POTENSI ARKEOLOGI LANSKAP BAWAH AIR INDONESIA

Potential of Submerged Landscape Archaeology In Indonesia

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Abstract. *Indonesia has a great potential to be a country-wide laboratory of underwater landscape study. This is due to the fact that its two main contingents, Sunda and Sahul, had been experiencing sea level rise event in the late of ice age , in which intersectedcrosses the timeline of prehistoric human migration. Even though Indonesian ocean preserves the richness of underwater resources, including archaeological data, the study itself has not been touched by many. This paper will focus in two objectives: 1) Reconstructing paleo-river model and; 2) Potential prehistoric remnants in Misool Islands caves. The method used includes a field survey , by diving and data brackets by using sub-bottom profiler. Besides, we also conducted literature reviews.The results of this study indicate that the Sunda and Sahul Exposures are likely to be inhabited by humans, but at this time the remains have sunk on the seabed. It is hoped that this study can be the basis and motivation for future archeological research such as prehistoric human settlements and migration in a submerged landscape environment.*

Keywords: *Submerged landscape, Sunda shelf, Sahul shelf, Sea-level change, Underwater archaeology*

Abstrak. Indonesia memiliki potensi yang besar untuk menjadi sebuah laboratorium penelitian lanskap bawah air. Gagasan ini didasarkan pada fakta bahwa dua kontingen yang membentuk Indonesia, Paparan Sunda dan Sahul, mengalami perubahan air laut pada akhir zaman es yang bersinggungan dengan migrasi manusia prasejarah. Walaupun lautan Indonesia menyimpan kekayaan alam, termasuk data arkeologi, penelitian tentang lanskap bawah laut belum banyak disentuh. Studi ini bertujuan untuk membahas dua hal: 1) rekonstruksi model sungai purba dan ;2) potensi peninggalan jejak prasejarah di gua bawah air di Pulau Misool. Metode yang digunakan adalah melakukan survei lapangan, dengan melakukan penyelaman dan perkeman data menggunakan alat akustik sub-bottom profiler, selain itu kami juga melakukan kajian dan review pustaka.Hasil studi ini menunjukkan bahwa Paparan Sunda dan Sahul kemungkinan besar telah dihuni oleh manusia namun pada saat ini peninggalannya telah tenggelam di dasar laut, diharapkan kajian ini dapat menjadi dasar dan motivasi untuk riset arkeologi mendatang seperti hunian dan migrasi manusia prasejarah pada lingkungan lanskap yang tenggelam.

Kata kunci: Lanskap bawah air, Paparan sunda, Paparan sahul, Perubahan tinggi air laut, Arkeologi bawah air

1. Introduction

The submerged landscape archaeology is a study of archaeology on a sinking site due to natural phenomena. The sinking is caused by the rising sea water level, flash floods, and even earthquakes, so that a land that was originally dry transform into underwater. Most of the sites and finds described were inundated as a result of the global sea-level rise of some 120 m that occurred during the Final Pleistocene and Early Holocene. This submerged landscape study has developed in the international world of archaeology such as those presented from Europe, Western Asia, and North America. Submerged landscape archaeology has begun to emerge as a serious sub-discipline of both maritime archaeology and world prehistory, with a largely untapped potential to fill in significant gaps in the archaeological record (Benjamin et al. 2011).

European archeology has been very serious in studying the archeology of submerged landscape. One of its sites is The Mesolithic (c.10,000 - 4000 BC) site of Bouldnor Cliff, off the south coast of England. Bouldnor Cliff is a submerged prehistoric settlement site in the Solent. The site dates from the Mesolithic era and is in approximately 11 meter from water surface, just offshore from the village of Bouldnor on the Isle of Wight in the United Kingdom. The preservation of organic materials from this era that do not normally survive on dry land has made Bouldnor important to the understanding of Mesolithic Britain. Investigations suggest that during the Mesolithic era, between 8000 and 4000 BC, the western Solent was a sheltered river basin, rich in woodland and fed by a river at Lymington and drained by the Western Yar at Freshwater. As sea levels rose, the Solent eventually flooded and the settlement area was swamped. The rising waters deposited silt and mud onto the original land surface, covering and preserving it (Smith et al. 2015). Similar submerged landscape sites in Europe also found in the North Sea, the fisherman in there sometimes found animal bones from the bottom of the sea, and their finds have a significant for ecology and archaeology study.

Another study is carried out in Florida, United States of America, archaeologists found a mastodon remains from 14,500 years ago in 30 feet underwater. Based on radiocarbon dating of stone artifacts and mastodon remains, researchers say that the Page-Ladson site, which is on the Aucilla River near Tallahassee, is the oldest submerged archaeological site in the Americas, and one of the oldest on the continent. This discoveries is push back the timeline of the peopling of the Americas it looks like another migration began closer to 16,000 years ago (Halligan et al. 2016).

The importance of submerged landscape archaeology has led scientists in Europe and America, in particular, to conduct large-scale surveys in waters that are suspected of being sinking land. Many of the results obtained from these surveys, one of which they can better understand about human evolution, the path of human migration, biostratigraphy, and ancient occupancy. The quality of archaeological data found underwater has also been shown to be better with those found on land. Nearly 70 percent of archaeological evidence can survive in underwater environments and are well preserved, this is an advantage for the study of submerged landscape archaeology (Bowens 2009).

Located between Pacific and Indian oceans, archipelagic country of Indonesia has water area around ~93,000 km2. Combined with the fact that the country has undergone a series of sea level drop in the Pleistocene era, Indonesia is a suitable laboratory for underwater archaeology researches. Nevertheless, to date, studies regarding underwater archaeology in Indonesia still remain untouched. Indonesia has 2 contingents which are Sundaland and Sahul, which being submerged caused by the rose of sea water level at the end of the ice age, 20.000 to the Mid Holocene. In these the two sinking contingents, the questions of the human occupancy and the human migration path at the time of the Pleistocene can be answered, which is until now have not been explained clearly. The ancient river channel in this submerged continents already being surveyed by a marine geology and oceanography, and have a strong allegation that Sundaland and Sahul are potential for human occupation in the period of early Pleistocene. What we can do is use the dataset from previous studies to make a model and do the ground-checking. Underwater exploration is expensive and needs a lot of effort for doing that, but we sure that the data from submerged landscape could be significant to get the explanation about human migration, human occupation, and paleo-environment. Note that one of the fundamental motivations to conduct this study is to indicate whether Sundaland and Sahul were once a supportive environment to sustain early lives of prehistoric humans. As such, the study is conceptually limited to one variable only, the fresh-water resources or terminologically known as the paleo-river network. However, there are several other physical landscape variables that were being neglected, including vegetation and air circulation. Due to the vast area of the sinking continents, we realize that it might be challenging to examine the whole landmass. Thus, the scope of this research is limited to: 1) reviewing literature studies and 2) analysing fieldwork data survey obtained in Sundaland and Sahul.

