4 New Water Village Planning Model: Preserving Ocean Biodiversity for Community's Health and Well-Being

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Abstract

Malaysia is one of the eleven countries in Southeast Asia. Long-term sewerage pollution is a source damaging 90% of coral reeves by 2050. Decades of untreated sewage pollution also exposes children living at water settlements to water-borne diseases. This paper proposes a new water village planning model for Malaysia which could empower the local community to pay for sanitation management through architectural provisions, hence could generate ecotourism revenue. This study combines results from three earlier studies on Lok Urai, a water village located in East Malaysia. From these studies, incorporation of ISTP wastewater treatment tanks must come with viable economic activities; the architectural solution must include related microarchitecture to support homestay activities; and the local community desires to develop a homestay program to improve their livelihood. The architectural aim is creating opportunities for water villagers to self-finance Lok Urai's sanitation provision and maintenance. This study posits that microarchitecture for small enterprises and combined with a well-planned homestay program are suitable amenities to attract tourists to stay with local families at Lok Urai. The proposed model consists of 98 housing units planned with twelve clusters of homestay units that will support the community to pay for their sanitation management and stop sewage pollution from spreading water-borne diseases. A viable water village model is replicable to 25,000 islands in Southeast Asia.

Keywords

Water security and health · Water village planning model · Sanitation management · Ecotourism · Ocean biodiversity

4.1 Introduction

Malaysia is one of the eleven countries in Southeast Asia. It has a population of 31.4 M. The country is divided into two parts: Peninsula Malaysia and East Malaysia. Sabah and Sarawak are two Malaysian states located on Borneo Island, one of 25,000 islands in Southeast Asia

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(See Fig. 4.1). Based on the World Health Organization (WHO 2023) report, 494 million people still defecate in the open such as in open bodies of water. 90% of Southeast Asian coral reeves are expected to die by 2050 if the countries did not take any actions (Becatoros 2017). Unlike open defecation in rural villages that are causing infestation of intestinal worms (Lim-Leroy and Chua 2020), the same is affecting spread of diarrheal diseases such as cholera and dysentery at water villages (WHO 2023). With water pollution, the human heart and kidneys can be adversely affected if polluted water is consumed regularly (Afroz et al. (2014). In addition, raw sewage is discharged directly into the sea are mixing with household trash and plastic debris. The outbreak of water-borne diseases like skin disease, diarrhea, and dysentery is inevitable (Haque et al. 2010). A major cholera outbreak among the sea gypsies happened in Sabah in 2014 (Jikal et al. 2019) and as recent as in 2020 (Vanar 2020).

In a satellite study by Evers (2015) on water settlements on Borneo Island, he documented 10,000 water homes in Sabah. Nor Efenday (2022) reported there were more than 1100 houses located in Lok Urai village alone. Lok Urai has no beach frontage as seen in Fig. 4.2. It is located in the vicinity of Tunku Abdul Rahman National Park and the residents are active in coastal activities including diving, snorkeling, island hopping, and deep-sea fishing. Their houses are traditional wooden homes built on pillars erected on the ocean floor (See Fig. 4.3) and the water environment is where the children of Lok Urai play and grow up (See Fig. 4.4).

The whole of Lok Urai was gazetted by the Kota Kinabalu City Hall which saw the whole village bounded into one piece of marine land. The gazetted land made the head of village a person of authority who decides the location of new homes to be built within the gazetted land. Interviews with the locals found the water homes would be passed down from parents to children. The traditional wooden homes are built on pillars erected on the ocean floor. The houses seem unorganized because their foundations followed the topographical contours in the seabed below the homes. It is common for immediate and extended families to stay together in one house resulting in more than seven people living

Fig. 4.1 Location map of Malaysia within the Southeast Asia region. Malaysia is divided into Peninsular Malaysia and East Malaysia consisting of Sabah and Sarawak states. Lok Urai water village is located on the east coast of Sabah. *Source* Google Map

Fig. 4.2 Satellite image of informal settlement at Lok Urai village, Sabah, Malaysia. *Source* Google Map

Fig. 4.3 Homes and boat jetties are made of timber materials. *Source* ACT Malaysia

Fig. 4.4 Sabah, Malaysia. *Source* ACT Malaysia

together (Said 2011; Kraus et al. 2016; Mohd Zaini and Ibrahim 2021). The placement of residences with various docks in the South China Sea promotes fishing and travel to the mainland. The jetty and docks are the main gate to enter each block in the Lok Urai village. The arrangement of the jetty (called as bridge by the locals) varies as some are located at an axis and some are not.

