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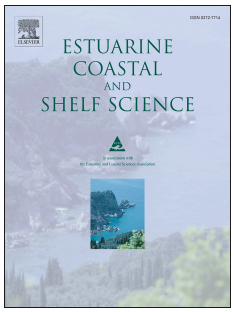

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Author CRediT Statement

Hattam, Then and Goh conceptualised the project and were responsible for funding acquisition. Project administration was led by Goh (Malaysia) and Hattam (UK) with support from Ruslan and Yap. All authors contributed to the investigation. Edwards-Jones led the data curation and analysis with input from all other authors. While Hattam led the development of the paper, all authors contributed to the writing of the original draft and reviewing and editing.

Using nexus thinking to identify opportunities for mangrove management in the Klang Islands, Malaysia

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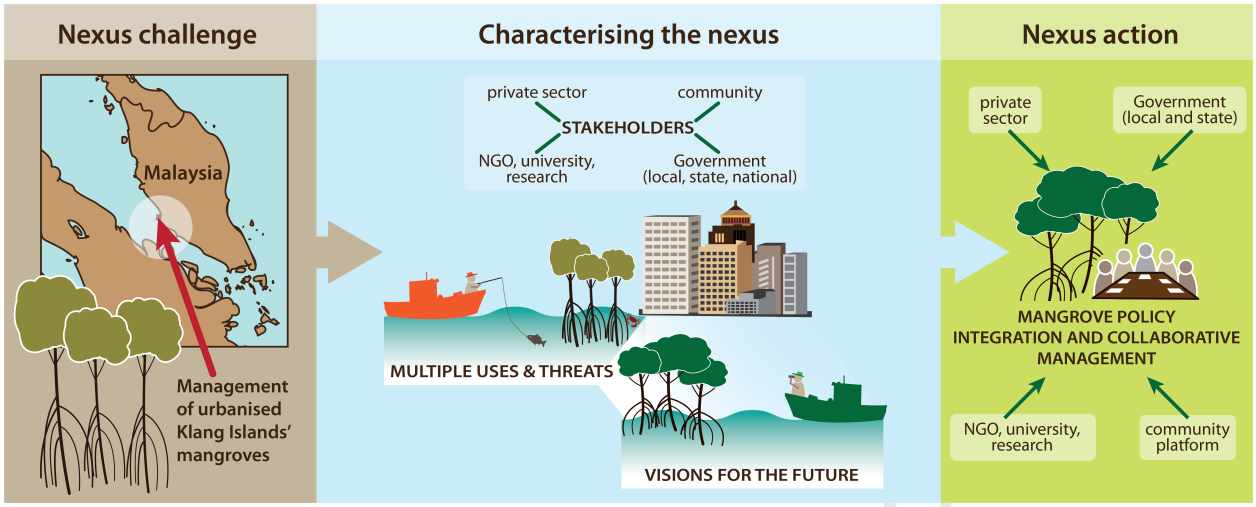
Abstract

Despite wide recognition of the multiple ecosystem services provided by mangroves, they continue to experience decline and degradation especially in the face of urbanization. Given the interplay between multiple resources and stakeholders in the fate of mangroves, mangrove management can be framed as a nexus challenge and nexus thinking used to identify potential solutions. Using the Klang Islands, Malaysia, as a case study site, this paper characterizes the mangrove nexus and stakeholders visions for the future to identify potential options for future management. Through a series of stakeholder workshops and focus group discussions conducted over two years results show that local communities can identify benefits from mangroves beyond the provisioning of goods and significant impacts to their lives from mangrove loss. While better protected and managed mangroves remained a central part of participants' visions for the islands, participants foresaw a limited future for fishing around the islands, preferring instead alternative livelihood opportunities such as eco-tourism. The network of influencers of the Klang Islands' mangroves extends far beyond the local communities and many of these actors were part of the visions put forward. Stakeholders with a high interest in the mangroves typically have a low influence over their management and many high influence stakeholders (e.g. private sector actors) were missing from the engagement. Future nexus action should focus on integrating stakeholders and include deliberate and concerted engagement with high influence stakeholders while at the same time ensuring a platform for high interest/low influence groups. Fortifying existing plans to include mangroves more explicitly will also be essential.

Lessons learnt from this study are highly relevant for coastal mangrove systems elsewhere in the Southeast Asian region.

Keywords: nexus action, stakeholder, community, private sector, integration, policy



Using nexus thinking to identify opportunities for mangrove management in the Klang Islands, Malaysia

1. Introduction

The importance of mangroves to society is well established (Brander et al. 2012), but despite growing levels of protection, the presence of comprehensive coastal zone management plans, and forestry legislation, degradation of these natural resources has continued around the world, and particularly in SE Asia (Friess et al. 2019). As found for other resources such as water, food and energy, siloed resource protection and simply raising awareness of resource importance appears insufficient to prevent their decline. To further their protection and management, there is a need to recognise how scientific facts interplay with other considerations such as individual and societal values, political motivations, wider economic interests and stakeholder interactions (Rose 2014). Trade-offs between sectors and resources need to be managed in a more integrated manner (Simpson and Jewitt, 2019a) to avoid shifting problems from one sector or resource to another (Halbe et al. 2015), such as the impacts of mangrove loss on fisheries and land uses.

One approach for the exploration of such integrated management and for rethinking sustainability is that of nexus thinking (Yumkella and Yillia 2015). Although no agreed definition exists of what constitutes the nexus approach (Allouche et al. 2019, Smajgl et al. 2016), it is widely considered to be a lens through which interdependent natural resource problems, and the trade-offs and feedbacks between them, can be viewed in a holistic manner (Hoff 2011). It emphasises the need for integrated approaches to deal with complex sustainability challenges at the intersection between natural and human systems, which can improve environmental, climate, human and political security (Hoff et al. 2019). Although nexus thinking has primarily focused on the water-energy-food nexus (Simpson and Jewitt 2019b), various nexuses exist at multiple scales (Groenfeldt 2010), and nexus challenges are everywhere (Reynolds and Cranston 2014).

Recognising the interrelationships between nexus components and integrating their management is anticipated to support the development of a green economy (Allouche et al. 2019), enable system actors to move towards a net positive impact on the environment (Reynolds and Cranston 2014), and contribute to the attainment of the UN Sustainable Development Goals (Benson et al. 2015). Effective nexus governance is therefore crucial in addition to understanding the physical connections between nexus resources (White et al. 2017). Nexus governance requires awareness of the mechanisms that influence decision-making and the motivations and visions of the different multi-level stakeholders who engage with the nexus (Hoolohan et al. 2018).

The nexus approach, however, has been criticised for its lack of practical application (Smajgl et al. 2016; Simspon and Jewitt 2019) and its limited recognition of issues of social justice

(Allouche et al, 2019). This is despite acknowledgement that the poor and disenfranchised need to be a focus of the nexus approach (Leese and Meisch 2015) as their inclusion in resource management has been demonstrated to reduce conflicts and result in better managed natural resources (Damastuti and de Groot 2017; Yang and Pomeroy 2017). It has led to calls for the use of transdisciplinary methods in nexus studies in which stakeholders from all levels (local to international) are included in nexus discussions to facilitate shared understanding and aid the design of potential solutions (Hoolohan et al. 2018). At local scales, this indicates the inclusion of communities and small-scale resource users alongside governmental and private sector stakeholders (Bielicki et al. 2019).

