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Narrative Literature Review

Opportunities for Implementing Low- Tech Dew and Fog Harvesting Architecture in Indonesia: A Narrative Literature Review

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ABSTRACT

The water crisis is affecting the entire world, including Indonesia. Java, Bali, and Nusa Tenggara regions are vulnerable to such disasters. Low-income and traditional communities will be the first to feel the effects. Low-tech dew and fog harvesting buildings have been built in several parts of the world as alternative methods to address water scarcity. This technology necessitates the collaboration of multidisciplinary researchers and practitioners, particularly in architectural science, in the design development of this building. These building design requirements must be tailored to local Indonesian conditions. This study will examine the building opportunities that use this technology in the local Indonesian context, focusing on the potential for the adoption and modification of traditional buildings. This research method employs a narrative literature review of official document data and scientific studies. The study's findings indicate that traditional buildings in Indonesia have a high potential for the use of this technology.

Keywords: dew harvesting, fog harvesting, architecture, atmospheric water, sustainability.

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ABSTRAK

Krisis air berdampak pada seluruh dunia, termasuk Indonesia. Wilayah Jawa, Bali, dan Nusa Tenggara merupakan wilayah yang rentan terhadap bencana tersebut. Masyarakat berpenghasilan rendah dan tradisional akan menjadi pihak pertama yang merasakan dampaknya. Bangunan pemanen embun dan kabut berteknologi rendah telah dibangun di beberapa belahan dunia sebagai metode alternatif untuk mengatasi kelangkaan air. Teknologi ini memerlukan kolaborasi peneliti dan praktisi multidisiplin, khususnya ilmu arsitektur, dalam pengembangan desain bangunan ini. Persyaratan desain bangunan ini harus disesuaikan dengan kondisi lokal Indonesia.

Kajian ini akan mengkaji peluang-peluang bangunan yang menggunakan teknologi ini dalam konteks lokal Indonesia, dengan fokus pada potensi adopsi dan modifikasi bangunan tradisional. Metode penelitian ini menggunakan tinjauan pustaka naratif terhadap data dokumen resmi dan kajian ilmiah. Temuan penelitian menunjukkan bahwa bangunan tradisional di Indonesia mempunyai potensi yang tinggi dalam pemanfaatan teknologi tersebut.

Kata Kunci: pemanen embun, pemanen kabut, arsitektur, air atmosfer, keberlanjutan.

INTRODUCTION

This scientific narrative literature review is a continuation of previous research, which is incremental. A bibliometric analysis of prior research revealed that architecture's position on the research issue of dew and fog harvesting has a significant chance to contribute to closing the research gap on this topic. Specifically on the themes of design form efficiency, locality, and community (Khamdevi et al., 2023b). The systematic literature review identified directions for future research in Indonesia, specifically the utilization of a combined harvesting system in three dimensions with passive and low-tech technologies. Aside from that, this discovery brings up new possibilities for the use of vernacular or traditional architecture and local natural materials that have not been explored in earlier studies (Khamdevi, 2023c). In later research, an analysis of the needs for low-tech dew and fog harvesting buildings revealed various criteria that must be considered when designing the two collectors and local contextual factors that must be facilitated (Khamdevi et al., 2023d).

One of the implications of global climate change is water scarcity (Ling, 2021). This water problem will jeopardize the energy, food security, economic, and financial sectors (Chakkaravarthy, 2019). This will have an influence on security and sustainability in drought-affected areas with high populations and unpredictable socioeconomic conditions (Singh et al., 2014). Water scarcity makes water unaffordable for low-income households and local communities in developing nations due to high water delivery costs or a lack of groundwater quantity and quality (Emile et al., 2022; Rachunok et al., 2023).

Architectural science's attention to this challenge, particularly in the context of green buildings, has thus far been limited to how to reduce water use rather than water conservation (Weeks, 2013). Because of this issue, numerous researchers have looked into extracting water from the sea and the air (Cassauwers, 2022). Since roughly 2000, substantial research has been conducted on atmospheric water harvesting, particularly from dew and fog (Jarimi et al., 2020). So, research on this topic is significant to study.

Indonesia is not immune to this water risk, despite its abundance of water resources (Afrilia, 2022). BMKG has issued a warning regarding the threat (Hapsari, 2022). However, because this dew and fog harvesting technology is currently unfamiliar in Indonesia, it has not been efficiently deployed, and little research has been conducted on it. Thus, Indonesia's natural environment has significant potential because of its high humidity, projected to produce plentiful water vapor in both the high and lowlands. So, this research is significant to apply in Indonesia.

