Peri-urbanisation in Papua: A participatory and geospatial impact assessment of peri-urban development and transmigration in Port Numbay

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Abstract
This article aims to shed light on the impacts of peri-urbanisation processes across two case studies in Port Numbay within the Province of Papua. Five methods were used to gather data: focus group discussions, semi-structured interviews, archival research, ethnographic observations, and remote sensing imagery and geospatial analysis tools. The results generated insights into: (1) the lasting legacy of historical transmigration and decentralisation policies that have influenced the processes of peri-urbanisation in shaping the social and economic conditions within peripheral communities; (2) how peri-urbanisation has impacted biophysical environments including social-ecological systems and environmental health systems; (3) a range of peri-urbanisation trends (land clearing, deforestation and expansion of settlements over time). The article tests an interdisciplinary method for monitoring processes of peri-urbanisation. It concludes that approaches to decentralisation, health service delivery and sustainable development interventions into peri-urban zones...
should consider local conditions. Recommendations for policy and further research are also provided.

KEYWORDS
Indonesia, Papua Province, peri-urbanisation, Port Numbay, transmigration

1 INTRODUCTION

Cities in developing countries are growing at an extraordinary rate. Indonesia is no exception. Between 2000 and 2010, population growth in the Jakarta urban area reached 3.7% per year, higher than in any other urban area in East Asia excluding China (World Bank, 2015). More recently, the nationwide population of Indonesia has grown from 241.8 million in 2010 to 270.6 million in 2019 (World Bank, 2019). Among the growing number of issues associated with rapid population growth, development and land-use change, peri-urbanisation has emerged as a sustainable development challenge. In essence, peri-urbanisation refers to the growth of peri-urban fringe spatial zones which blur the boundaries between urban and rural areas. The emergence and rapid expansion of this zone and the associated socio-economic processes have been described by Ravetz et al. (2013) as one of the ‘dominant urban ... and rural development and spatial planning challenges of the twenty-first century’. These processes are especially clear in countries such as Indonesia where the effects of rapid population growth and urbanisation impose increasing pressures on infrastructure and service provision. Such pressures have implications for the social, economic, agricultural and environmental health of these peri-urban zones. They also carry consequences for conditions of structural inequality and land tenure: the rules, norms and practices as legislated in formal law or through customs that dictate how individuals and groups manage land use and the development of their land (Asian Development Bank, 2016). This article considers local perspectives in order to shed light on the impacts of the processes of peri-urbanisation on social, economic and agricultural systems.

In Indonesia, McGee (1991) first described the process of peri-urbanisation as the emergence of ‘desakota’ or ‘village-city’ regions. Since then, there has been an emergent body of literature focused on peri-urbanisation within the populated centres of the largest, and arguably most problematic, cities for urban planners otherwise known as the ‘megacities’ of Indonesia: Jakarta (see Firman, 2004; Firman & Dharmapatni, 1994; Goldblum & Wong, 2000; Hudalah et al., 2007; Winarso, 2011; Winarso et al., 2015); Surabaya (Prakasa & Istijanto, 2017); Bandung (see Budiyantini & Pratiwi, 2016; Maryati & Humaira, 2015; Woltjer, 2014); and Yogyakarta (Legates & Hudalah, 2014). Other studies have looked at the wider phenomena of urbanisation across Java, ‘the island of mega-urban regions’ where the remaining majority of Indonesia’s population reside (Firman, 2017). These examples show a growing body of recent studies investigating the processes of peri-urbanisation in Indonesia. However, in terms of geographic focus, the literature remains severely limited as, for the most part, it has not yet been looked at beyond the one island of Java.

Indonesia is an archipelago of 18,108 islands (Cribb & Ford, 2009). Managing the provision of services, infrastructure and governance across this complex geography, particularly within the most rural and remote areas, is problematic. As a result, this article looks beyond the largest core cities at peripheral case studies to inform development policies, interventions and programs for service provision within rural and remote parts of Indonesia. The study aims to add
to the discourse by providing insights from the perspectives of peri-urban communities in Port Numbay (Abe Pantai and Koya Barat), Papua. Some Jakarta-based studies have also delved into the province of Papua (Ananta et al., 2016; Dewi, 2017). This article seeks to add to this by contributing different perspectives through social research led by local researchers based in Papua. In doing so, the article addresses the following core research question: how have the processes of peri-urbanisation around Port Numbay impacted upon local social, economic, agricultural and environmental health systems?

The article is structured as follows: Section 2 provides a brief background of Papua Province and the selection of case studies. Section 3 outlines the research methodology. Section 4 presents the results, including a synthesis of community perspectives from both Abe Pantai and Koya Barat of the historical and socio-economic context, as well as of changes to agricultural and environmental health systems in their respective communities. The results of geospatial analysis of both case study areas are also presented. Section 5 discusses the results within the wider context of peri-urbanisation across Indonesia and Melanesia. Section 6 assesses the wider implications for development policy and peri-urban planning and provides recommendations for future policy, programs and research.