This paper explores the use of a nexus approach to mangrove management in Malaysia, using the Klang Islands in the state of Selangor as a case study. Given that the future of mangroves is dependent upon decisions taken on the use of other natural resources, such as water, land and marine resources, as well as the mangrove resources themselves, the management of mangroves can be framed as a nexus challenge and nexus thinking used to identify potential solutions. Recognised for its ability to change policy debates (Al-Saidi and Elagib, 2017), nexus thinking may be particularly insightful in the Malaysian context where existing approaches to mangrove management have resulted in continued mangrove loss (Friess et al. 2019). The Klang Islands form a microcosm for the application of this approach, and provide an accessible illustration of complex stakeholder interactions, as well as the trade-offs between rural and urban development, modern and traditional lifestyles and livelihoods, as well as experiencing on-going mangrove decline.

To initiate the application of nexus thinking, the nexus components first need to be identified, as well as how these components are institutionally linked (White et al. 2017). This paper therefore focuses specifically on 1) Who are the multi-level actors who interact with the mangroves of the Klang islands? 2) How do these actors interact with the mangroves? 3) What are the stakeholders' visions for the future of their mangroves and associated fishery resources? and 4) What does this mean for future mangrove management? Evidence is gathered through participatory stakeholder engagement, recognising that learning from different knowledge sources is important for sustainable management (Weible et al 2010). Lessons learnt may guide future nexus action in the Klang Islands, and are expected to be highly relevant across similar urban mangrove systems in Malaysia and Southeast Asia.

2. Method

2.1 Context

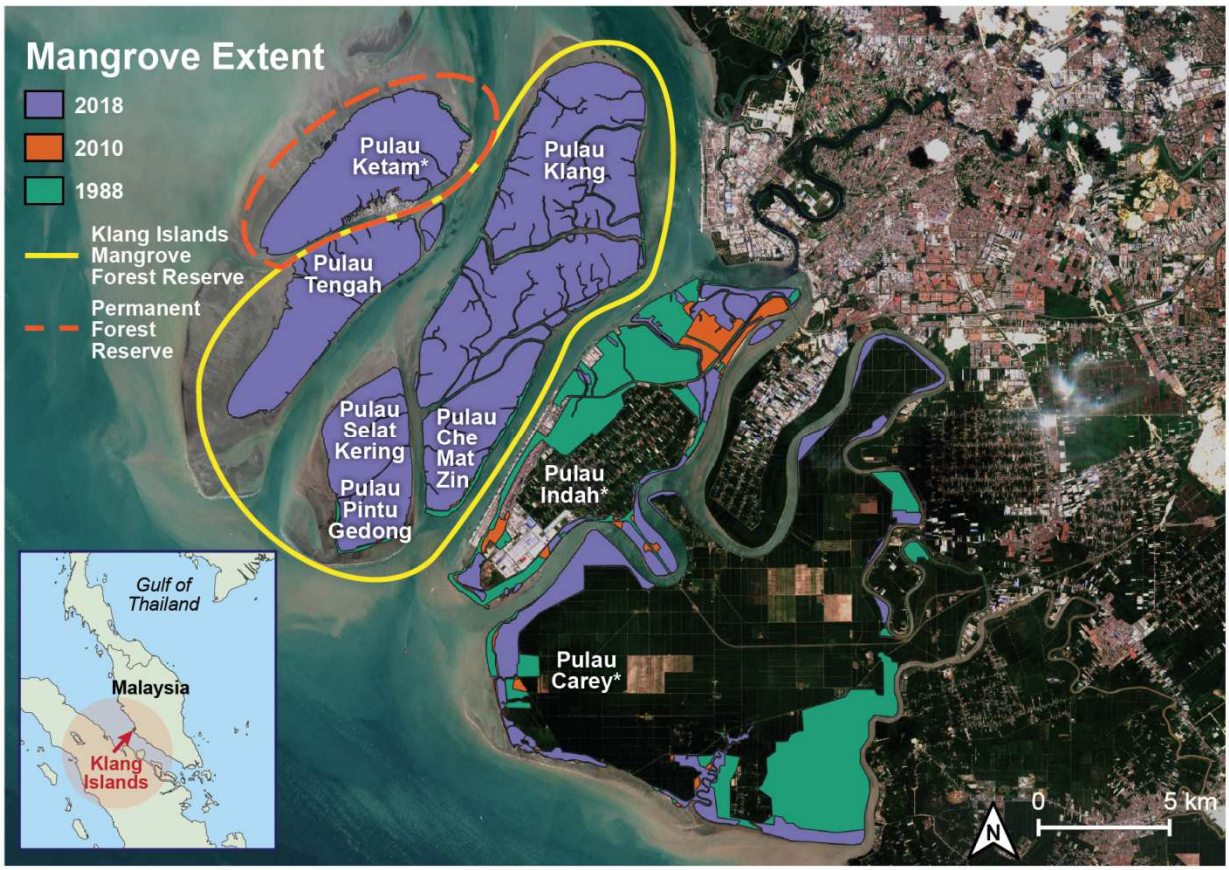
In Malaysia, decision-making for natural resources such as forests and fisheries is typically top-down, centralised and compartmentalised as set in the Ninth Schedule of the Legislative List in the Constitution of Malaysia 1957. Communication and co-ordination between departments and tiers of government is limited (Amir 2018). Consequently, mangrove management is fragmented and poorly integrated with land-use policy directions (Asmawi et al. 2012; Friess et

al. 2016; Amir 2018). Furthermore, fisheries- and mangrove-dependent communities typically have limited involvement in management (Suhaili 2012), despite calls for increased engagement and recognition of the importance of knowledge-based traditional and informal management systems (Friess et al. 2016).

This, coupled with Malaysia's drive for economic development, has resulted in continued decline of natural resources (Mokthsim and Salleh, 2014). Malaysia is the third largest mangrove-holding nation globally with the second highest annual rate of deforestation (Hamilton and Casey 2016; Friess et al. 2019). Approximately 1165km^2 were lost between 1975 and 2000 (FAO 2003) and a further 278km^2 between 2000 and 2014 (Hamilton and Casey 2016). Urban development (industrial, infrastructure and housing) accounted for about 60-70% of the loss, while aquaculture and agriculture uses and coastal erosion accounts for the remaining loss (Khali Aziz et al. 2009; Hamdan et al. 2012). The impacts of mangrove loss are particularly felt by dependent coastal fishers, who are also the poorest group of Malaysian society (Solaymani and Kari 2014).