Unstructured (informal) human settlements are usually defined as dense settlements comprising communities housed in self-constructed shelters under conditions of informal or traditional land tenure (Acqua et al. 2006). If informality is the characteristics of Lok Urai, it is merely the results of how the head of village would allow families to build their homes within the Lok Urai village boundary. Another criteria of informal settlement is higher density, but for water settlements such as Lok Urai, that high density is due to the number of persons per household which could range from an average of six to fourteen persons.

Lok Urai has water and electricity provided by the local utility companies to legal Malaysian residents. As families tend to live close together, many households are sharing the utility points with their neighbors. Unfortunately, the most critical utility service not available at Lok Urai is

the sewerage treatment service (Mohd Zaini and Rahinah 2021). All the homes at Lok Urai village are currently disposing their feces directly into the ocean below their homes. Despite this dire need, majority of the water villagers cannot afford to purchase their own sewerage treatment system or the local authority could not provide a standard sewerage treatment system until today.

The purpose of this study is to present a creative architectural solution—the consequential response to findings from selected earlier studies conducted by the authors. The architectural aim is creating opportunities for water villagers to self-finance Lok Urai's sanitation provision and maintenance. This project supports a symbiotic collaboration between communities and local service providers to build a community on social capital as mooted by Mitlin and Bartlett (2018). This study is limited to proposing a feasible new water village planning model that would allow water villagers to pay for their own sanitation maintenance from a homestay program and home-based micro businesses.

4.2 Materials and Methods

4.2.1 Materials

Smart Sanitation for Water Settlements Program: The first project is called the Smart Sanitation for Water Settlements (SSWS) Program (Ref. UNEP/SSFA 3036). It was a small pilot project sponsored by the United Nations Environment Program (UNEP) in collaboration with a civil society organization, Action Caring Team (Malaysia) Berhad or ACT Malaysia. The pilot project was recognized by the United Nations as one of the SDG Good Practice Project (Department of Economic and Social Affairs, United Nations 2021). Visits to study the water settlements' architectural typology in Sabah in 2011–2013 had led to a shocking discovery that the homes were not connected to any kind of sewerage treatment plants. Similarly, too, the water village of Lok Urai has about 1100 homes with neither centralized nor independent sewerage treatment system. The water village households are too poor to purchase their own treatment tanks. The study reported unexpected benefits to the women and girls living at the water village. Interviews with the women and girls in the households revealed feeling unsafe when using their present toilets, and more so during their menstrual cycles.

The pilot project found no one to blame for, especially the local authorities, for not prioritizing sanitation for Lok Urai and other water settlements by the state of Sabah per se. In fact, various local governments in Sabah have made many attempts to provide sewerage treatment systems to water villages in their jurisdictions. Their installations failed to withstand the twice-daily water level changes between 1 and 1.5 m. Flushing from the toilets have little water to carry sewage water over long distances causing blockages that are difficult to detect in the long plumbing system. In addition, the timber pillars supporting the houses have limited capacity to structurally support a 2000 L sanitation system. In lieu of these geographical challenges, researchers at Universiti Putra Malaysia (UPM) had come up with a sewerage treatment solution that is modular, small in size, and effective with minimal piping connections. Most importantly, the local community could learn how to install and maintain the system on their own.

UPM's innovation has two detachable modular parts totaling 350 L working volume. The small size and detachable features allow easy handling when the water villagers are transporting and maneuvering the parts among timber columns beneath the homes. The technology eliminates long connecting pipes to the treatment tank. Once attached, the tank functions like a mini sewerage treatment plant that has three anaerobic–aerobic-anaerobic chambers and treats the sewage for a total of 7 h before being discharged as Standard A effluent into the ocean below. For 6 h aeration, the effluent data measure 11.60 mg/l for BOD_5 51.88 mg/l for COD, 12.50 mg/l for TSS, 2.48 mg/l for AN, and 7.03 pH (Mazandarani 2016). Figure 4.5 is the conceptual diagram showing treatment process for the technology, and Figure 4.6 shows how the