With the condition of the Indonesian economy, attention is paid to ensuring that this technology can be accessed by various groups using a low-tech approach, especially the lower middle

economic groups in urban areas or rural communities. The superiority of traditional architecture in Indonesia, which a long history has tested, needs to be given attention to the direction of study so that the local wisdom in it can once again become an architectural approach solution to the problem of the water crisis in Indonesia. This is actually the state of the art for this research, which also differentiates it from previous research in dew and fog harvesting topics. What are the opportunities for this technology in the context (natural, cultural, and economic conditions) and design needs (utility and spaces, structure and construction methods, material qualities, building mass and scale, building height, building slope, and form and shape) in Indonesia? This review has an objective to discover and analyze opportunities for low-tech building of dew and fog harvesting.

RESEARCH METHOD

The data was gathered from many sources, including literature and other official documents, and then processed using a narrative literature review strategy to identify and find formulations to answer the research objectives. This research uses research instruments to analyze data. The criteria were obtained from previous research. These criteria include utility and spaces, structure and construction methods, material qualities, building mass and scale, building height, building slope, and form and shape. Aside from that, there are local contextual elements that must be addressed: natural, cultural, and economic conditions (Khamdevi, 2023d).

RESULT AND DISCUSSION

Contexts

Natural Conditions

Geographically, Indonesia is an archipelagic country consisting of land, islands, and seas located on the equator. The average temperature ranges between 27-30 °C and relative air humidity ranges from 70-95% (BMKG, 2020). However, this is of course just an average number on a national scale. It is therefore necessary to consider more contextual local temperature and relative humidity conditions in which the dew and fog harvesting structures will be realized. However at least, in general, this is following the requirements needed to establish fog and dew harvesting, namely a temperature between 0-40 °C and relative air humidity close to 100% (Khamdevi & MLT, 2023c).



Figure 1. Climate Type Zones in Indonesia

Source: Febrianti, 2008

The climate characteristics in Indonesia in general are a warm, humid tropical climate and relatively high rainfall (BMKG, 2020). However, in detail, the climate in Indonesia consists of three types; tropical rainforest climate, tropical monsoon climate, and tropical savanna climate, see Figure 1 (Febrianti, 2008). The tropical rainforest climate is characterized by calm winds, high rainfall, and a dry season lasting only two months. The tropical monsoon climate has characteristics that are almost similar to the tropical rainforest climate but are exposed to more sunlight and warm air. The tropical savanna climate tends to be dry and has low rainfall.

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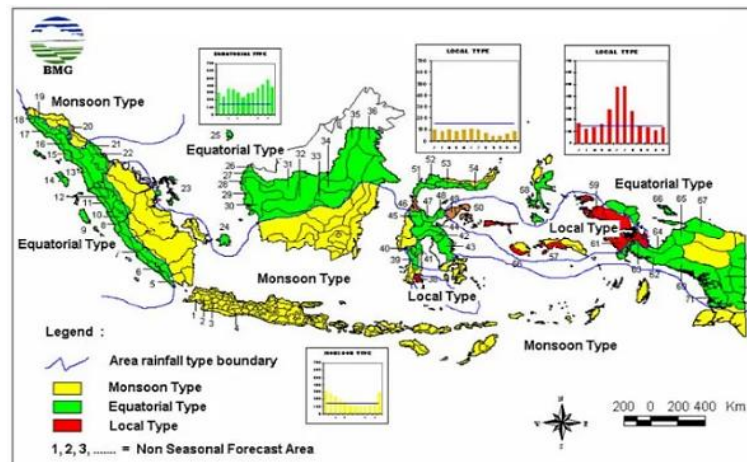


Figure 2. Rainfall Pattern Zones in Indonesia

Source: Aldrian and Susanto, 2003

Because it is located on the equator and between Asia and Australia, this influences three rainfall patterns in Indonesia, namely monsoonal, equatorial, and local, see Figure 2 (Aldrian & Susanto, 2003). The monsoonal pattern is characterized by a clear difference between the rainy season and the dry season in one year, where monthly rainfall occurs only once a year. The equatorial pattern is characterized by twice the monthly rainfall in one year. The local pattern has a character that is influenced by local physics, where monthly rainfall occurs once a year.

The potential for drought and water crisis due to climate change exists in the Java Island and Lesser Sunda Islands, see Figure 3. (BBC, 2019). The El Nino disaster in 2023 will also worsen this situation (BBC, 2023). As we know, Java and Bali are regions with a tropical monsoon climate type and monsoon rainfall patterns. Meanwhile, other islands in the Lesser Sunda Islands have a tropical savanna climate type and monsoon rainfall patterns. These areas have great potential as priority locations that have high urgency for building dew and fog harvesting buildings.