2.2 Klang Islands case study

The Klang Islands comprise eight major mangrove islands (known locally as *pulau*), three of which are inhabited and local livelihoods have traditionally been fisheries-linked. The islands are located in the Straits of Malacca, approximately 50km to the southwest of the Malaysian capital Kuala Lumpur (Figure 1). In 2018, the mangroves of the Klang Islands covered approximately 15,064 ha (Varga et al. 2019). Seven of the islands fall within the jurisdiction of the Klang Municipal Council, while the eighth (Pulau Carey) sits under Kuala Langat Municipal Council. The three inhabited islands (Pulau Carey, Pulau Indah and Pulau Ketam) are the focus of this study (Table 1) although recommendations emerge for the islands as a whole. The five uninhabited islands, Pulau Klang, Pulau Pintu Gedong, Pulau Che Mat Zin, Pulau Selat Kering and Pulau Tengah, have been gazetted as the Klang Islands Mangrove Forest Reserve (KIMFR) since 1904 (Norhayati et al. 2009). The mangroves of P. Carey have faced a long history of clearance, first to make way for rubber plantations, but latterly for oil palm (Lai 2011). On P. Indah, following the allocation of concessions to a land developer, the island has seen ongoing mangrove clearance since the 1990s to enable industrial and port development (which includes both container and cruise terminals). In 2009 the Selangor Department of Forestry gazetted P. Ketam as a Permanent Forest Reserve, terminating all licenses for mangrove wood production.



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108 **Figure 1: The Klang Islands, demonstrating the change in mangrove extent between 1988 and**
109 **2018 using Landsat 5, 7 and 8 and Sentinel satellite imagery. Purple areas indicate mangrove**
110 **extent in 2018 (15,064 ha), orange areas show the original mangrove extent in 2010 and**
111 **green the original mangrove extent in 1988. * denotes inhabited islands. Modified from Varga**
112 **et al. (2019).**

113 **Table 1: Characterisation of the three inhabited islands * Source: Varga et al. (2019) ** author**
114 **observations.**

Island	P. Carey	P. Indah	P. Ketam
Mangrove area (2018)*	1,514 ha	934 ha	2248 ha
Change in mangrove extent 1988 – 2018*	-2,288 ha (-60.2%)	-2,216 ha (-70.3%)	+172 ha (+8.3%)
Ethnicities**	Malay, Indian and Mah Meri (indigenous people)	Majority Malay with some Mah Meri	Majority Chinese with some Mah Meri
Main livelihood sources**	Oil palm plantations, some fishing, limited tourism	Port, light industry, commercial centre, some fishing	Fishing, fish cage aquaculture and seafood tourism

2.3 Data collection

Data collection was undertaken through two one-day workshops and six focus groups (Table 2). Group approaches were used to encourage exchange of opinions and exposure to different ideas, as well as to allow individuals who rarely meet to interact. The workshops focused on institutional stakeholders, while the focus groups targeted local communities to ensure a platform for their voices. Careful facilitation helped to reduce dominant voices. Taking inspiration from the NetMap method (Schiffer and Hauck, 2010), workshop 1 focused on characterising the mangrove nexus in terms of identifying who is part of the nexus and how they interact with it. Workshop 1 involved a series of group and plenary activities in which conceptual maps were created depicting the mangrove and mangrove-fishery ecological and stakeholder system. Workshop 2 was used to explore participant's visions for the future of the Klang Islands mangroves using visioning techniques (DFID 2003). Participants were given maps of the Klang Islands to annotate and were encouraged to imagine that they had the power and authority to implement their visions. In both workshops, breakout groups were self-selected, but if more than one person represented the same organisation, they were asked to move groups. Participants were also encouraged to change groups in subsequent group activities.

To ensure that community voices were heard and not overshadowed by more influential participants, six community focus group discussions were held, three on P. Carey, two on P. Indah and one on P. Ketam. Focus groups comprised five or six community members of different ages, genders (where possible) and connection to the mangroves, each lasting approximately 2.5 hours. Participants were asked to discuss the current use and management of the mangroves and then, in a similar way to the visioning workshop, to describe their future visions for the mangroves on their island.

In both workshops and focus groups, participants were briefed about the purpose of the activity and their rights. Written consent was obtained from workshop participants, while verbal consent was obtained during focus group discussions in light of issues around literacy. Ethical approval for this research was granted by the University of Malaya Research Ethics Committee (Ref: UM.TNC2/UMREC-214) and the University of Plymouth Faculty of Health and Human Sciences Research Ethics and Integrity Committee (Ref: 17/18-869).

2.4 Participant selection

Invitees to workshop 1 were identified through literature review and recommendations by project partners and stakeholders involved in mangrove and fisheries management on the Klang Islands. The outputs from workshop 1 were used to identify organisations to invite to the second workshop as well as inform a wider project communication strategy. Priority stakeholders for workshop 2 were considered to be those who attended workshop 1; stakeholders who directly interact with the mangroves as well as those who threaten the mangroves; and indirect stakeholders with a policy interest in mangroves (local and state).

While participants to workshop 1 were invited to workshop 2, only two participated in both workshops. Appendix A, Table A1 provides the full list of invitees and participants.

Focus group participants were recruited via village heads, who also gave permission for the focus group discussions to take place. To promote inclusivity, no limit on participant numbers or other criteria were stipulated although village heads were asked to invite a range of different participants in terms of age, gender and relationship with the mangroves. Food was served to encourage participation, especially of women with children.

Table 2: Workshop and focus group objectives and attendees

Workshop / focus group	Research objectives	Workshop themes	Attendees
Workshop 1 (14th June 2017, Klang)	1. Who are the multi-level actors who interact with the mangroves and fishery? 2. How do these actors interact with the mangroves?	1. Who uses, and benefits from, the Klang Island mangroves? (Distinguish direct or indirect). 2. What benefits do mangroves provide each stakeholder? 3. What are the current threats to the mangroves of the Klang Islands? How are these being driven? 4. Who influences/impacts the mangroves? 5. Who is missing from today and how can all relevant stakeholders be brought together to support better mangrove management?	Nine representatives (3 women, 6 men) from: • The local fishermen's associations • The state fisheries development authority • The municipal council • The district forest office • The Port Klang Authority • An international environmental NGO
Workshop 2 (23rd January 2018, Klang)	1. What are the stakeholders' visions for the future of their mangroves and associated fishery resources? 2. What does this mean for future mangrove and mangrove-fishery management?	1. How are mangroves and mangrove-dependent fisheries currently managed and have been managed in the past? 2. Describe how you envision the mangroves and mangrove-fishery to be like in the future (20-30 yrs). 3. How achievable are these visions, given the current mangrove situation in the Klang Islands? 4. What can be done to make these visions achievable? 5. How can stakeholders collaborate to achieve these visions?	17 representatives (3 women, 13 men) from: • The local fishermen's associations • The heads of four villages • The state and district fisheries authorities • Forest and hydraulic research institutions • Department of Irrigation and Drainage, • An international environmental NGO
Focus groups (April and May 2018, P. Indah, P. Carey and P. Ketam)	1. How do these actors interact with the mangroves? 2. What are the stakeholders' visions for the future of their mangroves and associated fishery resources?	1. How are mangroves and mangrove-dependent fisheries currently managed and been managed in the past? 2. Describe how you envision the mangroves and mangrove-fishery to be like in the future (20-30 yrs) 3. How achievable are these visions, given the current mangrove situation in the Klang Islands? 4. What can be done to make these visions achievable? 5. How can stakeholders collaborate to achieve these visions?	16 villagers from P. Indah (all male) 26 villagers from P. Carey (10 female and 16 male) 8 villagers from P. Ketam (all male)

2.5 Data analysis

The main output from workshop 1 was a series of lists and network diagrams illustrating the benefits from, threats to and users of the Klang Islands' mangroves. All exercises were digitally recorded and a summary report produced describing the state of the Klang Islands mangrove-fishery system. Benefits were broadly categorised according to high-level ecosystem service groupings following the Millennium Ecosystem Assessment classification (MA 2003). Stakeholders identified were grouped according to location (local, state and national or international) and whether they could be considered direct or indirect (following Grimble and Chan 1995). Direct stakeholders refer to both the local and non-local stakeholders who access and use mangroves and their resources on a regular basis, such as local communities and fishers. Indirect stakeholders are considered those who do not directly utilise the mangroves, but whose activities impact upon them (e.g. land developers) or whose decisions or actions may influence the behaviour of those who directly use the mangroves (e.g. local and municipal bodies as well as state, federal and international agencies and organisations).