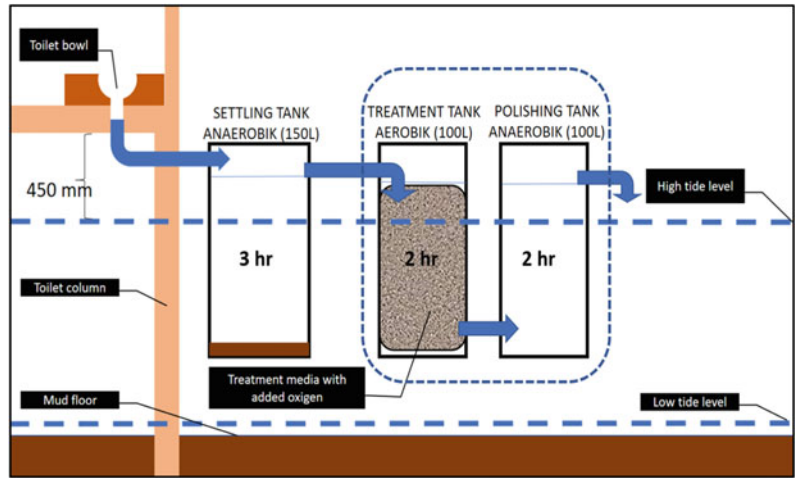

Fig. 4.5 Conceptual illustration of the IST sewerage treatment process. *Source* Rahinah Ibrahim, Universiti Putra Malaysia

Fig. 4.6 One ISTP tank after installation below a toilet at Lok Urai water village. *Source* ACT Malaysia

assembled ISTP tank below a toilet at a water home.

Results from the pilot project pointed to several urgent issues that must be addressed for the larger goals concerning the health and well-being of the water villagers and ocean biodiversity preservation in general. Firstly, the local and international standards for designing a five-member household sanitation system did not work at all at Lok Urai. It turned out that an average household could range from six to fourteen household members. Secondly, the villagers were not used to using water for cleansing since they could simply "drop" their feces directly into the ocean below their toilets. Thirdly, the water villagers were not keen on paying anything extra for a sanitation service from their hard-earned income. Upon cross-checking with the local authority, the authority realized that the Kota Kinabalu City needs a new guideline for sanitation management specifically for its water settlements along the coastal areas. Lessons gleaned from the initial pilot project are recommended to guide the development of a new guideline for sanitation management. In order to optimize any future guideline recommendations, this study proposes a design and planning feasibility study which would take into consideration the sociocultural behavior of the Lok Urai villagers, besides documenting the extent of their desire to maintain the new wastewater treatment technology in place.

Socio-economic Microarchitecture in Water Settlement: The second study from an architectural dissertation project (Nor Efenday 2022; Nor Efenday et al. 2022) on socioeconomic microarchitecture had recommended development of homestay activities for the water villagers. His dissertation attempts to understand the needs of water villagers and how microarchitecture could help in supporting revenue generating activities for them. The project proposes that "microarchitecture for small enterprises are suitable amenities

to maximize customer access hence increase income to households at water villages." "Microarchitecture" refers to the way resources are structured in connection to design and development in a given setting such as a suburban region (Tazilan et al. 2008). Similarly, the presence of traditional street vendors at Lok Urai such as ice sellers, noodle sellers, local delicacies, and "nasi lemak" sellers could form microarchitectural typoscape. With street merchants are familiar scenes along Malaysian streets, this microarchitecture concept at Lok Urai village would allow family-owned small businesses to improve their incomes for their households.

Several types of enterprises were identified by the Lok Urai villagers in Nor Efenday et al. (2022) study. 90% of respondents strongly agree in developing fish and marine resources farming at Lok Urai village to provide food and income to their households. Another prospect is fish drying where wider walkways and public spaces could be used for the activities. 78% of respondents support turning Lok Urai into a tourist destination to boost the locals' standard of living. The homestay program is one of Malaysia's newest tourist attractions that is well-liked in many of the rural regions. Visitors can experience the host community's way of life and culture when they live with the adopted families (Ramele et al. (2017). Under the Ministry of Rural Development or the Ministry of Tourism, Culture and Environment of Sabah, the homestay programs can help rural communities flourish while preserving their cultural, historical, and environmental legacy. Being located adjacent to the Tunku Abdul Rahman National Park is an advantage for Lok Urai. 90% of respondents strongly agree that participating in an entrepreneurial training and coaching program could better prepare the community for participating in the tourism economy. 100% of respondents agreed that the women in Kampung Lok Urai could contribute to the household income by running a small business industry from home. Commercial operations such as selling snacks and soft drinks can be accessed by customers through a small grocery store near a house's main entrance. From there, one can earn a living and support the family.

Homestay Program and Community Participation at Lok Urai: The third study is a master's thesis (Hairal 2021) which specifically evaluated whether a homestay program is feasible at Lok Urai and how the villagers can work together to make it successful. The criteria for working together as a community is critical for a homestay program and so does the participation of every member of the community. The implementation of the homestay program is expected to elevate the state's economic income and also help in increasing the level of socio economy for those who participate in them (Ramele et al. 2017). Among the successful homestay programs in Malaysia are community-based tourism, rural tourism, cultural tourism, sustainable tourism, and special interest tourism (Ramele et al. 2017). All homestay programs in Malaysia welcome tourists to stay with families in the villages and participate in the rural community activities. In contrast with most sites, Lok Urai village is literally built over a water body.