Figure 3. Potential Drought and Water Crisis in Indonesia

Source: BBC, 2019

Wind speed on land in Indonesia is around 4-6 m/s. The Java Island region and the Lesser Sunda Islands are included in this category, see Figure 4. This is following the wind speed requirements for dew and fog harvesting buildings of 0-6 m/s (Khamdevi & MLT, 2023c).



Figure 4. Wind Speed Map in Indonesia
Source: BBSPKEBTKE, 2021

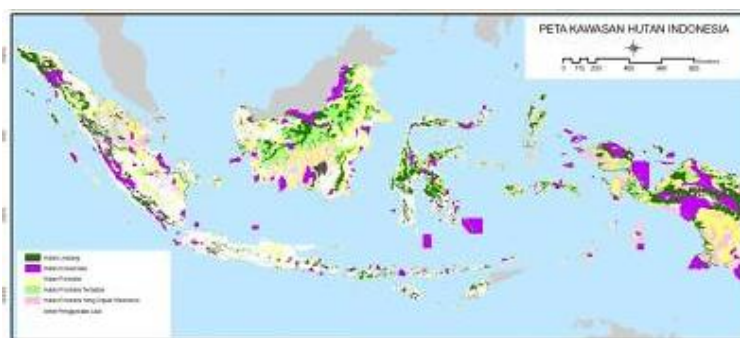


Figure 5. Map of Forest Areas in Indonesia
Source: PKTL, 2023

Rural communities are very dependent on the availability of natural resources to build houses and other buildings, especially indigenous communities. Java, Bali, and the Lesser Sunda Islands have limited forest areas, see Figure 5. Although each location has illegal forests, conservation forests, production forests, and so on. Natural materials are materials that are renewable and environmentally friendly. Using natural materials can encourage the replanting of trees and plants used for buildings and encourage wider conservation action.

Cultural Conditions

Indonesian culture has a very diverse culture with diverse ideas and knowledge. The most dominant culture is Austronesian speaking culture, apart from Papua. Indonesian cultures have various social systems, but their socio-cultural values are almost the same, especially in togetherness or solidarity (Ranjabar, 2006). They live scattered in the highlands, lowlands, and coastal areas, according to their livelihoods in their natural conditions.

They have a variety of local buildings that are still being developed and are resistant to Indonesia's natural conditions, especially in the form of houses on stilts (Waterson, 1990; Fox, 2006). Austronesian houses can adapt to swamp environments, seasonal flooding, and less stable peat soil, and are resistant to earthquake disasters (Khamdevi, 2019; Amin & Hadi, 2022). With the ideas and knowledge contained in them, Austronesian houses can once again become a solution to the current and future water crisis. Not only houses, but they also have buildings that function as storage areas and communal areas.

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Economic Conditions

Indonesia's economic growth in 2022 will reach 5.31%. The transportation and warehousing sector had the highest growth, namely 16.99%. The accommodation and food and drink sector had growth of 13.81%. The processing industry sector is the largest contributor to GDP with a growth of 5.64% (Haryono, 2023). Meanwhile, growth in the agricultural sector was only 2.25% (Nasution, 2023). On the other hand, the national poor population fell from 9.54% in March 2022 to 9.36% in March 2023, both in urban areas where most are unemployed and in rural areas where farmers and fishermen work (Subekti, 2023). As we know, rural communities are the communities most affected by the water crisis. So harvesting buildings has a very high urgency in this region.



Figure 6. Kampung Naga, one of traditional rural area in Indonesia
Source: Genpi.id, 2020

With low-income levels, rural communities have limitations in meeting their needs for building houses and other buildings. Especially the problem of building availability. The dilemma in rural communities is the problem of natural resources starting to become limited due to irresponsible consumption both by industry and society itself, the problem of cheap non-natural materials which are widely available but are not environmentally friendly and disrupt the continuity of local houses which have been traditional since the past, and issues of prestige and status in using natural materials, see Figure 6.

Design Needs

Functions

Of course, an architectural object cannot possibly exist without the function that forms it which is based on the need for shelter and dwelling. However, when there are new needs and wants (desires), existing architectural objects can be transformed or modified due to new needs and desires. Existing architectural material objects have the potential to become the actualization of new formal objects to accommodate these new desires.