Workshop 2 and the subsequent focus groups were digitally recorded and fully transcribed. Using Nvivo 12 Qualitative Data Analysis Software (QSR International Pty Ltd., 2018), descriptive coding was undertaken of the summary presentations of the key features of the envisioning exercise for each breakout group. This included the group's common vision for the future, enabling factors and barriers to the vision. Inter-group synthesis was used to create a common vision statement that was validated by checking back through the original recorded conversations to ensure that it accurately reflected the key priorities raised by the stakeholders.

The less structured nature of the focus group conversations favoured a general inductive approach to analysis. Data from each focus group were used to generate summaries for each island and principle themes underpinning the visions were identified. These themes were validated by cross-referencing to the original recorded conversations.

Information gathered from workshop 2 and the focus groups was also combined with the outputs of workshop 1, relevant secondary data (e.g. policy documents) and expert opinion to support further stakeholder analysis through the creation of an interest-influence matrix (Reed et al. 2009). A description of the stakeholder group, their reported interest in the Klang Islands' mangroves and their level of influence over the status of the mangroves were first described. Their interest and influence were then ranked by the project team on a scale of one (low) to three (high) to enable the different stakeholders to be plotted in an interest-influence matrix. The organisations represented by workshop participants were characterised through this matrix and used to support the interpretation of the stakeholder visions.

2.6 Positionality

The interaction between the researcher and the researched introduces a power and privilege dynamic that may influence the outputs of an engagement process, particularly in the form of confirmation bias. While this may have influenced our findings, efforts were made to reduce its impact by emphasising the role of the engagement as a platform for participant voices rather than those of the researchers, by careful facilitation of discussions to avoid leading their direction, and by engaging with community leaders before holding workshops. Although Village Heads were asked to invite a range of people to the focus groups, this method of participant identification did lead to a dominance of male voices. We recognise this as a limitation to our work and the need for further engagement with women to advance the outputs of this research. The research team itself was of mixed gender and ethnicity. The Malay researchers led the delivery of the workshops and focus groups. The language of both workshops and five of the focus groups was Malay; the sixth was held in Chinese. The British researchers were only present as observers during the workshops and one of the focus groups, in part as a result of language restrictions. To facilitate understanding by all research team members, informal, summary translations were undertaken during the workshop and all the workshop and focus group transcripts were translated into English.

3. Results

3.1 Klang Islands' mangrove stakeholders and their mangrove-related interactions

As in many nexuses, the Klang Island's mangrove system involves a diverse range of stakeholders. The stakeholder mapping exercise from Workshop 1 identified 53 stakeholder groups with some level of direct or indirect interest over the Klang Islands mangroves (Appendix A, Figure A1). Given the diversity of activities that are undertaken in the Klang Islands and the proximity of the islands to major industrial and administrative centres (Table 1), this complexity is not unanticipated. The links between direct stakeholder groups identified in workshop 1 and the mangroves and their associated resources are illustrated in Appendix A, Table A2. The full range of ecosystem services (provisioning, regulating and cultural) provided by mangroves were identified by workshop 1 participants. In one break-out group, this was driven by an NGO participant who was well versed in the concept of ecosystem services. In the group with no such expert, benefits from the mangroves focused more on provisioning and cultural services, with less emphasis on regulating services.

Direct stakeholders include local communities and fishers, who workshop participants disaggregated according to ethnicity (Malay, Chinese and Mah Meri) in recognition of the different ways through which they interact with the mangroves (Appendix A, Figure A1). For example, the use of non-timber forest products was primarily associated with the Mah Meri indigenous community, in particular for mask making and leaf origami, but even this use was considered limited due to the small number of people continuing with these traditions. Individuals and groups with responsibility for local-level decision-making (e.g. village heads, Tok Batin (heads of Mah Meri villages) and local fishers associations), were also included as direct stakeholders, alongside private sector businesses located on the islands. Mangrove related

private sector activities range from tourism (e.g. local seafood restaurants) to mangrove replanting (e.g. through Corporate Social Responsibility activities). The major port operator was singled out for specific attention, given the scale of impact of the port development on the mangroves, as well as the result of ship wake from increased shipping traffic and ship size.

A small number of non-local stakeholders were included in the direct stakeholders group as their activities impact directly upon the mangroves and their associated resources. Examples included land developers and plantation owners who have been responsible for mangrove clearance, but also individuals responsible for illegal logging, pollution, and expansion of aquaculture and agriculture activities.

Indirect mangrove stakeholders are more diverse. They range from government departments (state and local) who can introduce legislation and management actions that impact the mangroves and fishery (e.g. Local government which has the responsibility for land-use zoning at the district level), to environmental NGOs and universities with research or outreach interests in mangroves, and those with more coincidental interactions with mangroves (e.g. Immigration Department, national and international tourism organisations). Many of these indirect stakeholders are not physically located in the Klang Islands.

The interest-influence matrix (Figure 2; Appendix A, Figure A2 and Appendix B) provides further insights into this stakeholder landscape. It reveals that many of the direct stakeholders, and particularly the island communities, despite their high interest in the mangroves, have little influence over the decisions and activities that impact on mangroves. In contrast, the direct stakeholders who are responsible for mangrove loss (e.g. land developers and plantation owners) have a low interest but high influence over the mangroves. Stakeholders deemed to have higher interest and high influence on mangroves included institutions with a clear forestry remit (Department of Forestry, FRIM) as well as local and state agencies whose planning responsibilities and decisions have a direct impact on local land use. The Selangor State Department was recognised as having a particularly high influence but low interest in mangroves. This reflects its ability to determine land-use and development applications, potentially overriding decisions made by local government. According to workshop participants, it often favours economic, rather than environmental, priorities.