Janjua et al. (2021) stated many researchers from developing countries are working on community-based rural homestays. Despite their efforts, their study found prior researchers lacking in homestay entrepreneurship and homestay development for sustainability. Another study by Mohamad and Nasir (2019) describes motivation competency is the main factor contributing to the sustainable entrepreneurship in Terengganu and Pahang while the opportunity competency is the main factor contributing sustainable entrepreneurship in Terengganu. Both studies found financial sustainability is critical to sustain the respective communities. Therefore, this current study is recommending that future planning of homestay program at water village shall include the need to preserve their natural environment against sewage pollution besides the global awareness on plastics waste as a motivation for water communities.

Hairal (2021) conducted a survey on 150 respondents involving the head of households or their representatives and further in-depth

interviews of fifteen informants (or village stakeholders) to ascertain the water villagers' commitment. Results showed 67.33% or 101 villagers agreed to participate in a homestay program.

> …iya in shaa Allah ahli keluarga saya menyokong ini buat homestay sebab dia mendatangkan hasilkan, lagipun saya sendiri memang mau ada satu ini homestay…
> …yes, if Allah wills my family supports this homestay program because it will provide us income, I myself really want to have one homestay… (Hairal 2021)
> ...penduduk kampung bersedia membangunkan program homestay di mana pembukaan homestay tersebut akan membuka peluang pekarjaan dan daya tarikan kampung…
> "…the villagers are ready to develop this homestay program in view that the homestay is expected to open job opportunities and make it the village's attraction… (Hairal 2021)

The survey results indicated the threat of social cohesion (Tavakoli et al. 2017) is very low at Lok Urai, a good indicator since homestay programs will need to strengthen the social capital among certain groups of a host community. Additionally, a study by Janjua et al. (2022) highlighted the importance of sustainable tourism marketing and brand equity in rural community-based homestays in Malaysia. Their study supports the authors' observation in which, involvement by local political authorities would be most crucial for rural tourism promotions. In fact, they may need to become the key players in sustainable rural tourism transformation at Lok Urai village. Figure 4.7 is a SWOT analysis finding showing a higher support between strengths and opportunities aspects provided the water villages improve their architectural and structural aspects for such program to take place.

4.3 Methods

This planning feasibility study follows Yin's (2014) case study research methodology containing: (1) research question, (2) theoretical proposition, (3) unit of analysis, (4) linking theory to data, and (5) criteria for interpreting data. The research question is "how can state authority provide supporting architecture in creating a resilient water village?" The study proposes inclusion of supportive economics in view of the water village's indigenous socio-cultural aspects for improving their resilience. The study maintains Lok Urai water village in Sabah, Malaysia as the location of the study. The new planning was superimposed upon

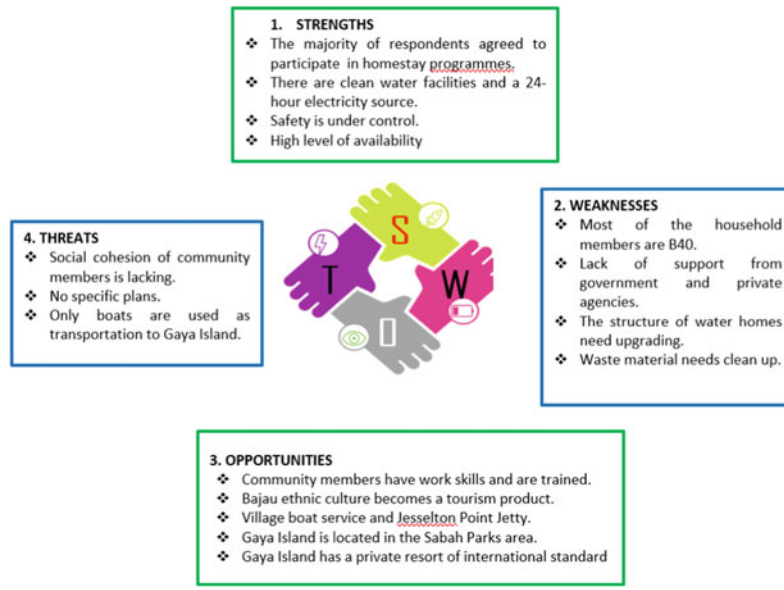

Fig. 4.7 SWOT analysis of community and built environment aspects at Gaya Island. *Source* Hairal (2021)