2 | HISTORICAL CONTEXT OF PORT NUMBAY AND THE PAPUA PROVINCE

Before Dutch colonialism reached the western half of New Guinea in 1828 (Pouwer, 1999), the provincial hub of Papua, Jayapura, was known as Port Numbay. With the arrival of the Dutch, Numbay was renamed Hollandia, becoming a colonial port and outpost (Bertrand, 2004). After Indonesia gained its independence in 1945, it claimed all of the territory of the former Dutch East Indies, including Western New Guinea (Viartasiwi, 2018). Through later integration into Indonesia, the town of Port Numbay underwent rapid development and expansion into what is now the present-day provincial capital of Papua, Jayapura City. In accordance with the history of Papua, in this article we refer to the capital of Papua Province as ‘Port Numbay’.

The growing diversification of Port Numbay and the resultant increase in socio-economic opportunities also contributed to the urbanisation of the city. This, in turn, put increasing stress on Port Numbay’s population growth, which was further intensified by transmigration policies introduced across Indonesia (Abdoellah, 1987). The transmigration program was first initiated during the Dutch colonial period but it later became part of the official policy of the Indonesian Government, with movements of hundreds of thousands of people and reaching the highest volumes between 1979 and 1984 of the New Order years (Tirtosudarmo, 2015, p. 22). The policy aimed to address the issue of overpopulation in Java, which was densely populated compared to other islands and provinces in Indonesia. Under Indonesian rule, transmigration policies involved the clearing of land that was previously uncultivated or perceived as being sporadically and ‘illegally’ cultivated, and the deliberate resettlement of people (Yuminarti, 2017).

Processes of peri-urbanisation were also impacted by national decentralisation programs. Sahide et al. (2016) defined decentralisation as the process of devolution in which functions,
powers, human and financial resources are distributed from higher levels (the central government) to lower levels (the regional authority). Despite the multi-scalar processes of ongoing decentralisation, Schusser et al. (2015) observed enduring channels and structures of stratified influence maintained by the central authority. This is particularly the case in areas that have been considered for special autonomy status such as the provinces of Aceh, Papua and West Papua. Since Law 22 of 1999 concerning Regional Government came into force in Indonesia, the implementation of regional government has substantially changed from centralisation to decentralisation, including in Papua (Simanjuntak, 2015).

Papua is the largest and easternmost province of Indonesia, making up close to 17% of the country’s total land area (Badan Pusat Statistik [BPS], 2021b, p. 10). Yet, only 4.3 million people live in Papua in 2020 compared to Indonesia’s general population of around 270 million (BPS, 2021b, pp. 2, 87). Papua has five customary lands—Anim Ha, La Pago, Mee Pago, Saireri and Mamta—each of which consists of a number of regencies (BAPPEDA Provinsi Papua, 2019; Dewi, 2017). Papua Province is composed of 28 regencies and 1 city. In 2020, it had 576 subdistricts with 159 urban settlements or kelurahan and 5549 villages or desa (BPS, 2021a, p. 77).

It is also worth noting that Papua is ethnically different from the rest of Indonesia. For instance, Papuans are predominantly of Melanesian descent and share cultural ties with their Papua New Guinea (PNG) neighbours; they engage in cross-border interactions including for trade and visiting relatives (Conroy, 2020; Kirsch, 2010; Korwa & Rumabar, 2017). In addition, a majority of Papuans are Christian, whereas Indonesia has the largest Muslim population in the world (Farhadian, 2011).

2.1 Selection of case studies

Two areas on the periphery of Port Numbay were selected as our case studies: Abe Pantai and Koya Barat. These locations were considered to have the potential to provide insights into local social, economic and biophysical processes and the impacts of peri-urbanisation. Abe Pantai is an administrative district of Abepura, while Koya Barat is within the District of Muara Tami. The criteria used to select the case studies are represented in Table 1. This study selected Abe Pantai and Koya Barat based on a range of observations and considerations. First, the two areas are located in the peri-urban spatial zone on the periphery of Port Numbay. Second, both areas have growing small industries. Third, these areas have histories of transmigration. Fourth, their locations represent geographic contrast. Abe Pantai is a coastal rural area which relies mostly on fishing and agriculture for livelihoods while Koya Barat is an inland area with more urban

| Criteria                                | Abe Pantai | Koya Barat |
|-----------------------------------------|------------|------------|
| Located in peripheral spatial zones of Port Numbay | X          | X          |
| Rural and agricultural economies        | X          | X          |
| Increasing urbanisation and industrialisation | X          | X          |
| Sites of transmigration                 | X          |            |
| Coastal                                 |            | X          |
| Inland                                  | X          |            |
| Bordering closed to Papua New Guinea    |            | X          |
industrialised characteristics alongside an agricultural mixed-economy. It is also worth noting that these two locations act as a buffer zone between Port Numbay and the border with PNG (see Figure 1).

3 | METHODOLOGY

The study adopted five main methods: (1) focus group discussions (FGDs); (2) semi-structured interviews (SSIs); (3) ethnographic observations; (4) archival research; and (5) analysis of open source remote imagery using Google Earth and QGIS analysis tools. The fieldwork was conducted between December 2017 and March 2018. The FGDs represent the final output of formal meetings at each case study site. The meetings were canvassed and arranged through local government procedures and permissions months in advance. These processes included consultation with the ward office. The research team obtained permission from the ward office to book the meeting halls for a period of 1 hour per meeting. The formal meetings were facilitated by three local members of the research team and ward heads. The official FGD meeting minutes were only recorded for discussions that were co-facilitated by the government officers including 30 minutes at Abe Pantai and 45 minutes at Koya Barat. Outside of the official agenda of the

FIGURE 1 Indonesia–PNG border and two case study areas. Notes: (a) Indonesia–PNG border is shown in yellow; (b) Port Numbay is outlined in white; yellow markers locate the City of Port Numbay and the peri-urban settlements of Abe Pantai and Koya Barat; (c) area of Abe Pantai; (d) area of Koya Barat. Source: Google Earth, 2018
FGD meetings organised in collaboration with local government, the research team also conducted a range of other informal meetings and interviews.