2. Methods

In this study, methodology utilized to recIn this study, methodology utilized to reconstruct paleo-river is based on spatial desktop modelling verified with limited field survey and supported by literature study and review regarding to the paleo-environment of submerged landscape archaeology, as well as delineation technique of river network. The modelling process utilized modern-time bathymetry data conducted in Geographic Information System (GIS) environment by applying hydrological algorithm of Basic Deterministic D8 method.

In the study of Sundaland, the model of paleo-river is verified by using two techniques. The first one is sensitivity test that is completed by looking the spatial conformity of paleo-river and modern-time river maps. Subsequently, the second verification is a geophysical investigation, specifically the high resolution of single-channel seismic survey with sub-bottom profiler. This survey was carried out in the area between Java Sea and Karimata Strait (Ajeng Salma Yarista, 2016)

Another research to support the study of early human settlement in Indonesia was also conducted in Misool Island, Raja Ampat Archipelago, West Papua (Sahul Shelf) surveyed by National Research Center of Archaeology Indonesia (Puslit Arkenas) in 2014 and 2016. In such research, oceanography techniques with underwater archaeology methods was applied, like the kind used for shipwreck sites. The underwater cave in Misool Island is very dark, silt and dirt filter into it, so lights were required. The archeologists divers could only see what was in front of them. We measured the cave and do the observation and examine that some caves in Misool Island have the characteristic for cave dwelling.

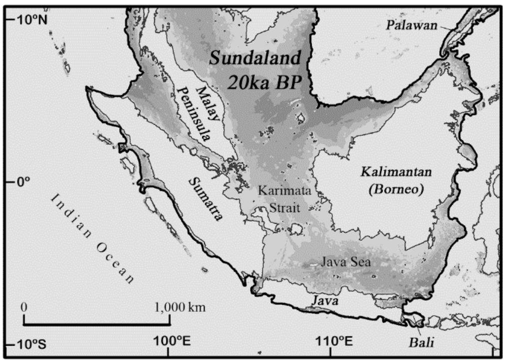
3. Result and Discussion

3.1 Predicting Sea-level History

Throughout 20,000 to 14,000 years Before Present (BP), global sea level has risen by 100 m or more (Hanebuth, T.J.J. 2003; Hesp, P.A. 1998). Due to this, new enclosed seas were formed between the surrounding elevations. In Indonesia, this includes Java Sea that separates the main islands of the present time western Indonesian archipelago, i.e. Sumatera, Java, Kalimantan (Borneo). This region -known as Sundaland- was the South East extension of the

Asian continent, which is now connected to the Indian Ocean by the Malacca Strait and Sunda Strait, and to the South China Sea by Natuna Sea (van Bemmelen, 1949). Along with the works are illustration of a linking landscape from the Indonesian archipelago to Malaysian peninsular and Indo-China in form of dry land with drainage network. These works are performed by a qualitative interpretation of present-day bathymetric contour maps (Voris, 2000), said to be with limited documentation and indication of the timing (Voris, 2000).

The history of drowning phase of Sundaland have been initially studied by Geyh, et al. (1979), Tjia et al. (1996), and Hanebuth, T.J.J. (2009) using dataset of sediment cores. To begin with, the Last Ice Age or the Last Glacial Maxima (LGM) reached its terminal phase by 21 ka BP which sea level low stand was -116 m before present sea level (bpl). The sea level gradually climbed and reached -56 m by 11 ka BP. Within 10 ka BP to 6 ka BP, the sea level rose 51 m, resulting the present sea level which corresponds to 0 m. Following this, during 6 ka BP and 4.2 ka BP, the sea level grew from 0 m to +5 m apl. After the mid-Holocene high stand, sea level rapidly dropped and reached the modern level at approximately



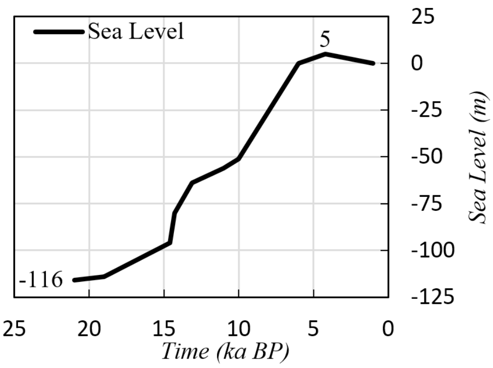


Figure 1. Reconstructed illustration of Sundaland dated circa 20,000 Before Present (BP), when sea level was 116 m below present; Figure. 2 Sea level prediction of Sundaland from 21 ka BP to present time, (Source: Geyhet al., (1979), Hespet al., (1998), and Hanebuth et al., (2003; 2009)