the home lots that were destroyed in the big fire in 2020. This study posits that to ensure the new water settlement planning would be sustainable, its new architectural planning must maintain the current indigenous lifestyle, include ecotourism and microeconomic activities and integrate sustainable features that preserve its natural environment. The proposed new water village plan consists of 98 housing units where an average eight members of a family live in one household. It incorporates 12 clusters of homes in a homestay program with supporting small business activities for the whole community. Additional infrastructure support is proposed for the sociocultural activities for the tourism economy. In determining the criteria for validating the theoretical proposition, the proposed new water village planning model must be able to incorporate all the above planning requirements into one water village planning prototype. This planning feasibility study is limited to the water village planning restructuring only and exclude any financial feasibility study.

4.4 Results

The resulting new water village planning model looks into integrating the new sewerage treatment system as well as water and power which are critical for the population of Lok Urai village. Herewith, this study reorganizes the water village planning to address the challenges mentioned above. Reducing cholera infection and returning dignity to women and girls when using the ISTP technology would meet SDG 3 Health and Well-Being for the community. Thereby, incorporating the ISTP wastewater treatment technology under the water homes would stop untreated sewage pollution being discharged directly into the ocean whereas installing rainwater harvesting system for hygiene care would meet SDG 6 Water and Sanitation. In fulfilling both SDG 3 and SDG 6, Lok Urai can meet the aims of SDG 11 Sustainable Cities and Communities when safe and better dwellings with decent utilities, services, and lifestyle upgrades are proposed in the new water village planning model. This study agrees with Dakhia and Berezowska (2010) that in creating today's natural living society, the "urban ecosystem" with functional space aspect of microarchitecture can be similar to the streets ambience and culture which had existed for more than 120 years at Lok Urai Village.

The overall proposed model applied clustering design concept consisting of eleven clusters of eight home units and one cluster of 10 home units. Lok Urai village planning prototype contains 98 homes with each home having separate bath and toilet rooms in consideration of larger household size of eight persons. Standardized modular homes are proposed to facilitate prefabricated assembly for marine installation. The proposed model also displays the similar traditional dwelling design in Southeast Asia that are suitable for hot-humid weather. Solar panels are proposed on rooftops in lieu of incoming tourists who may not be comfortable in tropical climate and to power the whole house. The whole planning layout employs open-space planning where as much as possible the front facades face the water body. Figures 4.8, 4.9, 4.10, 4.11, 4.12 and 4.13 are illustration for the proposed new water village planning model.

By manipulating the spatial planning layout, placing all living and sleeping areas elevated on stilts, creating permeable apertures and longer

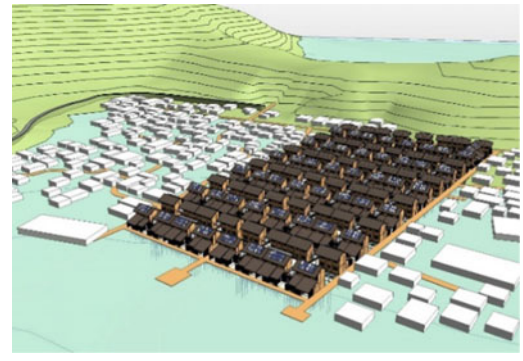

Fig. 4.8 Perspective view of new water village planning model for Lok Urai village, Gaya Island (Illustration by: Nor Efenday)