The FGDs were to include heads of household. On the days of the FGDs there were 5 heads of households in Abe Pantai ($n = 5$) and 10 heads of households in Koya Barat ($n = 10$). These heads of household would ideally represent the perspectives of a sample made up of their households (Abe Pantai: approximately 20 people represented by 5 household heads; Koya Barat: approximately 40 people represented by 10 household heads). These figures are based on the average number of residents per household (4 people) in the district of Jayapura (BPS, 2018a). This sample reflected a wider population of 3020 in Abe Pantai and the relatively larger population of 5044 in Koya Barat (BPS Jayapura City, 2018b, pp. 70, 71). The FGD in Abe Pantai involved the hamlet head along with other members of the community. In Koya Barat the FGD included the hamlet head, elders and religious representatives. The FGDs followed a structured set of questions designed to allow for comparison of peri-urban conditions across the two case study settlements.

For the SSIs, the three local members of the research team were able to interview a larger population sample size from each of the two case study areas. The questions in the SSIs covered the same questions as the FGDs but with additional scope to allow for a wider focus. These SSIs were conducted in the 2 months leading up to the FGD meeting days over a total of eight separate field trips: four visits to each of the two field sites. This also included 60 minutes of SSIs before and after the FGD in Abe Pantai and 75 minutes of SSIs before and after the FGD in Koya Barat. Discussions were also held with members of the various settlement communities to explore some of the complexities within different ethnic and religious groups. In Koya Barat this included an indigenous group at the Church and a transmigrant group in the Mosque. SSIs were also used to verify and ground-truth the processes of settlement expansion, agricultural expansion, forestry clearing, and other forms of land use. The total number of participants involved in the SSIs from all four visits was 28: Abe Pantai, $n = 12$; Koya Barat, $n = 16$.

Ethnographic observations were gathered by the three local Papuan members of the research team in the lead up to the final FGDs. Reeves et al. (2008) emphasise that ethnographic observation focuses on investigating the nature of a particular social phenomenon, collecting unstructured data, and working on a small number of cases (perhaps even just one case) in detail. The ethnographic observations were conducted using the following checklist: observations and interactions with community members at (a) ward office, (b) health clinic, (c) farm and deforested areas, and (d) houses assessed to be at higher risk to natural hazards. These observations also served as a form of ground-truthing observations of: (i) settlement expansion, (ii) agricultural expansion, (iii) forestry clearing, and (iv) other forms of land use change.

Archival research was also utilised in this study. It involved investigation of materials created by and about institutions in the local context of Papua (Ventresca & Mohr, 2017), such as locating, evaluating and systematic interpretation and analysis of sources found in archives or other repositories. Sources included profile data of the two case study areas from: the Kantor Lurah (urban village office); the official website of Koya Barat's subdistrict; reports from the Central Bureau of Statistics (Badan Pusat Statistik or BPS); official website of the government of Jayapura City; and reports from the Agency for Regional Development of Papua Province (BAPPEDA Provinsi Papua).3

3Kantor Lurah subdistrict office provided profile data of the case studies (Abe Pantai and Koya Barat). See also the official website of Koya Barat's subdistrict, https://pemerintahkelurahankoyabarat.blogspot.com/p/profil.html; and official website of the Government of Jayapura City, https://www.jayapurakota.go.id/.
Lastly, the methodology involved analysis of spatial and satellite imagery to identify the areas of rapidly expanding peri-urban spatial zones, and to provide an idea of the general land use change issues affecting these peri-urban communities. This was part of the initial peri-urban settlement scoping process that could then be verified through site visits, FGDs, SSIs, archival research and ethnographic observations. Relevant remote sensing satellite imagery datasets included images from the Google Earth Engine Data Catalogue. The remote sensing literature already demonstrates how satellite images offer the potential for high-temporal and spatial monitoring across land use change. Landsat 8 provided land use classification images for temporal analysis of land use change. The Google Earth Pro ‘clock tool’ provided a visual time-lapse of change over time across both Abe Pantai and Koya Barat settlements as well as change seen more widely across Port Numbay. This allowed for comparison across both spatial and temporal scales through the use of vegetated forest layers as well as urban and peri-urban areas. This geospatial analysis draws on methods used in other studies of peri-urbanisation including Lupala (2015), which examined the effects of peri-urbanisation on forest reserves in Tanzania, and Tavares et al. (2012), which explored spatial and temporal land use change in peri-urban areas in central Portugal.

4 | RESULTS

The results of the FGDs, SSIs, archival research and ethnographic observations are documented below as a summary of community perspectives. These insights reflect the collective understanding of the groups involved in the FGDs and semi-structured discussions about their own local settlement including the historical context. Results are structured in terms of the historical and socio-economic context followed by systems that have undergone change through processes of peri-urbanisation including agricultural and environmental health systems.