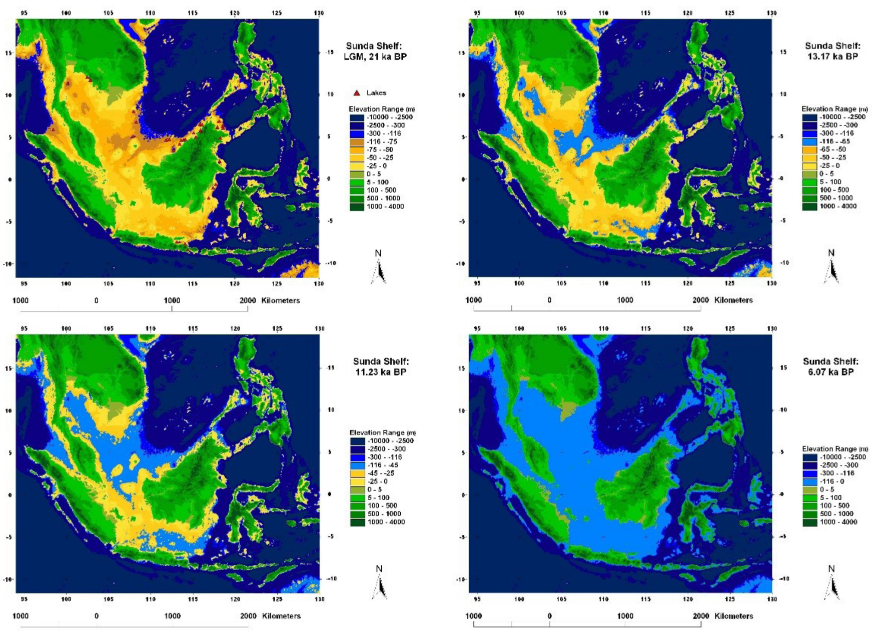


Figure 2. Ilustration the timeline of Sundaland during LGM, starting from 21.000 BP until 6.000 BP, this dataset is taken from Field Museum Of Natural History website based on expert studies (Source: Voris, 2000, Voris, H.K., Sathiamurty 2006)

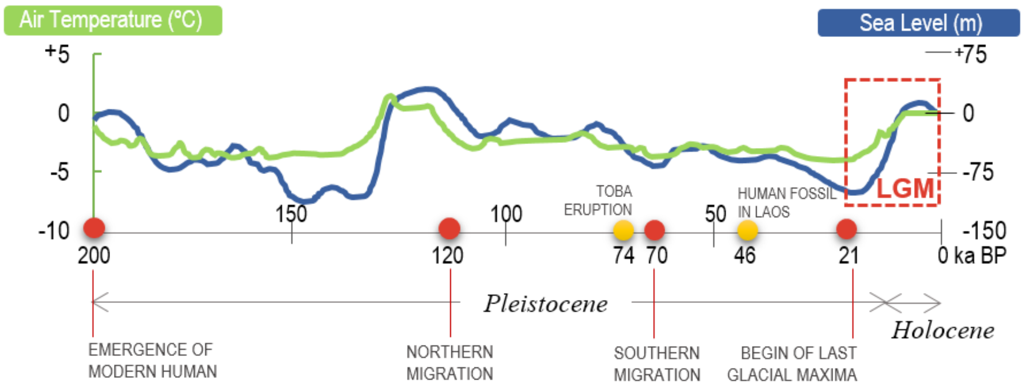


Figure 3. Reconstructed timeline compilation of modern human and relevant events regarding inhabitation: temperature (Source : Jouzelet al., 2007, sea level change (Waelbroecket al., 2002), and historical human lineage (Oswald, 2016)

1 ka BP (figure 1 & 2).

In order to contextualize the environmental condition of post-glacial marine transgression along with human migration in Sundaland region, a simplified timeline (figure. 3) was created.

IIt has been well advocated that human expansion began by about 200,000 BP due to the discovery of Homo sapiens fossil in Eastern Africa. Some 80,000 and 130,000 years after that, modern humans embarked from East Africa to the northern and southern hemispheres. The latest also includes the destination of Sundaland. There have been absences of human fossil evidence in Southeast Asia as the fossils do not well-preserved in the warm and tropical region of Asia. However, some notable findings include fossils found in Niah Cave, Malaysia 42,000 BP (Barker, 2005) and relatively new fossil discovery in Tam Pa Ling Cave, Laos 55,000-63,000 BP (Demeter, F. 2012) and in Tabon Cave new result shows ranging from 24,000 to 58,000 BP (Détroit et al. 2004).

In 74,000 BP, the super volcano Toba on Sumatra Island exploded. It had erupted many times before, but eruption at that particular time was quite exceptional; it released 2,800 cubic kilometres of magma, which is nearly the size of entire Mount Everest (Chesner 2011). The eruption was included in a category of super volcano catastrophe occurred in central Asia, at rank of 8.8 Volcanic Explosivity Index (VEI) scale, the largest in the scale. It is comparable to the massive asteroid that wiped out dinosaurs 65 million BP. The eruption eventually resulted years of volcanic winter, a phenomenon of sun blotting with ash and a reduction of global air temperature by 3-5o C. This environmental change is suspected to be the major cause of population bottleneck, as it left merely one third human survivors on the earth. The human population was sharply decreased to perhaps 3,000-10,000 individuals (Ambrose 1998). This is supported by a genetic evidence that infer present-day humans are descended from a small population between 1,000 and 10,000 breeding pairs existed 70 ka BP (Dawkins 2004). Furthermore, the evidence strengthens the theory of population in SE Asia which was derived primarily from Southern migration 70 ka BP (HUGO Consortium 2009).

Due to the increasing global air temperature 20 ka years ago, the ice caps began to melt. As a consequence, the sea surface which was 116 m below present sea level (bpl) rose gradually all over the globe. It reached its peak at 1 m above present sea level at 4.6 ka BP before it fell steadily. Sea level upsurge has flooded quite amount of lands, including the inner part of Sundaland that is currently known as Java Sea. Ever since, Sundaland has transformed to the present-day major islands comprising Malay Peninsula, Sumatra, Java, and Kalimantan (Borneo).

3.2 Potential of Human Occupation in Sundaland

Sundaland exposure is a continental shelf in the form of an extension of Eurasian Plate in Southeast Asia. At 20,000 years BC, the sea level was 116 m below the current sea level. This caused the Sunda Exposure to be fully open. On the other hand, humans who have inhabited the earth since hundreds of thousands of years ago finally reached the area that is now called Laos at ± 46,000 BC (Les Groube et al, 1986). This made a number of scientists argue on the gap between on land and in the submerged land because there was humans and faunas traces in the Sundaland during this period on land. However, until now there is no evidence to support the theory of early humans and faunas traces on the submerged of Sundaland.

The human footprint at the time of Lower-Middle Pleistocen is found in archaeological sites on Java Island such as Sangiran and Trinil sites. In that period, Java has become a place for humans to live, the archaeological evidence found on Java Island is in the form of stone tools and human remains of Homo erectus. Recent research reveals the creativity of Homo erectus at the Trinil Site, from the results of observations of shells collected by Eugene Dubois in 1890s, it is known that Homo erectus has been able to make geometric engraving on shells,being dating back to 500,000 years ago. From several experiments carried out, it is also known that they made scratches by using freshwater shark teeth. They use shark teeth not only to scratch but also to open shells so they can be consumed. This research was a remarkable breakthrough to find out patterns of human behaviour during the early occupational period in Sundaland (Joordens et al. 2015).