Existing local houses can accommodate dew and fog harvesting systems. Apart from houses, communal buildings (such as *balai* in Minangkabau, *maligai* in Iban, and *baruk* in Bidayuh), buildings as storage places for agricultural products (*lumbung*, *leuit* in Sunda, *rangkiang* in Minangkabau, and Orang Laut's *sapau*), and a combination of both (such as *bale lumbung* in Lombok, or *dhurung* in Bawean) can also accommodate this with modification activities (Syafwandi, 1993; Sim, 2010; Sudadi, 2018; Kusdiwanggo, 2020; Sani, 2021), see Figure 7.



Figure 7. *Baruk* or *Baluk* of Bidayuh (top-left), *Rangkiang* of Miangkabau (top-right), *Dhurung* in Bawean (bottom-left), and *Bale Lumbung* in Lombok (bottom-right)

Source: Bibliopedia.id, 2023; Tripadvisor.co.id, 2019; Gardencenter.co.id, 2024; and Ntb.idntimes.com, 2022

Dew and fog harvesting buildings can also be stand-alone by adopting these communal buildings and granaries, through a process of adaptation and modification to become new buildings. The storage building has a function that can be modified to become a water storage area for dew and fog harvesting systems, as a watershed. The dew and fog harvesting building can also be used as a communal place with a very positive impact on local communities as a place for socialization, culture, and education. There are many examples of Indonesian buildings that have two functions, namely where the granary is above it, while the communal space is below it (such as *dhurung* in Bawean, or *bale lumbung* in Lombok).

Constructions

Indonesian buildings consist of three parts, namely legs, body, and head (Waterson, 1990). There are two typical types of Austronesian building structures, namely the foot structure type (base or bottom) which is separate from the upper structure (body structure and roof or head structure) as in Toba houses and Toraja houses, and the roof structure type (or head) which is separate from the body structure and leg structure like those of Minangkabau houses and Sundanese houses (Khamdevi, 2023a), see Figure 8. Indonesian cultural building construction has sturdiness and flexibility because it is connected by a system of pegs and a tie system (Koesmartadi, 2022). Knowledge of this structure still exists in the memory of the local community, which makes it potential for the implementation of dew and fog harvesting structures that are easier, more practical, cheaper, and low-tech.

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Figure 8. *Tongkonan* of Toraja (left) and *Rumah Gadang* of Minangkabau (right)

Source: Toraja.tribunnews.com, 2022 and Id.wikipedia.org, 2024

The natural materials used which are very sustainable because they are renewable, environmentally friendly, and easy to find on site are the next potential. Roof covering materials derived from leaves, grass, thatch, palm fiber, and clay tiles have the potential to be studied further regarding their shape and hydrophilic and hydrophobic properties, as a requirement for the effectiveness and efficiency of dew and fog harvesting systems. Some natural materials have grooved surfaces, and some also have hydrophilic and or hydrophobic surface properties.

Appearances

Traditional buildings in Indonesia are of sufficient scale and height to implement dew and fog harvesting systems. The height of the building for the dew collector is 2-3 meters. Meanwhile, for fog collectors, there are no height requirements (Khamdevi & MLT, 2023c).

The appearance of a building that can be relied on as a dew and fog harvesting system is found in the shape of the roof. Indonesian buildings have roofs that are dominated by gable roofs. Apart from that, there are roof shapes of triangular pyramids (*limas*), rectangular pyramids (*meru*), circular cones, and oval cones (Koesmartadi, 2019), see Figure 9. Roof shapes that climb an angle or curve like this with the slope angle required for dew and fog harvesting buildings have great potential for application. The slope requirement for dew collectors is 30 degrees, while the slope for mist collectors is around 60-90 degrees (Khamdevi & MLT, 2023c).



Figure 9. *Omah Limas* of Java (left) and *Omah Joglo* of Java (right)

Source: Dekoruma.com, 2018 and Ruparupa.com, 2021

CONCLUSION

This narrative literature review shows that the low-tech dew and fog harvesting buildings has great opportunities to be implemented in Indonesia, focusing on the advantages of traditional architecture approach. The research indicates that the Indonesian environmental context has great potential for implementation, with natural conditions like air temperature, humidity, wind speed, geography, and forest resources supporting the realization of these structures. Cultural conditions, particularly in rural communities affected by water crises, and economic conditions highlight the urgency of implementing these structures for water needs and conservation. Local construction,

renewable materials, and unique features of local buildings can provide ideas and knowledge for designing effective, efficient, and low-tech buildings for dew and fog harvesting.

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