4.1 | Abe Pantai: Historical and socio-economic context

According to the FGD and SSIs, settlements around Abe Pantai have existed for many decades but were only officially recognised by the government in 2006.4 Before the settlement was built, the area of Abe Pantai was characterised by dense forest. The land of Abe Pantai itself belonged to the Ondoafian of the Nafri-Jayapura Tribe who were the original customary owners of the land. Respondents in the focus discussion group and SSIs observed that there have been a range of development processes in Abe Pantai over the past 5 to 10 years. This has included the growing population and the resultant demand for housing development (see also BPS, 2018a). According to the ethnographic observations, FGD and SSIs, the people of Abe Pantai are divided into two main groups: non-indigenous migrants from areas such as Ternate and Tidore (Maluku Islands), Buton and Makassar (South Sulawesi) and Java; and indigenous Papuans, many of whom have come from areas outside of Port Numbay including Biak (West Papua) and Wamena (Papua highlands). The first group of migrants who settled in Abe Pantai were from the Ternate Tribe. Interestingly, in Abe Pantai the settlements have transformed into smaller micro-enclaves of groups from various parts of Papua as well as other groups from Indonesia. There are seven rukun warga (RW; hamlets) in Abe Pantai and each is known by the name of

4Data provided by the Kantor Lurah subdistrict office (Abe Pantai).
the community from which the non-indigenous ethnic majority residents originated. For instance, RW1 is the village of Wamena; RW2, the village of Fak-fak/Selayar; RW3 and RW4, the village of Buton; RW5, the village of Makassar; RW6, the village of Biak; and RW7, the village of Ambon. These micro-enclaves provide an interesting insight into the formation of micro-communities within our case studies.

### 4.1.1 Agricultural systems

Agriculture is the largest sector of the economy of Papua (Pemerintah Provinsi Papua, 2016). This sector includes both food products, such as rice, sweet potato, water spinach and sago, and forestry products including wood and cork, straw, bamboo and rattan (BPS, 2019b).

The FGD, ethnographic observations and SSIs identified that most people in Abe Pantai earn their livelihoods as farmers. This was also in line with the profile data produced by Abe Pantai subdistrict office, and reviewed as part of the archival method, which stated that the largest occupation was farmer (239), followed by entrepreneur (93). There are some small groups of people who work as civil servants, fishermen or in private businesses. However, often these people still supplement their incomes with farming and agricultural activities, as evidenced through semi-structured discussions and the FGD findings.

Agriculture can be considered as the most common income generating activity in Abe Pantai. Spinach is the main crop, including red, green, ‘batik’ and water spinach. Other common crops include basil, beans and chilli. The majority of people in Abe Pantai sell their crops in the Youtefa market, one of the central markets in Port Numbay. Sometimes people from the market visit the farmers directly to buy the crops. Only a few crops are used for household consumption.

Both the FGD and SSI participants had observed recent rapid population growth and plantations and croplands expansion. According to community members and our observations, this has also led to decreasing distances between homes and farmland. Before the population expansion, people in Abe Pantai lived further from their farmland but this distance has been closed and more people live in much closer proximity to their land. The community also observed increased land clearing and deforestation as a result of demand for settlements. There is government support for water and irrigation, including Perusahaan Air Minum (Municipal Water Cooperation) which provides water services to the area (see also BAPPEDA Provinsi Papua, 2018). Abe Pantai also has five public wells and mountain springs.

### 4.1.2 Environmental health systems

In this article, environmental health refers to access to clean water, drainage, sanitation and management of rubbish, as well as access to roads and health facilities (Effendi, 2013; Metherall et al., 2016). In Papua there are 1146 health clinic units and 41 larger hospital facilities (BPS, 2019b). According to the FGD and SSIs, the most common health issues in Abe Pantai include mosquito borne diseases such as malaria and metabolic diseases such as diabetes. Using archival research, this information was expanded with data from BPS (2018b), which includes public health information for the two case study areas. In Abe Pantai, the most common public health conditions include upper respiratory tract infection, gastritis, diarrhoea, tropical malaria and malaria tersiana.
Based on observations, there is one larger health clinic—*puskesmas* (community health centre)—in Abe Pantai, which employs around 20 staff. There is also a smaller *posyandu* (integrated health post). Participants of the FGD and SSIs noted that there were also midwives in Abe Pantai who assisted with child birthing. A ‘*dukun*’ practitioner of traditional medicine also helps in child delivery. Many community members from outside Abe Pantai come to the clinic for treatment placing additional burden on health service providers.

In terms of environmental health, all households in Abe Pantai discharge liquid waste on a daily basis. This waste flows through a man-made channel that runs underneath the houses. The liquid flows of waste discharge are often uncovered. Solid waste including household rubbish is habitually thrown outside of homes and then periodically burned in a pile. Drainage facilities in Abe Pantai are distributed unevenly and many do not function properly. This situation is worsened when people intermittently use these drains to dispose of garbage, which adds to blockages. As a result, during a rainfall event, the garbage often overflows over roads and contaminates the surrounding areas including the houses of local residents. Community members in the FGD and SSIs also observed an increasing number of floods after settlement. Many of the sewers and drainage areas had been closed to prevent further rubbish blockages. However, this had also led to increased small-scale flooding.