The period of human occupancy on Sumatra Island is even younger when compared to archaeological sites at the Pleistocene on Java. Residential sites on Sumatra have not been found in the Lower Pleistocene layer. Recent research shows that Sumatra Island was inhabited by humans at least 73,000-63,000 years ago by identifying the findings of human teeth from Eugene Dubois' collection found at the Lida Ayer Site, West Sumatra. The Lida Ajer teeth are smaller than fossil of orangutans and east and southeast Asian Homo erectus/ archaic Homo sapiens. Late Show of the East Asian Late Pleistocene H. sapiens than to the Southeast Asian Late Pleistocene to mid-Holocene H. Sapiens (Westaway et al. 2017).

The latest rock art dating is shows that human already lived in Kalimantan (Borneo) at least since 40.000 years ago (Aubert et al. 2018). This is new data because previously we did not think that Kalimantan (Borneo) had rock art that was as old as that, even this has opened a possibility that the island of Borneo had been inhabited older than their paintings. This new data will reopen the migration path that we know about. In the same periodization, Homo wajakensis 1 lived on Java Island indicate a minimum age of between 37.4 and 28.5 thousands of years ago (Paul Storm et al, 2013) and until now rock art has not been found on Java, has there been a difference in behaviour or just not been found?

Glacial-interglacial cycles generate eustatic sealevel fluctuations, periodically turning the Sumatra Islands of the Indonesian Archipelago into mountain ranges on the sub-aerially exposed Sunda Shelf (Janssen et al. 2016; Voris 2000). This makes sense because it will not be easy to find sites in the lower Pleistocene in the present time, especially Homo erectus which suspected to live in the lowlands.It is very likely that we can find traces of humans in the lower Pleistocene on land that has now sunk underwater.The recurring land connection and greater extent of more open vegetation during glacial periods enabled repeated biotic migrations from mainland Asia into Sundaland.

Subsequent isolation during interglacial periods encouraged genetic divergence and speciation of faunas (Janssen et al. 2016). The theory of modern human inhabitation in Sundaland is well supported by the environment, including temperature, moisture, and vegetation. In the past, sea levels below present-day levels influenced climatic condition significantly (Morley, 2000.; Wang, L. 1999). Provided from geological records, Morley (2000) stated that during Last Glacial Maxima (LGM), there was a reduction in the moisture which inferred a drier and cooler temperature. It is predicted that temperatures were reduced by not more than 2-3°C throughout LGM.

Type of vegetation inhabiting Sundaland during LGM remains a key question until today. However, there are currently two rising hypotheses, whether Sundaland was partially covered by rainforest belt or savanna corridor. However, the second theory promotes a land bridge between Malay Peninsula and the major islands of Sumatra, Java, and Kalimantan (Borneo) that could explain dispersal of rainforest dependent species between Sumatra and Borneo. A prediction map of savanna corridor in the central of Sundaland is depicted in (figure 4). Based on data isotope on bovids and cervids teeth shows that's vegetation d18O values coinciding with C4-abundance during (inferred) glacial periods(Janssen et al. 2016). It is possible for the glacial savanna in Sundaland to become an occupations and migration path for both humans and faunas.

Figure. 4 Reconstructed illustration of Savanna corridor (green area) extending from Malay Peninsula to the central part of Sundaland (Source: Heaney, 1991; Bird, 2005)

The potential of submerged landscape site in Sundaland can be examined from the study of mapping of the paleo-river of the Sundaland. Studies on the reconstruction of paleo-river in Sundaland had been pioneered by several authors, among other is Voris (2000) in which then improved by Voris and Sathiamurty (Voris, H.K., Sathiamurty 2006).

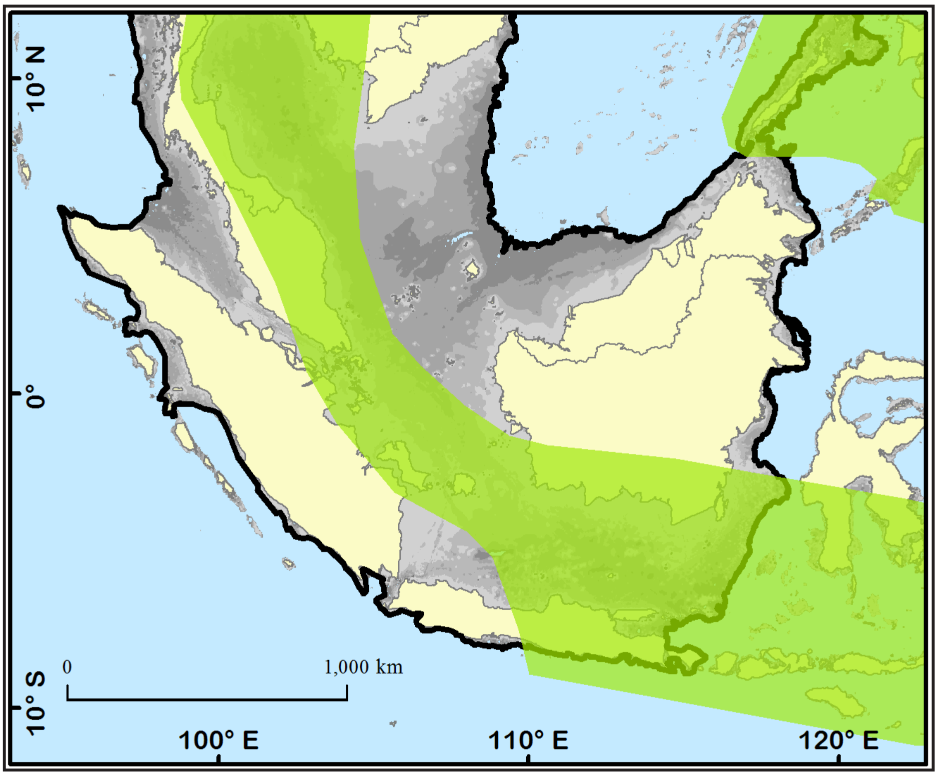


Figure 4. Reconstructed illustration of Savanna corridor (green area) extending from Malay Peninsula to the central part of Sundaland (Source: Heaney, 1991; Bird, 2005)

Voris had an intention to reconstruct landscape of Sundaland as well as its drainage system. In his study, Voris (2000) utilized present-day bathymetric depth contours as a proxy due to the assumption of during Quaternary period, Sunda Shelf had been always a tectonically stable plate (Tjia 1996). Consequently, any geological influences such as subsidence, tectonic uplift, discharge of meltwater from ice sheets, and tidal scouring are considered as minor factors affecting today's bathymetry and they can be negligible.

3.3 Paleo-river Model

3.3.1 Reasoning

To date, several works have been made to reconstruct system of paleo-river model in Sundaland. Among others, North Sunda River that ran north-east coast of Sumatra to join the large river in Borneo and East Sunda River in which it probably only had a single main channel (Molengraaff, M.A.G. 1921). Another study by Voris (2000; 2006) proposes two additional river systems termed Siam/Chao and Malacca Strait rivers. Voris developed the paleo-river model from various ancient maps and modern bathymetric data.

Yet, the previous models of paleo-river can be considered to be hypothetical only – there have not been many scientific or sufficient evidences to support the model. In advance, poor spatial and temporal resolution of the input data, outdated data acquisition technique, and river network modelling tool also play key roles in the river modelling. Therefore, this research has an importance to deliver a surrogate approach of paleo-river in the extent of Sundaland which also be equipped with new evidences from underwater field survey.

3.3.2 How-To

Paleo-river model was derived from modern surface representation, Digital Elevation Model (DEM) in Geographic Information System (GIS) environment. Cells in DEM are separated every 30 arc-second (~925m) and every cell has an elevation value, or in this case, depth value, depicted in meter. Taking DEM data as the input, the method relies on flow direction. In such mechanism, the direction of one cell to another cell is determined. Hence, a river is defined by establishing the minimum value of the accumulated flows in every cell.

3.3.3 Assumptions & limitations

In relevance with the modelling of the submerged river network, several underlying assumptions and constraints prevail. The first one is the modern-time gridded bathymetry and topography DEM utilized to proxy the physiography of the Sundaland and latterly used to generate the paleo-river. The reasoning of using modern time data for paleo modelling is supported by the fact that Sundaland has been geologically stable since the beginning of Tertiary period (Geyh, M.A. 1979 ; Tjia, 1996). In addition to this, the seismicity and volcanic activities are also seen as nearly devoid in the interior of the landmass. Despite of its stability, the geometry of the present-day DEM is still prone to error. It cannot accurately represent the former landscape due to the intervention of seabed scouring and sedimentation that have taken place over time. At this present state it is least known how the scouring and sedimentation processes have modified the shape of the seafloor of Java sea.

Another limitation is originated from the primary dataset itself, i.e. bathymetry and topography data in the state of DEM. The most fundamental problem in employing such data is the presence of sinks, which refer to cells with no down slope neighbours and reasonably problematic as they stop water to flow. In most cases, sinks are spurious topographies, albeit some truly represent the real landscape variability's. They may arise from interpolation errors during DEM generation and limited spatial resolution of the grid (Martz and Garbrecht, 1998). As sinks could lead to geographical misinterpretations, precondition treatment they shall be removed prior to producing a model of drainage network. In addition, the uncertainty coming from resolution of DEM should also be pointed out. Coarse resolution may prompt under sampling, which correspondingly causes incised hills, filled valleys, shortened drainage lengths, and flattened slopes. Further, since DEM cannot capture all structures of the landscape, particularly if the features are finer than its resolution, discrepancies between the real drainage networks and the modelled one are expected to occur.

3.3.4 Verification: Field Study

For the purpose of grasping a more thorough study, a marine seismic survey was conducted. The site visit had a purpose to identify any possible sub-seabed structures, which were accidentally indicated by seafloor's outcrops during an earlier Search and Rescue mission of the crashed airplane (AKSLI 2015). In this site visit, an identification of sub-seabed structures was done by high-resolution seismic systems and a single beam echo sounder (SBES) complemented with gravity coring and grab sampling. The survey area is situated in the NE part of the Java Sea, roughly close to the Karimata Strait between Belitung and Borneo Islands (figure.5). The resolutions provided by the underwater survey are 0.75m horizontally and 0.2m vertically.

The survey is carried out in two sites of 250 m × 250 m, with 7 km of separation. Within both survey locations, a total of eight soil

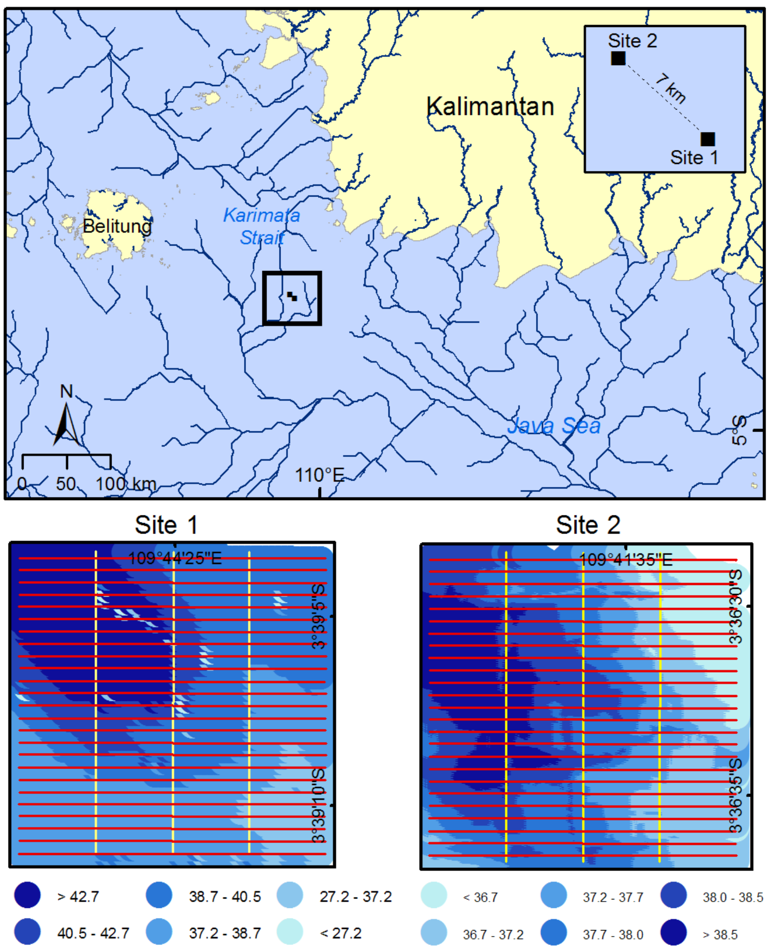


Figure 5. Survey locations. Colour grading denotes depth of seabed (in meter) according to bathymetry survey (Source: Yarista 2016)

