anonymous reviewers for accommodating comments and suggestions to strengthen this article.

References
[1] UNESCO 2017 Royal Belum State Park https://whc.unesco.org/en/tentativelists/6176/
[2] United Nation 2020 The Sustainable Development Goals Report 2020 United Nations Statistics Division, Development Data and Outreach Branch New York https://unstats.un.org/sdgs/report/2020/goal-06/
[3] Latip N A, Jaafar M, Marzuki A, Roufcheaï K M, and Umar M U 2020 Spectacle of conservation and tourism in protected areas: Analysis of management, issues and tourist satisfaction Journal of the Malaysian Institute of Planners 18(4) 477–498
[4] Scholz M 2013 Sustainable water systems Water 5(1) 239-242
[5] Stek P E 2009 Groundwater extraction modelling for Kuala Lumpur water resource planning Journal of the Malaysian Institute of Planners 7 111–132
[6] Othman A and Ariffin, M 2019 Source water protection from pharmaceutical contaminants: Assessment of Environmental Quality Act 1974 and its regulations Journal of the Malaysian Institute of Planners 17(2) 168–178
[7] Shaffril H A M Krauss S E and Samsuddin S F 2018 A systematic review on Asian’s farmers’ adaptation practices towards climate change Science of the Total Environment 644 683-695
[8] Sierra-Correa P C and Kintz J R C 2015 Ecosystem-based adaptation for improving coastal planning for sea-level rise: A systematic review for mangrove coasts Marine Policy 51 385-393
[9] Arendt R Imjela C R Schulte A Faulstich L Ullmann T Beck L Martinis S Johannes P and Lengricht J 2021 Natural pans as an important surface water resource in the Cuvelai Basin-Metrics for storage volume calculations and identification of potential augmentation sites Water 13(2) 177-198
[10] Corobov R, Ene A, Trombittsky I and Zubcov E 2020 The Prut River under climate change and
hydropower impact. *Sustainability* **13**(1) 66-83

[11] Danert K, Adekile D and Canuto J G 2020 Striving for borehole drilling professionalism in Africa: A review of a 16-year initiative through the rural water supply network from 2004 to 2020. *Water* **12**(12) 3305-3340

[12] El-Nwsany R I, Maarouf I and Abd el-Aal W 2019 Water management as a vital factor for a sustainable school. *Alexandria Engineering Journal* **58**(1) 303-313

[13] Fan M, Xu J, Chen Y, Li D and Tian S 2020 How to sustainably use water resources—A case study for decision support on the water utilization of Xinjiang, China. *Water* **12**(12) 3564-3584

[14] Fuentes-Galván M L, Medel J O and Hernández L A 2018 Roof Rainwater Harvesting in Central Mexico: Uses, Benefits, and Factors of Adoption. *Water* **10**(2) 116-131

[15] García I F, Novara D and Nabola A M 2019 A model for selecting the most cost-effective pressure control device for more sustainable water supply networks. *Water* **11**(6) 1297-1316

[16] Munawar AA, von Hörsten D, Wegener JK, Pawelzik E, Mörelin D 2016. *Eng Agric Environ Food*. 9(3):208–215.

[17] Garcia J, Salfer L R, Kalbusch A and Henning E 2019 Identifying the drivers of water consumption in single-family households in Joinville, Southern Brazil. *Water* **11**(6) 1990-2107

[18] Hamchaoui S, Boudoukha A and Benzerra A 2015 Drinking water supply service management and sustainable development challenges: A case study of Bejaia, Algeria. *Journal of Water Supply: Research and Technology* **64**(8) 937-947

[19] Ingram W and Memon F A 2020 Rural water collection patterns: Combining smart meter data with user experiences in Tanzania. *Water* **12**(4) 1164-1184

[20] Qiu D, Xu H, Luo D, Ye Q, Li S, Wang T and Ding K 2020 A rainwater control optimisation design approach for airports based on a self-feature map neural network model. *PLoS ONE* **15**(1) 1-23

[21] Wu J, Lin X, Wang M, Peng J and Tu Y 2017 Assessing agricultural drought vulnerability by a VSD Model: A case study in Yunnan Province, China. *Sustainability* **9**(6) 918-934