### 4.2 Koya Barat: Historical and socio-economic context

According to the FGD, ethnographic observations and SSIs, Koya Barat was one of the first transmigration settlements along the periphery of Port Numbay. This was at a time when the island of West Papua was previously known as ‘Irian Jaya’. The first settlement was opened in Koya Barat at the beginning of 1982. This was also verified using the archival method: researchers crosschecked information with historical data provided on the Koya Barat subdistrict official website, which gave a detailed history from 1970 to 2002, and with the BPS Muara Tami Subdistrict in Figures report (BPS, 2018c).

Before settlement, the area around Koya Barat was densely forested. Due to its location near the Indonesia–PNG border, it had been classified as a ‘red area’—that is, it was perceived as posing a high security risk of conflict (the FGD and SSIs). As a result, Koya Barat became a settlement for transmigrants or Unit Permukiman Transmigrasi (UPT). Most of the transmigrants came from Java and Makassar. There were also a few local Papuan families from the coastal area of Teluk Youtefa who moved to Koya Barat. This arrangement was agreed under, at the time, the Jayapura (Port Numbay) Regent, Barnabas Youwe, and some of the elders from each of the respective villages. The agreement involved the relocation of 25 family groups whose main source of income was fishing. Through the policy of transmigration, these families were relocated from surrounding villages including Kayu Batu, Kayo Pulau, Tobati and Enggros.

One of the transmigration program’s purposes in building these new settlements was to enable a mixture of foreign transmigrant and local Papuan communities. In Koya Barat this process was geared towards supporting knowledge transfer for agriculture. The relocation of Papuans was also undertaken within the context of a pre-existing sense of community between local Papuan families from the coastal and peripheral areas of Port Numbay, summarised as ‘1 *bantal*, 2 *kepala*’—meaning ‘one pillow, two heads’, denoting the closeness between these groups as living under one metaphorical roof.

Since the first waves of transmigration, there have been more recent waves of migration from other regencies of Papua including Biak, Serui, Sorong and Merauke and the mountain
tribes of the Central Highlands (Wamena, Oksibil and others). Other groups have also come from outside Papua including from Ambon and Sumatera. Many people are posted to Koya Barat to provide services such as teachers, health workers, civil servants, and military (TNI) or police (POLRI).

Currently the main faith groups in Koya Barat (represented in this study) include representatives from the Protestant group (Gereja Kanaan) and Islamic group (Masjid Al-Muhajirin). With the expansion of these diverse communities as a result of transmigration, there have at times been increasing frequency of local-level conflicts. The FGD and SSIs recalled that these conflicts culminated in December 2016 when there was a religious conflict between an Islamic group and a local Christian group during preparations for Christmas and New Year's celebrations. Ultimately, police and the government had to intervene to end the conflict.

### 4.2.1 | Agricultural systems

In the past, the local Papuan transmigrant communities from across Port Numbay did not have agricultural techniques that would allow them to grow crops intensively and maximise production. The transmigration policy brought about the transfer of ‘best practice’ on how to clear land from native forest for agricultural use (the FGD and SSIs). This land was then allocated by the government to transmigrants who, in turn, would become farmers and oversee production on the land. Crops that were introduced by the government for the transmigrants included agricultural crops such as rice and horticultural crops such as sweet potato, spinach, spices, tomato and sugarcane (FGD and official website of Koya Barat).

Based on our observations, the predominant forms of agriculture in Koya Barat today include paddy field crops with irrigation systems, dryland rice crops, and seasonal horticultural vegetables and fruits. Alongside these crops, farmers also have livestock (chickens, ducks, cows and goats). The community also has some freshwater aquaculture including Gurami, Nile Tilapia and Common Carp.

In terms of infrastructure for irrigation, the government has provided dams to harvest the surface water from the nearby Tami River. This water is crucial to support agricultural activities including floodplain rice crops and other crops. It was found through the FGD that local Papuan transmigrant households are more likely to grow crops for their own consumption and household needs. Some households do not have enough crops to fulfil their own needs and must also buy more to fill this gap. However, there are other groups from Papua (especially from the highlands) who are able to yield surplus crops and sell them at the market. These crops include sweet potato, taro, cassava, corn, bananas and pineapple as well as betel nuts. According to the FGD and SSIs, farmers in Koya Barat are considered very advanced because of high crop yields. One family household had at least two hectares of land for agriculture, which allowed them to lease one hectare of their land to another farmer. The income from these activities is enough to help farming households pay for their children’s education from school through to university. Farmers are also often able to have large houses—a reward for their labour.

### 4.2.2 | Environmental health systems

In terms of health infrastructure, based on the FGD, there is one puskesmas (public health centre) and three pustu (small-scale community health centres). The puskesmas serves the
wider subdistrict while the *pusru* serves a smaller subsection of the community. However, using archival data, researchers countered the information described through the FGD in relation to the number of *pusru* in the area. According to data from the Muara Tami Subdistrict in Figures report, there is one *puskesmas* in Koya Barat but no *pusru*; however, eight *posyandu* (integrated health posts), two clinics and three midwife practices are recorded (BPS, 2018c).