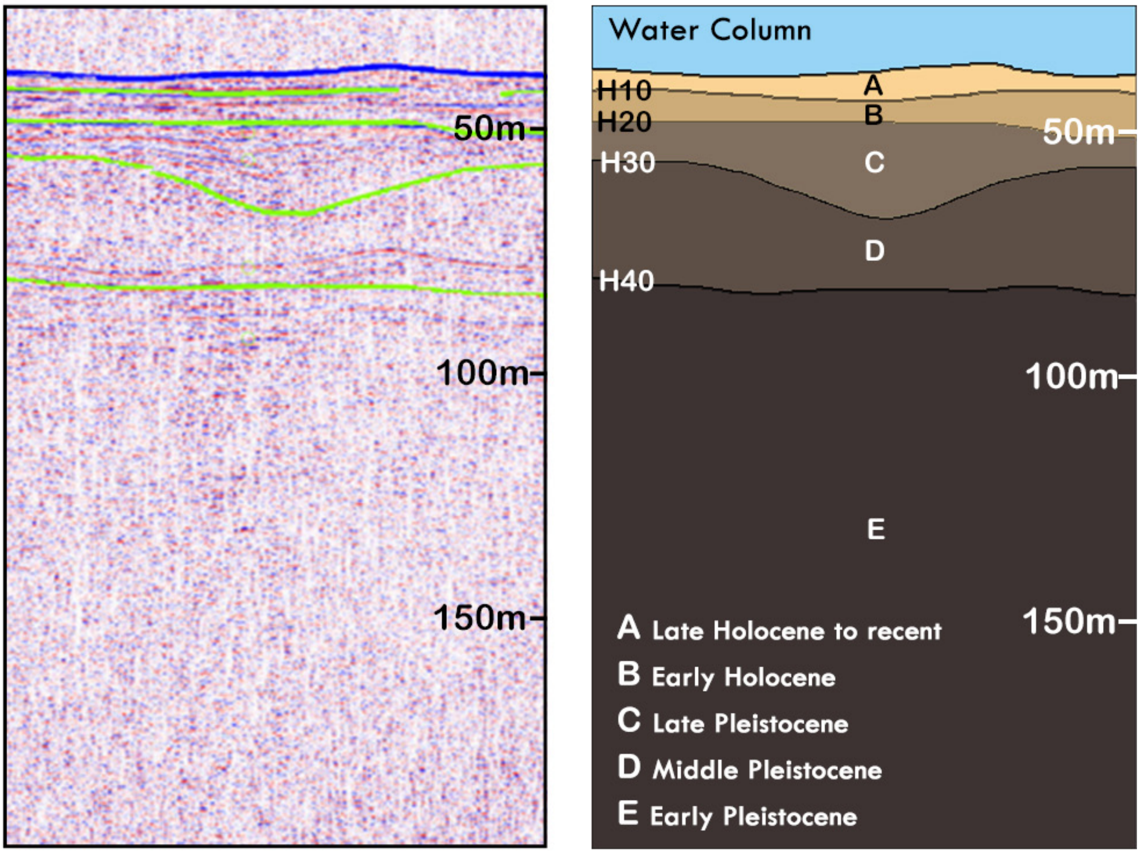


Figure 6. Sedimentary facies in Site 1 (Source: Amazoko - ITB 2016)

samples were collected. In each, there were two samples taken by Gravity Corer (GC) and two by Grab Sampler (GS). The seabed sediments of both survey locations are dominated by soft to firm sandy clay and occasionally included hard sandy silt. These sediments are then used as references to divide the shallow stratigraphy into sequences.

In Site 1, this sequence consists of pro-graded sediment deposited opposing above the erosion surface. The deposition is still active in the area that is supposed to be a paleo-channel and that could be assigned to a late Pleistocene age (figure. 6). Series of sub-seabed channel systems, i.e. the erosion surface of paleo-channels, are observed and cut deeply into the late Pleistocene sedimentary facies in this site.

In Site 2, late Holocene sedimentary facies cut shallowly into the uppermost sequence of the sub-seabed structure. These paleo-channel systems are striking in a Northward-Southward direction and in-filled by recent sediments. This direction is approximately perpendicular to the closest paleo-river system, i.e. the ancient East Sunda River.

From Site 1 and Site 2 in Karimata Strait, the survey proposes a strong suggestion of paleo-river existence, which corresponds to the desktop-based model conducted in GIS environment. Based on sedimentary facies, the paleo-river is suggested to be existed in the late Pleistocene and Holocene, which correspond with human migration mileage from Africa to Australia. In order to assemble the puzzle and get a bigger picture, a search for underwater cave sites, archaeological excavation and diving in Sundaland are needed to be executed.

3.4 Potential Underwater Cave Sites in Sahul Shelf

Between Sunda and Sahul lies the 1500 km-wide Wallacean Archipelago, sea level changes also affect island size and intervisibility between islands (O'Connell, Allen, and

Hawkes 2008; O'Connor et al. 2017). The lane between Wallacean archipelago and Sahul has never been bridged by dry land during the period of interest here. Even at maximum low sea levels (–120 m relative to modern), it measured well over 1,000 km across. Island-hopping through it required at least eight separate crossings (Birdsell, J.B. 1977; Kealy, Louys, and O'Connor 2018). All routes always included one leg >70 km and at least three >30 km (Allen and Connell 1977; O'Connell, Allen,

Figure 7. Map of Korwa Cave in Misool Island, West Papua

and Hawkes 2008). The results of U-series date on rock art in Maros, South Sulawesi (Wallacea) show that humans had arrived and did creative works during their inhabitation in karst caves of Maros area at least 39,000 years ago (Aubert et al, 2014).