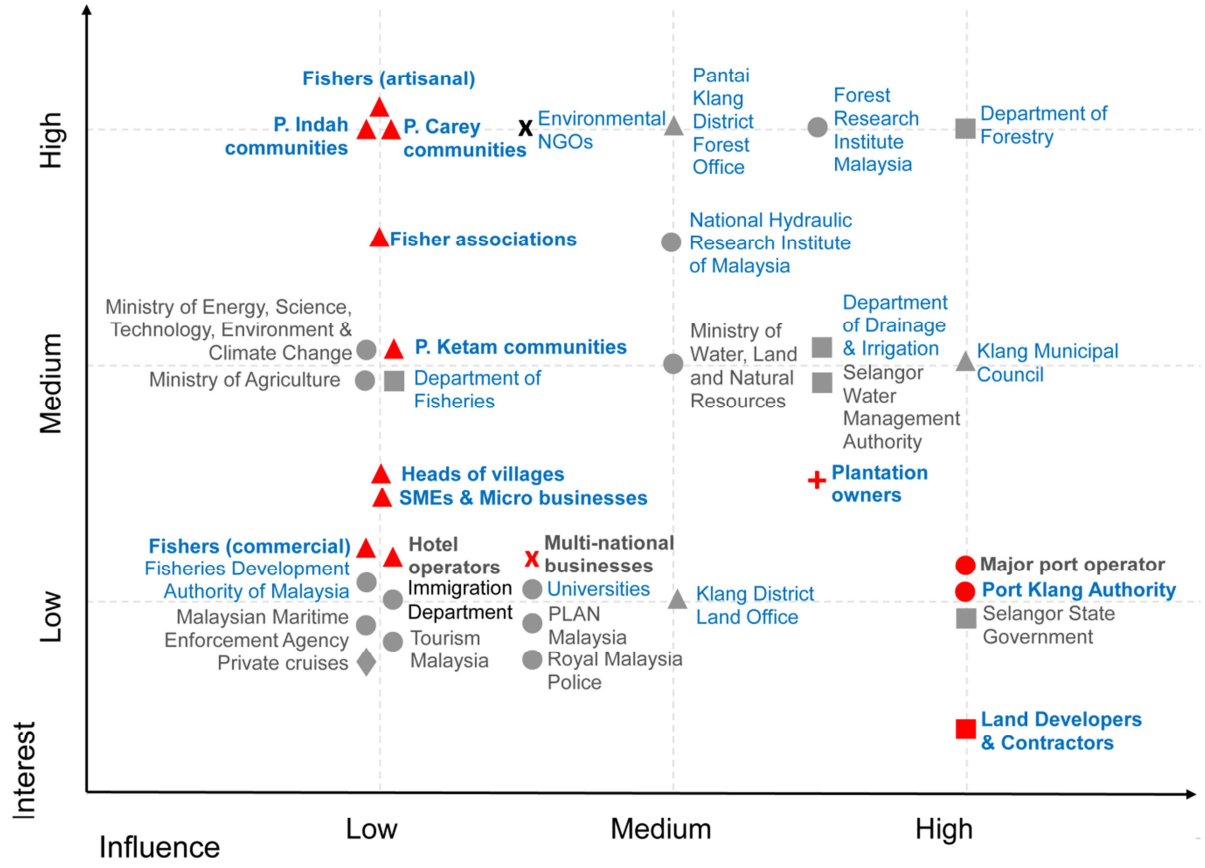

Figure 2: Interest-influence matrix of select stakeholders in the Klang Islands. Symbols indicate user levels: local - triangle, local/ national - plus (+), state - square, national - circle, national/ international - 'x', international – diamond. Colours indicate user types: direct users – red; indirect users – dark grey. Stakeholders highlighted in blue were represented by participants in the workshops and focus group discussions. Abbreviations: P. – Pulau; SMEs - Small-medium enterprises; NGOs – Non-governmental organizations.

3.2 Visions for the future of the Klang Islands' mangrove resources

Workshop 2 participants comprised representatives of stakeholder groups with high interest in the Klang Islands mangroves, but mostly low or medium influence over them. Only participants from FRIM (Forest Research Institute Malaysia) could be considered to represent a high influence stakeholder. These participants were, however, a mixture of direct and indirect stakeholders with six out of the 16 present being Heads of villages or members of fishers associations with direct experience of mangrove change. Focus group participants constituted coastal community members from the three inhabited Klang Islands, all direct stakeholders, with medium or high interest but low influence.

There was considerable commonality in terms of the main themes emerging from workshop 2 and the community focus groups (Table 3) with the sustainability of mangroves, fishers'

livelihoods and alternative livelihoods dominating. Differences focused on the detail of these themes.

Table 3: Key elements of visions put forward by workshop 2 and focus group (FG) participants

Vision element	Activity			
	Workshop 2	**P. Carey FG**	**P. Indah FG**	**P. Ketam FG**
Sustainability of mangroves	• Conservation area around all islands • Mangrove and nipa plantation to south of P. Carey for ecosystem services and marketable wood • Sea defence role particularly important • Illegal activities better controlled (logging, trawling and sand dredging) • Coastal bunds and artificial reefs to support mangrove replanting • Oil traps to reduce pollution	• Mangrove loss due to fate and poor soil conditions. • Nothing can be done, mangroves all gone within two generations • Want more mangroves to support fishing and to act as a sea defence • Seaward protection for the mangroves would be needed to protect seedlings from waves	• Mangroves must be replanted and potential sites identified • Replanted mangroves oxygenating the waters allowing fish to breed again • Developers instructed to replant mangroves before new developments built • School children learning about mangroves and fishery and able to access the mangrove directly • Developments organised to reduce unnecessary mangrove clearance • Mangroves to act as a buffer around developments • Ships banned from areas near replanted mangroves to avoid oils spills and toxic waste	• Mangroves self-replenish and preserve the status quo • No concern about future of mangroves

Sustainability of fishers' livelihoods	• Restoration of mangroves will support fishery • Ban trawling from inshore waters • Strengthen enforcement of management measures	• Regulation of size of shellfish for harvesting • Want to continue fishing but think end of fishing is in sight • Future port development beyond community control	• Future uncertain due to impact of loss of mangroves • Illegal fishing controlled	• Mangrove fishery link not significant • No concern about future of fisheries, price will remain high even if catch is lower • Aging population and young not encouraged to fish • Sand dredging around Indah will impact fishery
Alternative livelihoods	• Ecotourism development focused on the conservation area (for national and international visitors) • Visitor centre and recreational centre • Preservation of local indigenous culture (Mah Meri) particularly through tourism • Oil palms can remain on P. Carey as important cash generator until long-term replacement by more sustainable mangroves	• Aquaculture ponds for prawn, crab and seabass • Fertigation system for vegetable production in polybags • Little appetite for wider tourism development • Mah Meri cultural village continues to offer tourism experiences	• Current aquaculture practices improved if mangroves and water quality restored • New aquaculture practices introduced (fish cages) • Development of ecotourism especially through access to cruise ship tourists • Capacity building for local communities to support tourism and hospitality activities	• None considered necessary, aquaculture and seafood tourism already in place
Other		• Little motivation to continue wood carving as skills lost and increased difficulty in finding raw materials	• Decisions made on future of islands reflect community views	• Litter problem is addressed

All three breakout groups from workshop 2 produced similar visions for the whole of the Klang Islands. They envisioned a state designated protected mangrove conservation area focusing on the existing permanent forest reserve and supporting an ecotourism sector, of particular benefit to local communities. This would be accompanied by a replanted productive forest (including nipa palm) drawing on good practice from the Matang Mangrove Forest plantation (Ibrahim et al. 2015). Like the Matang forest, participants considered that it would support sustainable wood production for pilling and charcoal production, managed in rotation. A continued role for oil palms was envisaged until newly planted mangroves had matured. Better protection and expansion of the mangroves was anticipated to deliver a multitude of ecosystem services, especially coastal protection, as well as increase the resilience of the islands to long-term threats such as sea level rise. Fishing activities were not part of these visions beyond recognition that mangrove restoration would support commercially important fish and shellfish populations.