The most common diseases reported at the Koya Barat public health centre are upper respiratory tract infection, skin infection, muscle tissue conditions and gastritis, hypertension, diarrhoea, tropical malaria and malaria tertiana (BPS, 2018c). The proliferation of standing freshwater and wading puddles, particularly after flooding events, leads to increased numbers of stagnant water sources, which also become breeding grounds for mosquito vectors for malaria.5

Before settlement in 1982, Koya Barat was a densely forested area. The forests were largely made up of tropical hardwood trees including Merbau trees commonly known as Moluccan ironwood and Matoa trees. These trees were habitats for various birds and other animals. Wild pigs, deers and moles were once commonly sighted. Alongside the thick rainforest were areas of dryland vegetation and savannah. The clearing of this vegetation has increased run-off during rainfall events. Floods and inundation in low-lying residential areas after high intensity rainfall events and long duration rainfall events have also increased. Inundation has at times reached levels of one metre, flooding streets and houses, particularly in flat areas that do not have adequate drainage.

According to the FGD and SSIs, these conditions are likely to worsen due to increasing demand for cleared forested lands for agriculture and settlements. These trends correlated with the arrival of new groups including transmigrant groups in Koya Barat. The arrival of these communities led to increased dependence on forest and wood commodities, which in turn has led to further clearing.

### 4.3 Results of geospatial analysis

Using the time-lapse clock tool through the Google Earth Pro application, Landsat 8 earth observation imagery provides insights into land use change over time. Both expansions and increasing density of urban areas and peri-urban spatial zones as well as the related processes of land-clearing and deforestation are highlighted across Port Numbay district. This trend was also described by participants in FGDs and SSIs. These results demonstrate how geospatial analysis can be used as a tool to identify peri-urbanisation trends that can then be verified through fieldwork and social data collection.

Figure 2 shows processes of land clearing and deforestation that have taken place in Port Nambay since 1984. To observe these changes and the impacts of peri-urbanisation in more detail, the study hones in on the two specific case studies of Abe Pantai and Koya Barat.

A zoomed-in image of Abe Pantai in 2017 (Figure 3) shows areas of deforestation and land-clearing, highlighted in red, and the expansion of peri-urban coastal settlements, highlighted in blue. These areas were also verified through fieldwork during the FGD and SSI activities.

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5See Centers for Disease Control and Prevention, ‘Malaria’, https://www.cdc.gov/malaria/about/faqs.html; and World Health Organization, ‘Malaria’, http://www.who.int/ith/diseases/malaria/en/.
FIGURE 2  Land cover and land use change over time observed through images of Port Numbay between 1984 and 2016. Source: Google Earth, 2018

FIGURE 3  Peri-urban expansion (blue) and deforestation (red) in Abe Pantai, 2017. Source: Google Earth, 2018
Extensive land-clearing for agriculture, expansion of settlements and the extraction of forest products has also occurred in Koya Barat. Deforestation between settlement in 1982 and 2017 has been extensive. This area has been digitised in GIS as shown in red in Figure 4. These areas were also verified through fieldwork during the FGD and SSI activities.

Figure 5 shows the expansion and increasing housing density in Koya Barat within the short timeframe of 2014 to 2017. The increase in the number of houses is highlighted through the increased number of buildings with tiled and corrugated roofs (often painted blue). These trends are symptomatic of continuing increases in population and demand for housing.

**Figure 4** Peri-urban expansion, deforestation and land clearing trends in Koya Barat, 2017. *Source: Google Earth, 2018*

**Figure 5** The growing settlement in Koya Barat, 2014 and 2017. *Source: Google Earth, 2018*
5 | DISCUSSION

Three key themes emerged from the results of this study: the legacy of transmigration and other related policies such as decentralisation policies; the biophysical impacts of peri-urbanisation on agricultural and environmental health systems; and insights into land-clearing and peri-urban spatial zone expansion trends yielded from historical analysis using geospatial and cartographic tools. Alongside these three themes, further insights are drawn by comparing the results of this study with other case studies across Indonesia and the wider literature.

In terms of the legacy of transmigration and peri-urbanisation on social and economic systems, the FGDs and SSIs highlighted two main points: social cohesion and conflict, and structural inequality. The Koya Barat FGD group recalled the eruption of religious conflicts in 2016 between Christian and Islamic groups. This required intervention from the government to end the conflict. There were no forms of social or religious conflict in Abe Pantai. This may suggest that the role of transmigration in forming peri-urban settlements, as seen in Koya Barat, may have been conducive to creating the conditions for conflict. However, correlation does not prove causation and further research into these questions may be needed. Another potential source of conflict may have stemmed from inequality. Between peri-urban and core urban spatial zones there are disparities in terms of access to infrastructure, facilities, goods and services. When combined with decentralisation policies which were reinforced in 1999 (Silver, 2005), rapid peri-urbanisation and decentralisation led to a range of social crises as a result of population growth in peri-urban spatial zones, imposing increased pressure on inadequate infrastructure and service provision capacity. This has contributed to issues described as ‘krismon’ (krisis moneter or monetary crisis) relating to urban economies, employment, poverty, rural-to-urban migration, local government revenues and spatial development (Firman, 1999). Akita and Lukman (2006) have further provided quantitative evidence of a correlation between rapid urbanisation and growing inequality within Indonesia. Future research may be needed to assess the risks of rapid development leading to the formation of a new class of disadvantage in peri-urban areas as seen for example in China (Hu & Chen, 2015).