Earlier Pleistocene hominins would have had to undertake sea journeys to reach Sulawesi and Flores, and late Pleistocene Homo sapiens would have had to undertake even longersea crossings to arrive on Sahul (O'Connor et al. 2017). The research in Sahul area was carried out in Misool Island, Raja Ampat Archipelago, West Papua. In this island, dozens of rock arts were found in the cliff. The man-made arts have varied patterns, such as human figures, geometrics, marine fauna (fish, turtle, jellyfish, and many more). These archaeological remnants show that Misool Island was already being occupied by humans for many years. Nowadays, the Misool people community blend in so well between the Melanesian and Austronesian communities (Adhityatama, 2017). During glacial era, this island was part of the Papua mainland, in a part of Sahul shelf. After the water level rose from 60 m to 120 m (O'Connell, Allen, and Hawkes 2008), this small island of Misool separated from the mainland (figure 9). The rising sea water caused some of drylands including caves in Misool islands to be submerged.

From the survey, a big underwater cave was found in the depth of 9 m to 22 m. The cave was then named Korwa Cave / Gua Korwa (GK), respecting the local guide who brought us there. This cave is potential for human occupancy as the width of the cave entrance is 12m and the length of the cave is as long as 24 m inward (figure 8) (Priyatno Hadi Sulistyarto et al, 2014). During glacial era, this cave ought to be on dry land (figure 7 & 9) approximately until 10,000 BP . It was the stalagmite, one of the strong indicators that's this cave was on the dry land, was found inside the cave. For further research, underwater excavation is suggested as this cave has a potential of human inhabitation during early Plestocene. By doing an underwater excavation inside this cave we probably will find human remains, animal bones, and also artifacts which could be solid evidences for early human occupation in Misool Island before being submerged.

Based on the study of early human inhabitation, people who come to Sahul consists of two categories: accidental and deliberate. Small groups on Sundaland were occasionally washed offshore during storms, then carried east on drifting mats of vegetation until they reached Sahul. Anderson (2000) thinks accidental crossings might have been more successful if the humans used bamboo rafts in connection with near-shore rafting. Their reliance on rudimentary watercraft may have increased the odds of being swept away in bad weather; subsequent survival may have been aided by water, food, and gear that were happened on board. But this argument led to many disagreements from many experts (O'Connell, Allen, and Hawkes, 2008).

Arguments in favour of purposeful colonization, supported by marine-capable watercraft, are more promising in particular to make a strong, if speculative, case for deliberate crossings using wind- or paddle-powered boats. He describes the zone from Sunda east to the Bismarcks as a 'voyaging corridor, predictable seasonal reversals of wind and current, a sheltered equatorial position between bands of cyclones and a large measure of inter visibility' between neighbouring islands, all of which favoured purposeful seafaring and related developments in marine technology (O'Connell, Allen, and Hawkes, 2008).

There is no doubt that Sahul shelf was sustainable for human lives and humans had been able to cross the ocean (Sundaland to Sahul) with the existing technology. This is interesting because in Australia there has been evidence of human inhabitation in Sahul which is from 65,000-40,000 years ago (Les Groube, John Chappel, John Muke 1986; Clarkson et al. 2017). However, no evidences from the relatively same age were yet found in Papua. It is likely that the remnants of early Pleistocene inhabitation have sunk. Massive exploration must be carried out to map the sinking lands of Sahul. All things considered, submerged landscape in Misool Island has a great potential to be studied.

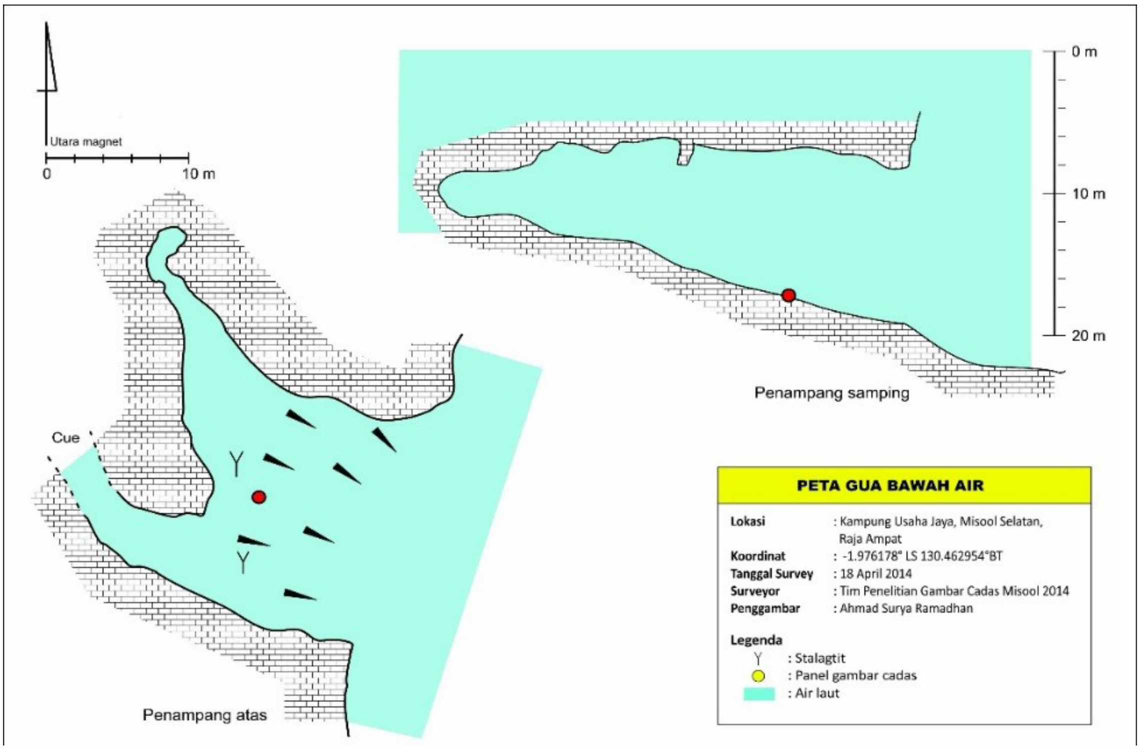


Figure 8. Illustration of Korwa Cave in Misool Island, Raja Ampat,West Papua which has potential to be cave dwelling activities (Source : Ahmad Surya Ramadhan, 2014)

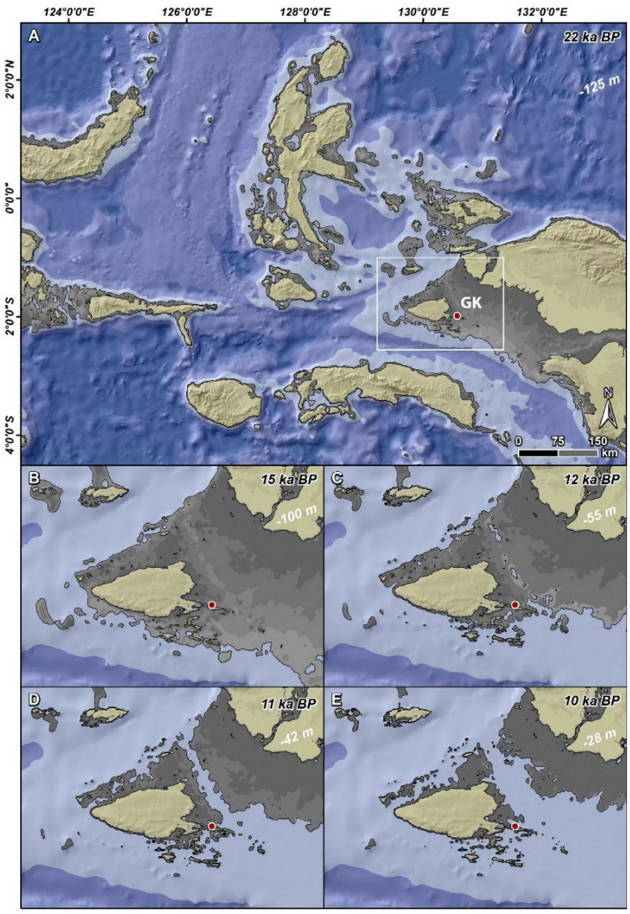


Figure 9. Location of Korwa Cave (GK) during the LGM when the water lever rises starting from 22.000 BP until 10.000 BP, as we can see the location of Korwa Cave was being submerged during the LGM (Source: Fabian Boesl and Shinatria Adhityatama).

The authors also suspect that Misool Island was the entrance to human migration to Sahul and also to the islands of Micronesia. It was based on the migration theory presented by Birdsell (1977) for the North lane model about the possibility of humans arriving on Misool Island (Sahul) after carrying out shipping activities from island to island. Current conditions prove that people of Misool Island are very easy if they want to sails to the surrounding islands (Kealy, Louys, and O'Connor, 2018), such as Seram Island, one of which only takes a short 2-4 hour sails to suit conditions weather. Evidence of human migration during the Pleistocene can be sought if we can explore underwater remains. Korwa Cave which is currently underwater, is a proof that several caves are suitable to be inhabited, but maybe we can start the search from here. In the future research can also be carried out by mapping the ancient rivers which has been done in Sunda Shelf. That way we can take into account and predict the human movement in Sahul Exposure during the Pleistocene.

3.5 Discussion

The data about Sundaland and Sahul have been done and collected by many experts from geology, paleoenvironment, and also archaeology. Indonesian archaeologists can compile the data from previous works and do the ground-checking to the submerged landscape areas in Indonesia. Archaeology can't work alone in thid study, which means multidisciplinaries should be applied to conduct the research, such as geology and environmental studies. The research ship to support this study already being provided by the government like Baruna Jaya ship owned by BPPT. Although this kind of research is expensive and covering quite vast areas, we should keep exploring because it's potential to find the answers of scientific questions such as the human migration, human evolution, paleoenvironment, and many more.

4. Conclusion

This study concludes several things as follows:

1. Model of paleo-river could be generated from modern-time bathymetry data, the 30-arc second GEBCO Grid to be precise. In coastal areas of main islands encircling Java Sea (Sundaland), visual conformities are observed: the paleo-river model has similar patterns with present-day river. There are nevertheless significant incongruities due to years of scouring and sedimentation. Bear in mind that river widths were not able to be produced. Higher resolution of bathymetry data will be needed to perform this.
2. Generally, civilization of prehistoric humans could be indicated from areas that are close with water resource such as river. Furthermore, a river also provides a transportation mode to ease the mobility using traditional rafts. Apart from river proximity, other physical landscape parameters are to be considered for further studies. These parameters are identified but not limited to flat land surface, fertile soil, warm temperature, sufficient humidity, and many others. This indication makes Sundaland a decent habitat for humans and faunas.
3. Survey in Misool Island reveals an archaeological potential: an underwater cave with the depth of 9-22 m. Before LGM occurred, this cave was initially exposed on land and has a high position from water surface. Dimensions of the cave, the surrounding environment, and the scattered rock arts in the island on the surface, suggest that the cave was a potential place for human inhabitation. It is also suspected that Misool Island was the entrance of human migration to Sahul and to Micronesia islands.

The study of submerged landscape archaeology is very important to be developed in a scientific direction so that people are not trapped in things that are not scientific fact, such as myth of the existence of Atlantis in Sundaland, the Java Sea. Scientists including archaeologists can provide comprehensive knowledge of occupancy and human migration paths in accordance with the existing cultural context. Indonesia is one of the largest marine laboratories in Indonesia, but we only know no more than 5% of our sea.

Sundaland and Sahul exposures for hundreds of thousands of years were exposed (dryland) which then submerged, logically, it was impossible for these two exposures not to be fostered by humans or faunas. However, the remnants of life cannot be seen now because they are in the depths of the sea. There is still much that can be done, archaeological excavation must be carried out at points that have the potential to be inhabited, one of them as explained above, that the recorded river path can be used as an indication of human occupancy. Sundaland and Sahul have an important role in our understanding of human and faunas occupations and migration in Indonesia and the evidences are waiting to be discovered.

This article is an introduction of the submerged landscape study that's we can do in Indonesia. This research needs to develop more advance in the future, we hope this article can encourage researchers in Indonesia to explore more our waters and open the new scientific question so it will also impact in the development of our science, especially study of archaeology in Indonesia. As some experts said, the water is the final frontier for archaeology.

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