Focus group participants from P. Indah and P. Carey had similar aspirations with most participants wanting an increase in mangrove extent particularly for coastal protection purposes. This was supported by local knowledge, particularly on P. Indah, of potential re-planting locations as well as areas considered unsuitable for planting. As participants from P. Ketam had not witnessed a reduction in mangrove extent (as confirmed by satellite data; Figure 1), they did not share a vision for better mangrove management, stating that mangroves naturally regenerate.

P. Indah and P. Carey participants identified a clear connection between the fate of mangroves and fisheries. Nevertheless, they saw a limited future in fishing driven by existing mangrove decline coupled with expanded port and shipping activities (including a possible new port development on P. Carey). Participants from P. Ketam were less concerned about the current state of their mangroves and fishery. They engage in more offshore fishing and saw no strong connection between their fishery and mangroves. The did envisage an increase in fish prices due to growing demand but were more worried by out migration of young people from P. Ketam and lack of interest in traditional livelihoods.

P. Indah participants shared the vision of workshop participants for ecotourism, considering the role of resources to which they already have access such as boats to provide island tours, the aesthetic appeal of the islands, access to cruise ship customers. Participants from P. Ketam and P. Carey were more reticent. Despite P. Ketam's reputation as a seafood tourist destination, tourism did not form part of their vision, with participants anticipating that tourism development would be initiated by outsiders. Similarly on P. Carey, participants' envisioned continuing dependence upon the mangroves and its fishery, with the exception of the Mah Meri village where cultural tourism is already promoted.

Aquaculture was not part of the stakeholder workshop visions, beyond recognising a role for eco-friendly aquaculture practices. It did, however, form part of the visions of P. Indah and P. Carey participants. The former viewed aquaculture as an alternative income source, while the latter saw it as a way to mitigate further fisheries decline. Despite the existence of some fish cages around P. Ketam, it did not form part of focus group participants' visions. P. Ketam participants felt there was no incentive for further aquaculture development.

Some P. Carey participants also expressed an interest in vegetable production in polybags. They envisaged this to be a sustainable alternative to fishing with minimal land requirement. While P. Carey participants indicated their preferred livelihood would be as fishers, if not possible, they expressed a strong preference for working on the island rather than on the mainland as, for example, labourers. Other alternatives, such as charcoal production, were not discussed by focus group participants, perhaps reflecting the long-term absence of this industry on the islands.

3.3. Stakeholder interactions with visions

Participants from the workshops and focus groups highlighted that the main challenges to these visions came from a range of negatively impacting activities, some involving low interest, high influence private sector actors. Such activities include sand dredging resulting in coastal erosion (some of which workshop participants thought was illegal); illegal logging impacting mangrove quality (especially on the uninhabited islands); illegal inshore trawling for trash fish for aquaculture feed impacting fish populations; further port development leading to mangrove loss; and pollution from shipping reducing the water quality around the islands. Focus group participants particularly acknowledged the need to improve the general health of the waters around the islands. They were also concerned with the capital costs needed to set up alternative livelihoods such as aquaculture and where this would come from.

An associated challenge identified by all participants was the lack of both interest and influence of actors charged with enforcement responsibilities to address the activities listed above. These failures were exemplified by insufficient monitoring and the non-enforcement of bans. Municipal and district authorities were accused of ignoring and/or being unable to enforce laws that might protect mangroves.

To overcome these challenges, it was recognised by all participants that education, awareness raising and training would be essential to the long-term sustainability of mangroves on the islands, and the realisation of the visions. Workshop participants also envisaged a redefinition and integration of the roles of primarily government and private sector stakeholders. Government actors considered necessary to the better management of mangroves included the state Departments of Forestry, Fisheries, Irrigation and Drainage, the Selangor Water Management Authority (LUAS), Klang Municipal Council, Klang District Land Office as well as relevant enforcement agencies such as the Malaysian Maritime Enforcement Agency (MMEA) and the Royal Malaysia Police (PDRM). With the exception of the Departments of Forestry and

Fisheries, all of these stakeholders are found to be of medium or high influence, but low interest (Figure 2). Port authorities, land developers, plantation owners and Tourism Malaysia were identified as important private sector actors. These private sectors actors have low interest and, with the exception of Tourism Malaysia, a medium or high influence. Little empowerment was envisioned for local communities, beyond a role in mangrove monitoring and being beneficiaries of alternative livelihoods

Despite the level of interest in mangroves of some island communities, none of the focus group participants saw communities at the forefront of management of mangroves or their related fisheries. Focus group participants from P. Indah and P. Carey felt it was the responsibility of the Department of Fisheries to take care of the fishermen and their welfare. It was felt that any movement into alternative livelihoods (e.g. aquaculture, agriculture and eco-tourism) would require support, both capital and technical, from for example, the Department of Fisheries, the Department of Agriculture or relevant tourism bodies. The general sense of resignation reported by some focus group participants from P. Carey perhaps reflects their low influence status and lack of empowerment.

4. Discussion: implications for future mangrove management

This paper aimed to characterise the mangrove nexus of the Klang islands (in terms of resource use and stakeholders) as well as understand stakeholders' visions for the future with a view to supporting mangrove management. It has identified that mangrove conservation is a priority for those who participated within this study, with all participating stakeholders able to identify ecosystem services from mangroves that go beyond the provisioning of goods. Participants also recognised the impacts of mangrove loss, with a particular acknowledgement of the role of mangroves in coastal protection. The network of Klang Islands' stakeholders identified by participants as relevant to the mangroves and fishery extends far beyond the local communities and includes influential private sector actors who currently play little role in mangrove management. Many non-community actors were acknowledged as important to the realisation of the visions, but they do not necessarily have the interest or influence to support their implementation. Community members, while interested in mangrove management, did not view themselves as the leaders of these initiatives. The findings from this study are therefore discussed in the light of these observations.

4.1 Klang Islands stakeholders, their interests and influence

The stakeholder landscape of the Klang Islands' mangroves was identified by study participants to be structurally complex with a multitude of competing interests. Understanding this landscape and its boundaries is important because it is within these boundaries that policies and plans will be developed and implemented (Liu et al. 2018). The imbalance in interests and influence among stakeholders is reflected in mangrove management. Mangroves have received low priority, a limited future is seen for small-scale mangrove-fisheries, but the land beneath the mangroves is highly valued for economic development purposes. As a nexus approach aims

to move towards a multi-centric situation in which all sectors are equal (Benson et al. 2015), one challenge is how to ensure that this complex stakeholder landscape acts collaboratively to redress the balance and effectively govern mangroves and the resources that impact them (e.g. land, water and fisheries).