Through our research, a lasting legacy of transmigration policies was also identified. This theme emerged from the ethnographic observations, FGDs, archival research and SSIs. Local participants in both Abe Pantai and Koya Barat reflected on how transmigration policies have been ingrained in local communities’ understanding of the collective history and identity of their settlements. This was especially the case in Koya Barat, which was established as a transmigrant settlement. According to the FGD and SSIs in Koya Barat, the mixing of ethnic groups through the transmigration policy was seen to have a range of impacts on social cohesion within the settlement. On the one hand, this was manifested in the formation of a more mixed local community rather than the separated micro ethnic enclaves seen in Abe Pantai. Indeed, transmigration was espoused as a means of generating agricultural skills exchange and the formation of a national identity embodying Pancasila or a shared sense of community regardless of ethnic diversity (Hoey, 2003).

However, these policies have also been described as tools serving the implicit political aims of the ‘Javanisation’ of the outer islands of Indonesia (Elmhirst, 2000; Van Der Wijst, 1985). This involved transitioning from ‘state-led to neoliberal governance approaches to agricultural development’ often resulting in mono-culturing for gross domestic product as seen in the example of Suharto’s ‘rice economy’ (McCarthy & Cramb, 2009, p. 112). In a quest for increased productivity and intensification of agriculture, indigenous forms of agriculture and land
tenure were stigmatised as being marginal and backward practices only to be soon forgotten (McCarthy & Cramb, 2009). Yet, it is ironic that the national transmigration policy was also built upon what Elmhirst (1999, p. 813) describes as ‘environmental authoritarianism’—or environmental concerns over the activity of ‘illegal forest squatters’—given that the results of this article find rapidly increased logging and land-clearing as a result of the additional demand for land for agriculture and settlements for transmigration. Other forms of agricultural impacts on land and peri-urbanisation dynamics in Papua have been covered in the wider literature. For example, recent programs have also planned to allocate large areas of land in Papua for conversion to agricultural land for the purpose of providing food security (Indrawan et al., 2017). Studies have shown this is also likely to contribute to impacts on biodiversity and indigenous livelihoods (Indrawan et al., 2017).

The biophysical impacts of peri-urbanisation on environmental health systems were found across both Abe Pantai and Koya Barat. In Abe Pantai, coastal settlement growth has seen the expansion of agricultural land and the gaps between residential and agricultural areas narrowing. This has further resulted in increased land clearing. Similar patterns were seen in Koya Barat where increasing population from migration, transmigration and growing communities has not only increased demands for housing but has also led to the flourishing of small housing and construction industries in the settlement. The immediate anthropogenic impacts on the surrounding environment through the clearing of land have had broader consequences for the communities of both Abe Pantai and Koya Barat. These processes were first identified during an initial scoping process undertaken through satellite imagery and geospatial analysis. A deeper understanding of these local-level biophysical and social processes was sought through fieldwork and social data collection. The findings showed how in Abe Pantai, peri-urbanisation has resulted in increased paved areas and run-off. Furthermore, according to the FGD, observation and SSIs, many of the sewers and drainage areas have been closed off. This has correlated with increasing numbers of floods in the settlement. Similarly, Koya Barat, an area characterised by cleared inland floodplain terrain, is vulnerable to higher rates of run-off during intense rainfall events. The newly developed houses of the settlements along the outskirts where no adequate facilities for drainage or rubbish and waste management have yet been provided, are particularly susceptible. These paved areas are likely to experience greater rates of run-off, which often correlates to wider inundation and the formation of small flooded areas and puddles in the lower lying areas.

In both Abe Pantai and Koya Barat, some of the most common health problems have included upper respiratory tract infection, tropical malaria, diarrhoea and various skin conditions. All of these conditions can be linked to declining environmental health as a result of poor drainage infrastructure coupled with increased frequencies of inundation and flooding. Furthermore, these stagnant pools and flooded areas described in the FGDs and SSIs also serve as breeding grounds for mosquitoes and are likely to augment the virulence of mosquito borne diseases. Indeed, various strains of malaria were identified in the health data records of both Abe Pantai and Koya Barat as well as in data from the public health centre provided by BPS Abepura and Muara Tami Subdistricts (BPS, 2018a, 2018c).

The mutually reinforcing peri-urban processes of settlement expansion and land clearing are highlighted visually through the historical geospatial analysis. This analysis provides a birds-eye-vantage evidence base, with which to view the impacts of peri-urbanisation on both Abe Pantai and Koya Barat. As seen through comparing spatial records of these peri-urban spatial zones over time, it is clear that both Abe Pantai and Koya Barat have experienced
substantial land clearing and deforestation. Furthermore, both settlements have expanded rapidly over the past decade. Geospatial evidence of these processes can be used both as a preliminary method to identify peri-urban expansion and also as a secondary line of evidence to verify or counter community perspectives yielded through the FGDs and SSIs across both settlements.

Peri-urbanisation has been well documented in the core provinces of Indonesia: particularly within the megacities of Java. Results of past studies have shown some impacts of rapid peri-urban development which are comparable across these megacities: transitioning socio-economic structures from rural to urban activities, creation of new jobs and industries, and spatial segregation (Winarso et al., 2015). Reflecting on these findings from other peri-urbanisation impact assessment studies across Indonesia, this article sheds light on a unique set of case studies with disparate outcomes. The unique nature of Abe Pantai and Koya Barat may stem, in part, from their geographic nature as the peripheral urban spatial zones of the city of Port Numbay, which itself is also part of the periphery of the nation. Indeed, at a nationwide level, the province of Papua is considered one of the most remote and peripheral of all the 34 state demarcated provinces of Indonesia. However, this perceived notion of a peripheral nature is imposed upon Papua both in terms of its geographic isolation relative to the capital of Jakarta and in terms of the human development index ranking which ranks Papua lowest at 34. This ranking brands Papua, based on standardised criteria, as the ‘least developed’ province in Indonesia (BBC News, 2018; BPS, 2019a). As a result, any attempts to measure or conceptualise the conditions of structural inequality in contexts such as Papua must take into account the additional imposed layers of remoteness, inequality and stigma, which are different to the conditions faced in core provinces (Budiardjo & Liong, 1988).