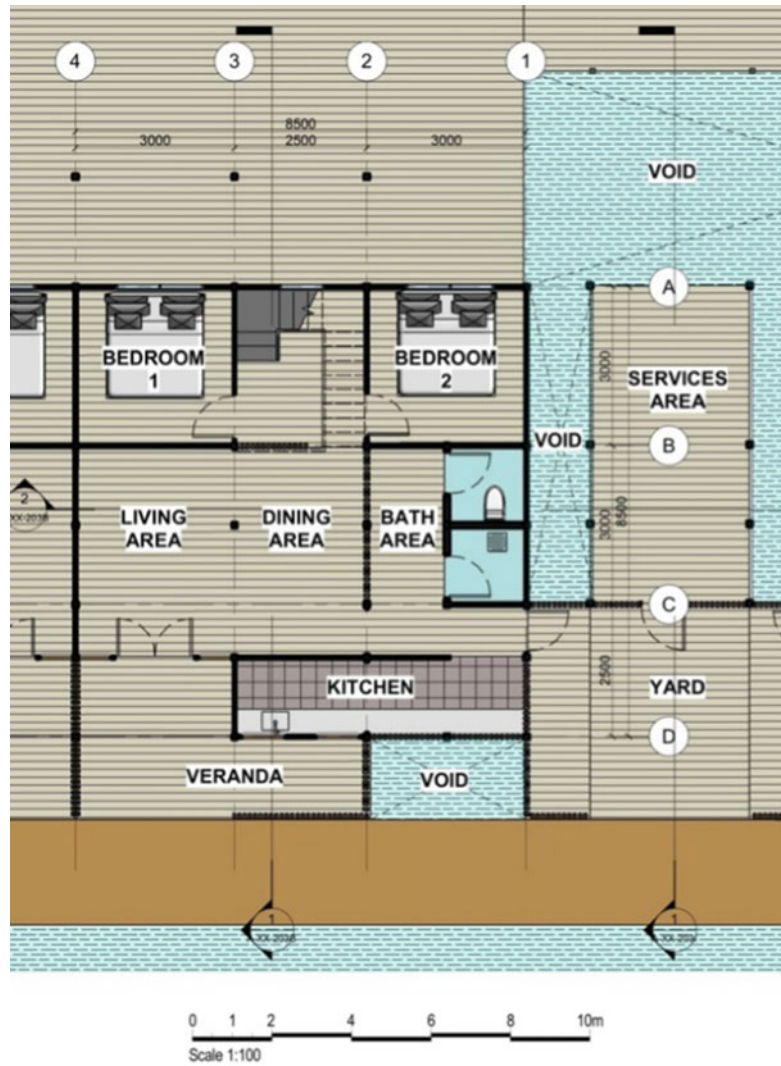

Fig. 4.9 House unit with public and private amenities to support homestay programs in new water village planning model. (Illustration by: Nor Efenday)

overhangs, the design team was able to maintain the interior thermal comfort in the home unit design. All windows will have insect netting protection to minimize insect's penetration. The proposed water village planning model added some distances to improve privacy between water homes. Moreover, the water residents prefer simple timber architecture. The 3 m by 3 m structural approach is employed in this house layout. The overall water village planning has successfully incorporated the recommended requirements for stopping sewage pollution, integrate passive design characteristics by exploiting the Lok Urai's natural resources, introducing homestay support facilities, and support home-based small business enterprises by families.

4.5 Discussion and Conclusions

This paper synthesized lessons from the UNEP program call for development of a new guideline regarding sanitation management. Hence, it proposes a planning feasibility study which takes into consideration the socio-cultural behavior of the villagers at Lok Urai. The key in proposing a new water village planning model is seeking how

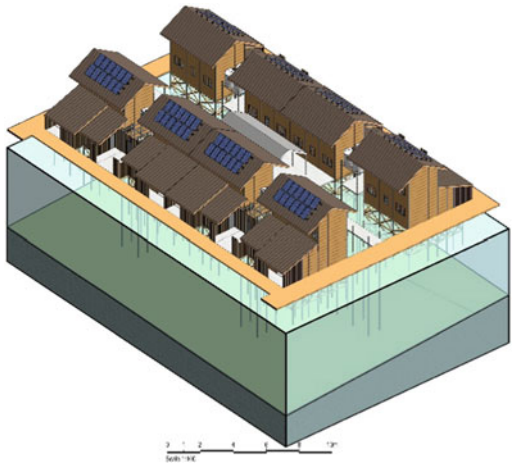

Fig. 4.10 Perspective view of homestay cluster planning in new water village planning model for Lok Urai village, Gaya Island (Illustration by: Nor Efenday)

the architectural approach can strike a balance between how local communities can preserve their natural environment, and the need to finance the purchase and maintenance of much needed sewerage treatment system. Without the sanitation system, the idea for creating a successful homestay program will be at risk due to the continuous sewage pollution condition. This proposed planning model also enforces lessons learnt from the other two research projects. Microarchitecture elements such as small nooks to sell candies and local delicacies have been incorporated into the individual home designs while the public spaces are available for cultural activities such as fish drying, fishing net repair services, local crafts making, and cultural shows. Twelve clusters of homes are supported by amenities such as extra water tanks, rainwater harvesting tanks, and solar power generation for each household and the operation of the sanitation system.

The Lok Urai project has started creating impacts after two years. Awareness is increasing among the local Sabahan how ocean conservation could protect the state's RM25B tourism (Fong 2022), RM2B fishing (Daily Express Online 2022) and RM60M seaweed industries (Jistoh 2022) and Sabah's local coastal communities. It could also contribute toward the advancement of strategic plans for the island and coastal settlements in Sabah. The project could open doors for interagency collaboration between universities and policymakers. The Mayor of Kota Kinabalu has been actively involved in supporting the development of sanitation management guideline and in advocating more ISTP tanks installation at water settlements along the coastal areas of Kota Kinabalu in the advent of the Sabah Tourism 2022 event. However, this huge effort must start with the development of a proper sanitation management guideline, specifically for water settlements for Kota Kinabalu.

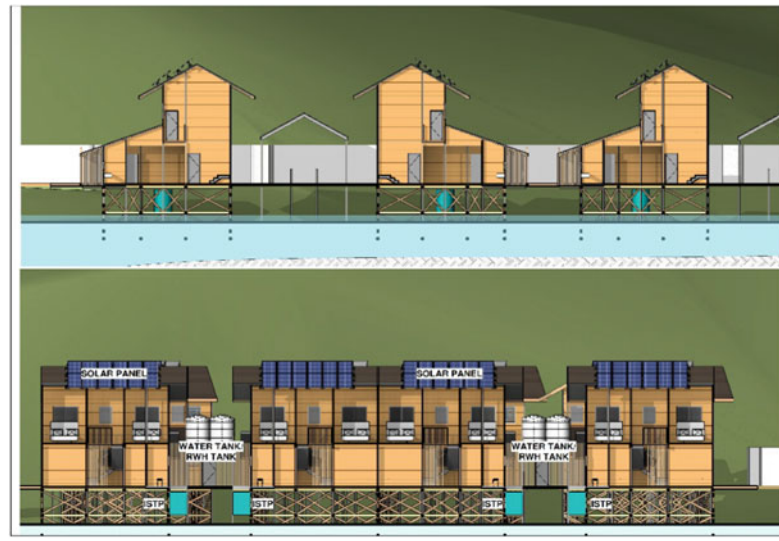

Fig. 4.11 Sectional view across new water village planning model for Lok Urai village, Gaya Island (Illustration by: Nor Efenday)

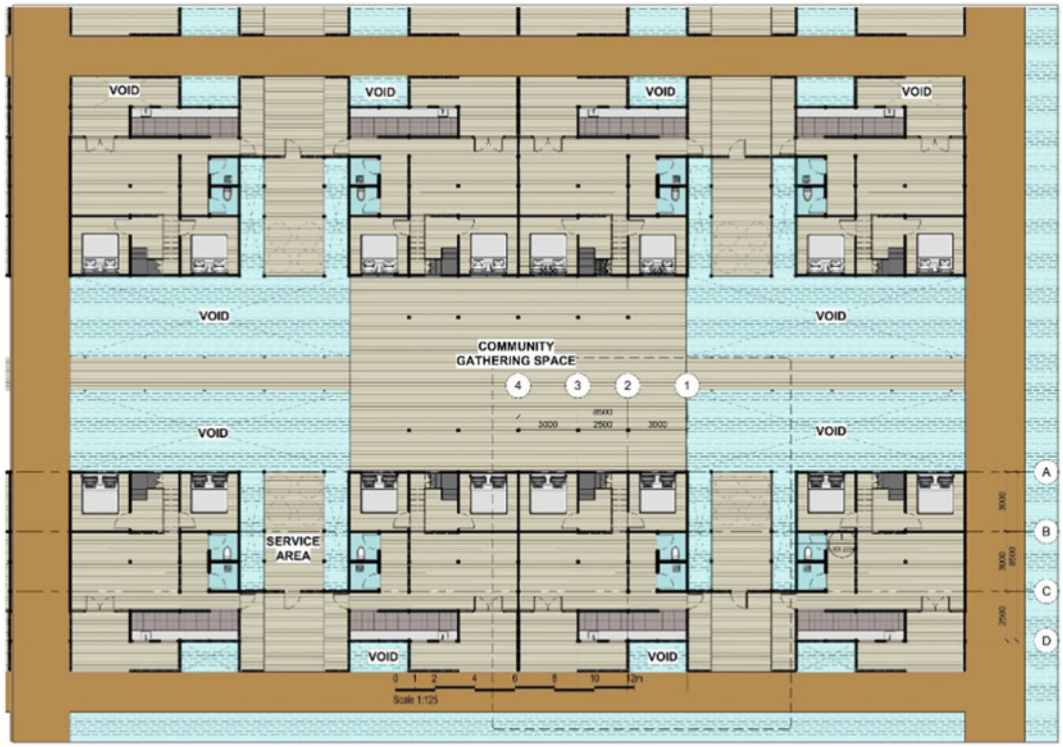

Fig. 4.12 Cluster planning at platform level with public and private amenities to support homestay programs in new water village planning model (Illustration by: Nor Efenday)

Through awareness campaigns on the importance of understanding biodiversity challenges and their consequences at the national level, the Malaysian Federal Government has approved RM4B for conserving the environment in the 2022 Budget (Government of Malaysia 2022). This provides further avenue for the project to contribute toward national policymaking. The corresponding author was appointed by ACT Malaysia as the lead researcher for the UNEP-ACT Malaysia demonstration project. She was later asked to become the focal lead for the Implementation Working Group of the Global Wastewater Initiatives Program under UNEP.

UPM had actively raised ocean pollution awareness by hosting eight (8) webinar series in the year 2021. The Webinar Series on SDG 6 Water and Sanitation was organized in conjunction with the 50th anniversary of UPM. Members from the Global Wastewater Initiatives Program partnered with Malaysian experts to speak about sanitation issues, wastewater pollution, microplastics, and other pollutants into the ocean. While the webinar series allowed the R&D project team to identify potential partners who can contribute further to the Lok Urai village demonstration project, the effort gave the limelight to Malaysia as a country having a potential technological breakthrough in providing sanitation to remote coastal settlements. The webinar series culminated in the organization of the Virtual Symposium on Wastewater and Sanitation that was held in conjunction with the UN's World Toilet Day 2021 on 19th November each year. Two (2) Malaysians were invited as expert panelists where one represented the Academy of Sciences, Malaysia and another represented ACT Malaysia.

The proposed water village planning model could improve health through better sanitation management for islanders and a viable planning model can be replicable to other 25,000 islands

Fig. 4.13 Cluster planning at platform level with public and private amenities to support homestay programs on upper floor in new water village planning model (Illustration by: Nor Efenday)

in the Southeast Asian region whose water villages do not have proper sewage treatment system. Asian Development Bank (2021) highlighted the plight of damaging impacts of polluted oceans to including and not limited to disappearance of seafood, disappearing of coastal habitats, rapidly rising sea levels, and increasing pollution. Hence, implementing the proposed water village planning model could give beneficial impacts as follows:

Stopping direct untreated sewage pollution by coastal settlements: Evers (2015) estimated the existence of 40,000 water homes Borneo Island. That would mean 40,000 homes are discharging untreated sewage into the water bodies surrounding Borneo Island. A five-person home is discharging 1125 L untreated sewage daily, hence discharging 45 M liters raw sewage daily or 16.4 T liters annually.

Prevention of dangerous infectious diseases: Integrating the ISTP tanks as architectural features in the new water village planning model can definitely help stop sewage pollution directly into the ocean below the water village. Over the long run, the water quality is expected to improve. Availability of clean energy and clean water from solar panels and rainwater harvesting in the proposed new water village planning model can reduce the numbers of cholera or diarrheal diseases when community members in the water village have access to clean water for washing. The improved environment is expected to lessen the exposure risk to children to the dangerous water-borne pathogens.

Self-empowering remote communities to pay for improving their ocean biodiversity preservation: The proposed new water village planning model has embedded functional features in its spatial planning that will support a homestay program such as at Lok Urai. Families could earn additional income by allowing tourists to stay in the family home and participate in

social and cultural activities of the water residents. New microarchitecture feature as part of the home layout design can open opportunities for small businesses which are operated by women while the men go out to work. The additional incomes will help the water villagers to pay for the ISTP tanks implementation.

Financing Sanitation Management by Local Governments of Nations with Islands through Ocean Health Credit Trading Programs: The proposed new water village planning model can become the base for many monitoring measurements such as water quality measures, income per water household, number of tourists visiting, income from homestay program, number of disease cases, etc. Such mechanism can be used by local governments or the water villages in negotiating funding in preserving ocean biodiversity or stopping sewage pollution to avoid future economic or health disasters arising from polluted water bodies or decline of fish stock. Alternatively, international organizations could create ocean incentive schemes where marine food producers can earn blue ocean taxation for helping in ocean preservation by sponsoring installation of ISTP tanks in current or new integrated water village facilities. Microcredits is possible for the women-run businesses.

In conclusion, the inconsequential benefits of installing the ISTP tanks at water villages to stop untreated sewage pollution include reducing water-borne infectious diseases and improving the ocean water quality. By providing a potential new water village planning model, a water community can self-empower itself to finance the installation and management of its own sanitation system through its community homestay program and home-based small businesses. More so, the new water village planning model could return the dignity to the women and girls at Lok Urai when they feel safe to use the toilets in their homes.

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