4.1.1 Government departments and agencies

Workshop and focus group participants indicated that government structures must continue to engage in mangrove management, but this cannot be in isolation. Collaboration with the private sector and local communities will be essential to redress the balance and ensure adequate representation of those with high interest and low influence. Given the level of influence some government Ministries and Departments have over mangroves (e.g. Department of Irrigation and Drainage, Ministry of Water, Land and Natural Resources, Klang Municipal Council), it will be important to raise their levels of interest in mangroves to gain greater priority for this resource within policies and plans. Other government bodies such as MESTECC (now Ministry of Science, Technology and Innovation) and the Department of Fisheries need to achieve greater influence over decisions made concerning mangroves. This, however, will require fundamental shifts in their approach to mangroves. For example, the Department of Fisheries will need to be empowered to take a holistic approach to fisheries resources and to manage the fish stocks as well as the ecosystems from which they are derived.

Policy integration is a key focus for nexus approaches, but bringing multiple tiers of government and different departments together will be challenging (Benson et al 2015). It must be accompanied by governance clarity to remove overlapping roles and jurisdictions (Friess et al. 2016; Amir 2018), as well as the closure of policy loop-holes and better implementation of existing plans that already accommodate mangroves, such as the Port Klang Integrated Coastal Management programme (Aswami et al. 2012). Policy change is also needed, especially at the state level where significant decision-making power is held. This must include the protection of mangroves that fall outside of existing permanent forest reserves (e.g. those of P. Indah and P. Carey) and facilitate the development of alternative mangrove-related livelihoods (e.g. ecotourism).

4.1.2 The private sector

Mechanisms to encourage the engagement of the private sector, given their high level of influence, need to be a priority. Engagement of the private sector is recognised in nexus thinking through calls for increased public-private coalitions for resource management (Benson et al. 2015; WEF 2011). While considerable effort was made to involve this stakeholder group, it was largely missing from our engagement process (being unresponsive or unwilling to participate). It was reported by others to rarely participate in mangrove relevant decision-making beyond limited replanting efforts driven by Corporate Social Responsibility (CSR) commitments. Businesses, however, especially property developers, are influential drivers of economic and physical change in the Klang Islands. Developments in process (e.g. the BioBay

development on P. Indah (Central Spectrum 2018)) or in the pipeline (e.g. planned port development on P. Carey (Singapore Independent 2017)) will fundamentally impact remaining mangroves stands on these islands through mangrove removal.

Means to increase private sector interest in mangrove preservation or reduce their influence are available. For example, the inclusion of mangroves in engineering solutions to protect infrastructure (Hashim et al. 2010; Chee et al. 2017); as a mechanism to reduce the release of pollutants from sediments (Tam and Wong 1999); or to work with local communities to develop alternative business opportunities (Cohen-Shacham et al. 2016) such as those identified through the visioning exercise. Additional economic opportunities such as payment for ecosystem services (PES) schemes (Thompson 2018a), including blue carbon trading (Ullman et al. 2013) could also be developed. PES schemes involve the provision of financial incentives by ecosystem service users (who may be global in the case of carbon trading) to resource owners to encourage improved resource management and ecosystem service delivery. They are increasingly promoted as a solution to mangrove degradation and loss, although few functioning schemes are in existence (Thompson et al. 2017). Evidence indicates that PES schemes, especially for locally delivered ecosystem services, may be preferred by stakeholders over options such as ecotourism, trade in non-timber forest products and CSR financed restoration (Thompson and Friess 2019), but in SE Asia there has been a reluctance among private sector actors to engage. This has been attributed in part to unfamiliarity with the concepts of PES and a preference for philanthropic activities that boost public relations over returns on investment (Thompson 2018b). For successful implementation, institutional change involving multi-level governance and co-management is needed (Thompson et al. 2017).

Voluntary commitments to reducing impacts on mangroves may be insufficient, however, and legal mechanisms may be necessary. This could include the introduction and formal use of ecosystem service concepts and the four tier biodiversity impact mitigation hierarchy (avoid, minimise, restore and offset) in all environmental impact assessments (EIAs) for proposed developments (Arlidge et al. 2018; Thompson 2018b). Such change would facilitate comparison of the costs and savings resulting from mitigation actions or inaction (Ekstrom et al. 2015).

4.1.3 Local communities and community groups

Interested constituents within island communities, including fishers' and women's groups, have a high interest in mangroves, but little influence over their management. Nevertheless, some community participants were of the opinion that they should have involvement in decisions impacting mangroves. They had appreciated the opportunity provided by this study to express their concerns, indicating a degree of latent motivation for greater community participation in decision-making.

Effective nexus governance and management requires that communities be given a platform to engage (Stein and Jaspersen 2018). Both the 11th Malaysia Plan 2016-2020 (Economic Planning Unit, 2015) and the revised Klang Local Plan 2035 (Klang Municipal Council, 2019) highlight the

importance of and need for local engagement, but few examples of community based mangrove management exist in Malaysia. One such success story is PIFWA (Penang Inshore Fishermen Association), established in 1994 (En Ilias Shafie, PIFWA, pers. comm.). A small number of state-led community mangroves initiatives also exist (e.g. the Kuala Gula Friends of Mangroves in Perak State), but are currently unevaluated. They may, however, provide a framework upon which to build and opportunities for lesson learning. They also hint at a willingness at the state level to try alternative approaches to governance and management, with recognition of how mangroves can contribute to alternative livelihoods.

4.2 Visions for the future and their feasibility

By exploring the visions of stakeholders with different levels of interest or influence over the mangroves, actions to support mangrove management can be identified (i.e. nexus solutions) that may act as motivators for change (Shipley 2002). Throughout this engagement process stakeholders and coastal communities recognised the multi-functional role of mangroves, particularly emphasising the regulating role of mangroves in coastal protection. There was clear concern about the declining capacity of the mangroves to provide such protection, especially in the context of increasing erosion. Protecting existing mangroves accompanied by mangrove restoration and replanting was put forward as a clear focus for future action. This was not anticipated to restore the islands' fishery sector, but it was identified as a driver for alternative livelihood options, in particular ecotourism and aquaculture (although the latter to a lesser extent). Many of the vision-makers, however, were not representatives of influential mangrove stakeholders. Taking these visions forward will require further consultation with absent groups and effective communication with organisations that have the capacity to turn these visions into reality, especially government and the private sector.

4.2.1 Mangrove protection and sustainability

The feasibility of improving the condition of existing mangroves and achieving the vision of a mangrove plantation in the Klang Islands will be dependent upon understanding the hydrology and ecology of existing mangroves on the islands (Lewis III 2009). This may be particularly important for P. Carey, where the land is already below sea level and protected by a series of bunds (Motamedi et al. 2014). Workshop and focus group participants commented that in P. Indah, industrial development has dramatically changed the hydrological characteristics of the island, potentially making unassisted restoration impossible. Where scientific knowledge is absent or lacking regarding appropriate sites, local knowledge can fill the gaps (Biswas et al. 2009). Such engagement with coastal communities can increase the likelihood of replanting success and decrease unwanted human disturbance (Jusoff 2013).