The benefit of conducting this study in an often overlooked or ‘peripheral’ case study is that it makes a unique contribution to the discourse that has otherwise been dominated by attempts to, as Wolter (2014, p. 1) describes, ‘identify generic attributes of peri-urbanisation and the way in which development planning tends to reply’. Instead of following this well-established path through the literature, this article illustrates a multifaceted and interdisciplinary understanding of peri-urbanisation. This has included a study of the impacts common to many cases of peri-urbanisation such as the biophysical impacts on agricultural and environmental health systems. However, it has also identified how peri-urbanisation processes can be differently affected by local and contextual factors. In Abe Pantai and Koya Barat, these include the historical, social, political and economic context. These contextual factors have included how both Abe Pantai and Koya Barat constitute destination settlements for both transmigration and decentralisation programs each with their own complex political agendas. Furthermore, as described in the Abe Pantai FGD and SSIs, the formation of micro-enclaves composed of ethnic diverse groups from within Papua and outside of Papua has had a unique impact on the social identity of an area which traditionally had a much stronger sense of Melanesian indigenous identity (Narokobi, 1983).

This study finds that outcomes of peri-urbanisation in Port Numbay are unique to those identified throughout wider Indonesia and particularly in Java where most of the literature has been focused. Due to this heterogeneity it may not always be viable to conceptualise peri-urbanisation in peripheral cities such as Port Numbay using frameworks based on case studies from overseas or even from other parts of Indonesia. This is demonstrated through the disparate conditions seen in the core provinces of Java, which display conditions that differ from Papua: in terms of their contextual characteristics and their responses to peri-urbanisation. For
example, the results yielded from this article on Port Numbay may not always be compatible with generic conceptual frameworks such as the peri-urban typologies—predominantly urban, semi-urban and potentially urban—used in a study of Bandung (Budiyantini & Pratiwi, 2016). Instead, local social and economic conditions in Papua present a social, cultural and economic system which has had connections between land and communities shaped by different forms of tradition and social custom.

Furthermore, cases such as Abe Pantai and Koya Barat have more recently been exposed to unique dynamics including flows of people as destinations rather than as sources of transmigration. In Papua these movements of people have flowed into areas that have previously had low population densities. In contrast, processes of peri-urbanisation in Java have taken place in contexts which have long been sources of transmigration. The contexts of ‘mega-urbanisation’ in peri-urban Java as described by Firman (2007), and smaller-scale urbanisation in peri-urban Papua investigated in this article cannot be compared as analogous cases. Connections between anthropocentric and ecological systems, land use change and settlement expansion cannot be accurately generalised across the diverse archipelago. As a result, approaches to decentralisation, health service delivery and sustainable development interventions into peri-urban zones should take into account local conditions by recognising cases of peripheral provinces as unique to core provinces.

To better understand local contexts in peripheral contexts, the authors recommend three areas of further research: (1) subnational-level empirical and participatory socio-economic studies of the Gini income inequality as well as happiness indices in Papua (Ura et al., 2012); (2) empirical environmental health impact assessments of peri-urban areas in Papua considered most vulnerable to growing population, environmental degradation, flooding and the spread of disease; (3) additional participatory impact assessments drawing evidence from peripheral case studies particularly in the outer provinces of Indonesia as well as case studies from Melanesia and the South Pacific.

6 | CONCLUSION

This article provides insights into the historical, social, economic, agricultural and environmental health systems of peri-urban spatial zones in Port Numbay. The social impacts of peri-urbanisation processes in Abe Pantai and Koya Barat highlight the residual legacy of historical transmigration and decentralisation policies. Furthermore, both case studies show evidence of the biophysical processes of peri-urbanisation including the mutually reinforcing processes of expanding settlements and clearing of vegetated land. Evidence of this was provided through the FGDs, SSIs, archival research, ethnographic observations and geospatial analysis. The study highlights how each of these separate methods and lines of evidence can be combined for interdisciplinary socio-economic and environmental monitoring.

The article further finds that comparing evidence from Abe Pantai and Koya Barat with the cases documented within the wider literature yields mixed results. Impacts of peri-urbanisation which are biophysical in nature—affecting agricultural and environmental health systems—display greater similarity to those seen in other studies. Impacts of peri-urbanisation which are anthropocentric in nature—affecting social and economic systems—are more likely to be different to those seen in other studies. These anthropocentric impacts are more likely to be shaped by complex local historical and political settings. As a result, approaches to
decentralisation, health service delivery and sustainable development interventions in peri-urban zones should take into account local conditions by recognising cases of peripheral provinces as unique to core provinces.

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DATA AVAILABILITY STATEMENT
The data used in the analysis in this article is available from the corresponding author upon request.

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