Ad hoc mangrove replanting has already occurred on both P. Indah and P. Carey, achieved through CSR schemes aimed at increasing awareness among the public of the importance of mangroves (e.g. Westports Holding Bhd 2015). Stakeholders reported that replanting decisions (including locations) were taken by individual businesses, guided latterly by a local NGO, but

with little community engagement. Many of these attempts have been unsuccessful due to use of inappropriate planting sites, erosive forces of ship wake and fluctuations in nutrient levels (Sofawi et al. 2017). To increase success, stakeholders called for a comprehensive approach to replanting whereby efforts contribute towards a common, evidenced-based Klang Islands mangrove action plan that is used to direct CSR investments in mangroves.

4.2.2 Development of traditional and alternative livelihoods

Recognising the importance of traditional and alternative livelihoods that are dependent upon mangroves may provide another mechanism for redressing the balance in the mangrove nexus in terms of both resources and stakeholders. Despite the uncertain future for fishing, stakeholders acknowledged that mangrove restoration could improve fisheries livelihoods. Fishing is still an important source of income for some community members, despite the availability of alternative options following increased infrastructure connectivity to the mainland. This is especially true for those from P. Ketam and the Mah Meri people from P. Carey. For the Mah Meri, it is also part of their traditional culture (Carey 1973), which Malaysia has an obligation to uphold due to its commitment to the FAO voluntary Code of Conduct for Responsible Fisheries and Indigenous People (FAO 2015). While fishing may not drive future mangrove management in the Klang Islands, it should be considered an important component, especially given the dependence of off-shore catches on coastal mangroves (Chong 2007).

Although limited tourism infrastructure exists on the Klang Islands beyond transport links and some restaurants, chalets and hotels, small scale ecotourism was considered a future activity. Potential was largely recognised by stakeholders with low mangrove influence (e.g. community members and village heads), but tourism development does feature in the draft Local Plan of Majlis Perbandaran Klang 2035 (Replacement) and local tourism businesses may wish to champion this vision. Stakeholder understanding of tourism, however, needs further investigation. While the discussion referred to ecotourism, understanding of this concept varied and the content of the discussion was more akin to nature-based and cruise ship tourism. The presence of mangroves and the Mah Meri people and their culture were considered central to this discussion. While no negative comments were voiced about tourism, such development could result in conflict if poorly managed (Schellhorn 2010). Cruise ship tourism has been criticised for its inherent unsustainability due to high visitor numbers and the lack of benefits accruing to local communities (Johnson 2002). Furthermore, while some Mah Meri villages have already embraced tourism (for example, through the Kampung Sungai Bumbon Cultural Village on P. Carey), their culture is increasingly threatened due to the loss of natural resources upon which they depend (Kunasekaran et al. 2013). Concerns over the commodification of their culture and the influence of tourism on their self-representation have been raised elsewhere (Chan 2010). While sensitive nature-based tourism could incentivise the protection of existing mangrove sites, it would require a convincing business case, assessment of the trade-offs that may result between sectors and resources of the Klang Islands, as well as lesson learning from examples elsewhere (Thompson et al. 2018).

4.3 Nexus actions to support change

Integration of resources, stakeholders and their governance is at the centre of nexus thinking (Allouche et al. 2019) and must be achieved at all levels (Al-Saidi and Elagib 2017). At the macro-level this could include the integration of plans and strategic policies or the creation of super-ministries whose remit cover linked issues; at the meso-scale it might involve the co-ordination of regulations and laws; and at the micro-level individual actors such as businesses or local institutions need to recognise the interlinked nature of resources and the impacts of their day-to-day actions on these natural resource (Al-Saidi and Elagib 2017).

The challenges to achieving such integration should not be underestimated. A first step for the Klang Islands should focus on fortifying existing plans and policies to include mangrove ecosystems more explicitly. For example, buffer zones around mangroves should be enforced in immediate and future development plans, and an Integrated Coastal Management project completed for Port Klang (LUAS 2003) could form the basis for a Klang Islands mangrove action plan. Such a plan should set out stakeholders' visions and commitments towards mangroves, as well as recognise the impacts of these visions on other resources of the Klang Islands and ensure that trade-offs and cumulative effects are sensitively managed.

Enabling successful nexus action for mangrove management will require deliberate and concerted engagement with high influence stakeholders at all levels (e.g. state level and private sector actors). This must raise their interest in mangroves and encourage a shift in thinking from a siloed, single sector approach to one that recognises the wider impacts of their actions. An assessment of mangrove ecosystem service values, and the preparation of a business case outlining the costs associated with mangrove loss and the benefits of working with mangroves may be useful communication tools.

To ensure all mangrove-relevant stakeholders are represented in the decision-making process efforts are needed to develop a co-management approach. This can act as a platform for community members who have high interest, but require empowerment to ensure their concerns are voiced, listened to and acted upon. This could be facilitated by the research and NGO community, but will also require commitment from representatives of other stakeholder groups including the state and the private sector. Co-management approaches have been adopted elsewhere in SE Asia, providing opportunities for lesson learning (e.g. Brown et al. 2014; Datta et al 2012; Sudtingkong and Web 2008).

The recommendations for nexus action resulting from this research are not new. There are many calls in the literature for more integrated approaches to mangrove management, greater inclusion of the private sector and the development of co-management approaches (e.g. Amir 2018; Thompson et al. 2017; Friess et al. 2016). In fact, the nexus approach has been criticised elsewhere for its lack of novelty and inability to identify new issues (Simpson and Jewitt 2019b). Nevertheless, nexus thinking offers a number of advantages over other approaches to resource management (e.g. integrated coastal zone management, ecosystem service approaches) by

being multi-centric, applicable at all scales, focusing on institutional connections and actively promoting public-private sector coalitions (Fürst et al. 2017; Benson et al. 2015). It has also been recognised for its ability to change policy debates (Al-Saidi and Elagib, 2017) and act as a guiding framework that forces recognition of trade-offs (Hoff et al. 2019). While the application of nexus thinking to mangrove management remains untested, the approach may prove useful to the transition to sustainable mangrove management.

5. Conclusions

Using nexus thinking to explore the management of mangroves in the Klang Islands has revealed the interconnections and interdependencies between the users and uses of the mangroves and associated resources. It has identified multiple stakeholders with different levels of influence and operation, and different degrees of recognition of their impacts upon mangrove resources. Visions for the future include mangroves despite recent extensive losses on two of the Klang Islands, but the future for fisheries looks limited. Despite livelihood alternatives resulting from development, mangrove-based livelihoods including ecotourism and aquaculture were envisioned, but potential interactions between these alternatives and mangroves requires further exploration. Although wider consultation is needed to capture absent voices, a mangrove future nexus in the Klang Islands should focus more directly on protecting existing mangroves and managing them as a multifunctional resource that can support local communities and stakeholders. It must work towards the integration of all relevant stakeholders including local communities, community organisations, municipal and state government as well as the private sector. Engaging the private sector is a particular challenge that will require awareness raising, a collective approach to CSR, as well as development of alternative economic mangrove opportunities. To achieve these visions policy integration is needed to ensure that mangroves do not continue to fall through policy loop-holes and that there is no further loss of this incredible ecosystem.

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Highlights

Mangrove management can be framed as a nexus challenge.

Klang Islands' mangrove nexus characterised.

Future visions for mangroves include tourism and aquaculture but not fisheries.

Potential for collaborative mangrove management and must include the private sector.

Integration of plans and policies needed with more explicit inclusion of mangroves.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: