Assessing Integrated Coastal Zone Management (ICZM) Status in Aqaba: A Participatory Geographic Information System (PGIS) Approach

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Abstract

Integrated Coastal Zone Management (ICZM) has evolved as a response to the accelerating pressure from the expansion of various coastal activities on coastal zones worldwide. Issue identification and assessment is the first but crucial phase of ICZM, involving the development of a "Coastal Profile" that combines environmental and socioeconomic information. This thesis evaluates the usefulness of a participatory mapping approach to develop a coastal profile using a Participatory Geographic Information System (PGIS). It focuses on ICZM implementation in Aqaba, the only coastal city in Jordan, where an initial assessment of ICZM challenges using semi-structured interviews showed a clear need to capture spatial knowledge and enhance the role of non-officials in the decision-making process. Sixty hours of sessions allowed 41 stakeholders, officials, researchers, and local coastal-users (e.g. fishermen, boaters, divers) to map coastal information. The participatory mapping processes allow acquiring a rich and unique qualitative and spatial knowledge. Results show that the main coastal resources in Aqaba are corals, fish, seagrass, and sandy bottoms, land-based coastal activities consist of touristic, ports, and industrial, and marine-based coastal activities are diving, boating, and fishing. Coastal local users were shown to reflect a significant source of knowledge in relation to the status of corals, fish and seagrass coastal resources and marine-based activities. Multiple negative environmental impacts were found, either on the state of the coast (water, air, and solid waste pollution) or the coastal resources/ ecosystems (e.g. degradation of the corals). Intensive land-based touristic activities were found as the predominant coastal pressure. The use of PGIS also allowed for the identification of areas with high conflicts, providing a suitable way to reflect conflicting actors, conflicts' geographical location, and consequences. Twenty-four distinctive coastal-use conflicts were identified related to security, space, access to the beach, scope of work, and safety. Actors facing the highest conflicts are fishermen with touristic actors on use of space and access to the beach issues. Finally, priority areas for ICZM management were identified in this thesis emerging form the coastal profiles. Even though PGIS has been widely used to gather local knowledge, this study takes a novel approach utilising PGIS in the development of ICZM coastal profiles. This study is also an addition to the limited existing research on mapping coastal conflicts and comparing the spatial knowledge using the social group as a factor for contrasting local knowledge. This work is also argued to be the first study applying PGIS in Jordan. Findings of the study showed that PGIS can overcome both, the lack of, and difficulty in acquiring coastal local knowledge. It also helps in engaging the local community in the ICZM decision-making process and therefore supports participation of stakeholders at different levels.

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Dedication

Writing those words in your first year anniversary is just a heartbreaking, Daddy.

You always supported me, whatever path I took. You were passionately waiting for this moment, but what I am sure about, is that you are somewhere, very proud to see me complete my doctoral studies.

Until we meet again …

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Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this or any other University. All sources are acknowledged as References.

1 Chapter One: Introduction and Literature Review – Integrated Coastal Zone Management and Participatory Approaches

1.1. Introduction

The coastal zone can be defined as: "*A part of the land affected by its proximity to the sea and that part of the ocean affected by its proximity to the land, an area in which processes depending on the interaction between land and sea are most intense*" (Sorenson and McCreary, 1990). It is that narrow strip with a high level of heterogeneity and productivity that lies between ocean and land (Pak and Majd, 2011) characterized by unique and diverse environmental, social, economic, cultural and recreational aspects. Coastal ecosystem services include for example, food supply, storage of raw materials, climate regulation, water quality maintenance, and protection against coastal erosion, flooding, and biodiversity loss (Malone *et al*., 2014). It can also serve as a resource for education, research, and aesthetic value (Malone *et al*., 2014). Coastal zones include a significant number of the world's biggest cities (Duavin *et al*., 2004). Globally, 15% of the earth's land and around 37% of the total population on earth are within a 100 km of the coast (Pak and Majd, 2011; Agardy *et al*., 2005). Moreover, it is expected that three-quarters of the world population will settle in coastal areas by 2025 (Pak and Majd, 2011).

Agenda 21 stated that many poor people around the world are crowded in coastal areas, and coastal resources are a crucial source of income for the local community living along the coast (UNSD, 1992). As a result, numerous economic activities like fishing and aquaculture, transport, energy generation, species and habitat protection, tourism and recreation, industry, mining, and agriculture are found along coastal zones (EC, 2002). The multiple roles of the coastal zone, accompanied by human expansion and climate change have resulted in a continuous acceleration of different environmental, social and economic problems (Malone *et al*., 2014). The adverse impacts of human activities in coastal ecosystems include diminishing fish stocks, water contamination, degradation of historical heritage, coastal erosion and urbanization, sewage discharge and decreasing coastal habitats (Areizaga *et al*., 2012; González-Riancho *et al*., 2009). Moreover, it is expected that sea-level rise, coastal erosion, and coastal flooding will increase over time as adverse impacts of climate change (Storbjörk and Hedrén, 2011).

The concept of Integrated Coastal Zone Management (ICZM) was introduced in 1970 to reduce the adverse impacts of human activities along the coastal ecosystems (Breen and Hynes, 2014). ICZM targets the interface between marine and terrestrial environments, and deals therefore, with complex physical, ecological, and social processes, a variety of actors' stakes, and conflicting laws (Duavin *et al*., 2004). More efforts to develop ICZM policies and regulations are needed in order to protect coastal zones' environmental, social, and economic resources (Pickaver *et al*., 2004).

This thesis investigates Integrated Coastal Zone Management (ICZM) implementation at the coastal zone of Aqaba, which is the only coastal city and the marine gateway for Jordan, characterized by its strategic location (Manasrah *et al*., 2006; Khalaf, 2004). Aqaba is one of the main touristic destinations in the region especially with the unstable political situation in the surrounding countries. It is also a promising city from an economic perspective, attracting multiple development activities (e.g. Al-rousan *et al*., 2011). As a result, the limited and unique coastal resources in Aqaba, such as coral reefs, are facing an accelerating pressure from the huge expansion of urban, industrial and port development, especially in the last few years (Al-Saqarat, 2017; Khalaf *et al*., 2012). Even though considerable research on ICZM implementation worldwide exists (Billé and Rochette, 2015; Breen and Hynes, 2014; Areizaga *et al*., 2012; Duvat, 2011; Ballinger *et al*., 2010; Farhan and Lim, 2010; Chaniotis and Stead, 2007; EC, 2006; and Burbridge, 1997), no previous studies have investigated the opportunities for enhancing the level of ICZM implementation in Jordan. In particular, this thesis assesses the main challenges hindering ICZM implementation in Aqaba, as identified by ICZM stakeholders: lack of knowledge, especially, spatial knowledge, and weak participation of non-official stakeholders in the ICZM process; and suggests a novel method to overcome those challenges by conducting Participatory Geographic Information System (PGIS) approaches with officials, researchers, and locals whose scope of work is related to ICZM in Aqaba.

This Chapter explains the motivation of this research from the theoretical and empirical perspectives addressed in the content of this thesis. The next section provides the conceptual background of ICZM, explains in detail the need to develop a "coastal profile" within an ICZM cycle, which will be the focus of this thesis. It also gives a brief overview of the history of ICZM development and summarise key challenges that hinder a successful implementation for ICZM according to the literature. The following section discusses the basic requirement of public participation in an ICZM decision-making process, presenting the benefits of acquiring local knowledge using public participatory approaches. Participatory Geographic Information System (PGIS) is introduced to highlight its usefulness in overcoming ICZM challenges related to weak public participation and lack of sufficient knowledge. The fourth section introduces the theoretical background for the DPSIR (Driving force – Pressure – State – Impact – Response) framework, as a tool to structure the themes that emerge after conducting PGIS. The fifth section presents the empirical background by describing the case study area (Aqaba – Jordan). Finally, conclusions and the thesis structure are presented.

1.2. Integrated Coastal Zone Management (ICZM) - Conceptual Background

1.2.1. ICZM Definition and Cycle

Under an ICZM framework, management deals with all sectors which may impact the coastal zone and integrates the environmental, social and economic issues (Cicin Cain *et al*., 2000; Fabbri, 1998). This differs from other terminology often used to reflect management of coastal areas, such as “Coastal Zone Management”, “Coastal Resources Management”, and “Coastal Area Management”, which deal with only one sector or one coastal issue (World Bank, 1996). Cicin Cain *et al*. (2000) argued that the different levels of integration in an ICZM process includes 1) inter-sectoral integration, through integration of various coastal sectors (i.e. fisheries, touristic, and industrial), 2) inter-governmental integration, through integrating national, provincial, and local levels, 3) spatial integration, through integrating land-side with marine-side, 4) science-management integration, through integrating different disciplines (e.g. natural science, social sciences), and finally, 5) international integration, through integrating issues along neighbouring countries (e.g. countries bordering semi-enclosed sea).

ICZM has proved to be an effective framework for the development planning and management of various coastal zones, as it is adopted by many countries worldwide such as the Xiamen ICZM program in China (Islam *et al*., 2009), Scheldt and Thau Lagoon in France, Cork in Ireland (Reis *et al*., 2014), and the Baltic states (Burbridge, 2004).

ICZM has been defined as a:

> ‘*Continuous decision-making process that requires governmental support to implement a program within identified geographic spatial area for achieving sustainable development along coastal areas’* (Farhan and Lim, 2010, p. 422).

While according to Humphrey and Burbridge (1999, p. 1); ICZM is a:

> *'planning and management process which aims to balance multiple human activities and demands on coastal space and resources with the protection of dynamic and vulnerable coastal systems and the maintenance of the functions and services which they provide*'.

Both definitions focus on the fact that ICZM is a continuous process targeting the sustainable use of coastal resources and highlighting the spatial attribute in this management. The latter definition emphasises the importance of reaching a balance between the various activities along the coast. Similar definitions can be found in Farhan and Lim (2010), Chaniotis and Stead (2007), ATKINS (2004), Poitras *et al*., (2003), and GESAMP (1996), which illustrated its applicability to various coastal zones, recognizing the diverse range of issues that are often site-specific.

The ICZM cycle consists of five basic stages (Figure 1.1), Stage 1: Issue identification and assessment, Stage 2: Program preparation, Stage 3: Implementation, Stage 4: Formal adoption and funding, and Stage 5: Evaluation (Areizaga *et al*., 2012; González-Riancho *et al*., 2009; GESAMP, 1996).

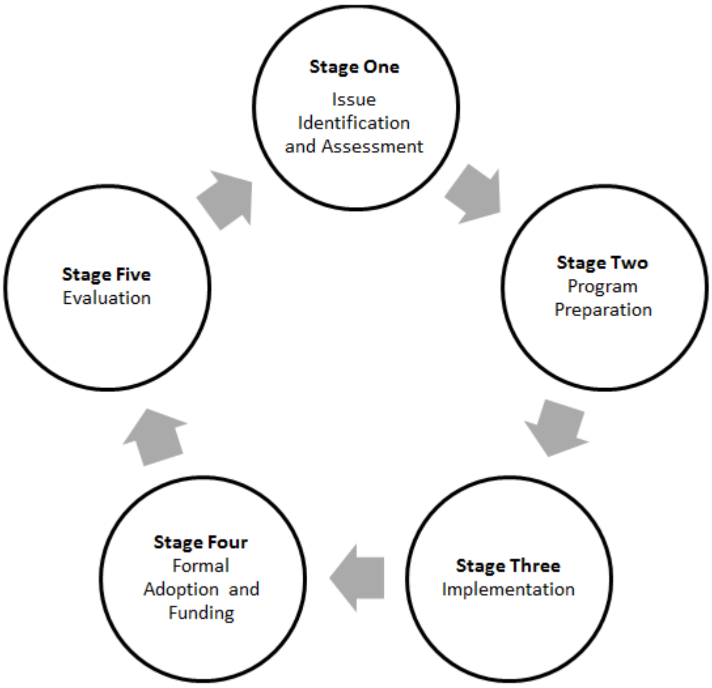


Figure 1.1: Illustration for the ICZM Cycle (GESAMP, 1996).

In stage one, environmental, socio-economic, institutional, and regulatory aspects along the coastal zone are identified and assessed through collecting, processing and analysing available information in order to develop a comprehensive coastal profile (GESAMP, 1996). The main objective of Stage two, program preparation is to develop a long-term management plan that defines the target environmental quality to be reached, mechanisms for resources allocation, and the required change in behaviours and resource usage (GESAMP, 1996).

Before reaching formal adoption and funding, Stage three may include additional questions and revisions, especially if the management shifts from a technical to a political point of view. In case of approval, it has to be authenticated by the ICZM official institution. Even if approval is obtained, this does not ensure adequate funding, and therefore the management plan may be revised to meet the available fund for implementation (GESAMP, 1996). Through stage four, all of the proposed management plans are reflected on the ground including physical implementation such as infrastructure construction, enhancing capacity building such as training, or political issues such as conflict resolution. Enforcement and monitoring may also be basic elements within this stage (GESAMP, 1996). The evaluation stage discloses the progress of the current cycle and bridging it with the next cycle. It must identify the learnt lessons and how they must be reflected in the next cycle, and the progress on the environmental issues after completion of the current cycle (GESAMP, 1996).

Completing the five stages of the cycle means completing the proposed ICZM program and being prepared for the following cycle. Larger ICZM cycles indicate more complex issues to be tackled. The complexity of a cycle may increase by engaging different actors with different responsibilities, priorities, and jurisdictions, which complicates the coordination task and may lead to the failure of ICZM implementation (Farhan and Lim, 2010). However, failure in some cases may not be a result of weak coordination; but rather is a matter of conflicting goals of different actors, which may be solved through prioritizing coastal decisions (Breen and Hynes, 2014). In fact, effective ICZM could go through a number of cycles before reaching the desired progress, therefore it is considered as a long-term process which may take a period of 8 to 15 years between identification to full implementation (Pickaver *et al.*, 2004). In summary, ICZM is a complex dynamic management process that includes a wide range of actors with different and overlapping objectives (Bracken and Oughton, 2013).

1.2.2. The Coastal Profile of Stage One in the ICZM Cycle

The first and essential step in implementing the ICZM program is within stage one, by combining all the required information in terms of environmental, socioeconomic, institutional, and regulatory aspects about the coastal zone under investigation in order to develop a stock-take or the “coastal profile” (Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009; Christie *et al*., 2006; ATKINS, 2004; Tortell., 2004; GEF/UNDP/IMO, 1996; World Bank, 1996; GESAMP, 1996; Robadue, 1995).

Table 1.1 reviews the main components of a coastal profile according to existing literature. These include: 1) environmental aspects that describe the conditions along the coast including living (e.g. species) and non-living (e.g. physical environment) resources, their characteristics and relationships, changes in the conditions and their short and long term impacts, in addition to identifying areas of priorities for ICZM to be managed, 2) economic aspects such as industry, transport, tourism, and recreation, 3) social aspects, that capture the main ICZM actors (e.g. local community) and their perceptions to the identified ICZM issues, their social characteristics, such as wealth and employment, level of income, health, population, education, and culture and heritage, 4) institutional aspects related to ICZM agencies, their scope of work, and their capabilities in identifying ICZM issues, and finally, 5) regulatory aspects such as legislation and policies related to ICZM. Moreover, the profile identifies the coastal issues of these components that need to be considered for the implementation of the ICZM program.

Throughout this research, the term “Coastal Profile” will be used to describe available knowledge being acquired from the ICZM stakeholders (officials, researchers, and locals) in Aqaba, covering therefore environmental, economic, social, regulatory, and legislative aspects along the coast and being spatially identified where applicable.

Table 1.1: A Review for the Components of the Coastal Profile for the Implementation of the ICZM Programs Worldwide.

Components of the Coastal Profile/ Coastal Stocktake		Reference
Institutional component	Identifying main ICZM actors, their roles, and responsibilities in relation to ICZM.	Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; ATKINS, 2004; EC, 2002; World Bank, 1996; GESAMP, 1996.
	Partnerships and projects (regional, national, and local levels). Existing environment and resource related programs.	ATKINS, 2004; EC, 2002.
	Understanding the demands and conflicts for the planning and management.	Tortell, 2004; GEF/UNDP/IMO, 1996.
	Identifying the management area (boundary of the site).	GEF/UNDP/IMO, 1996; World Bank, 1996.
	Allocated budget for coastal management [(2)]	González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008.
Regulatory component	Identifying ICZM related legislations and policies.	Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; ATKINS, 2004; EC, 2002; GEF/UNDP/IMO, 1996; World Bank, 1996; GESAMP, 1996; Robadue, 1995.
Economic component	Coastal economic activities and their importance, such as trade and industry, tourism and recreation, transport, fisheries, agriculture and forestry, and livestock.	González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; Christie *et al*., 2006; ATKINS, 2004; EC, 2002; GEF/UNDP/IMO, 1996; GESAMP, 1996; Robadue, 1995.
Social component	Identifying ICZM related institutions. Socioeconomic context such as income, health, population, education. Social characteristics such as urban communities, rural communities, culture and heritage. Social organization in the coastal zone (characteristics of human settlements, economic basis, indigenous people, and social issues).	Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; Christie *et al*., 2006; ATKINS, 2004; EC, 2002; GEF/UNDP/IMO, 1996; World Bank, 1996.
Environmental component	Coastal resources base including habitats, living and non-living resources and their relations. Identifying the current coastal resources, the present use of those resources, present status of the coastal resources, and potential for present and future use).	Christie *et al*., 2006; ATKINS, 2004; Tortell, 2004; EC, 2002; GEF/UNDP/IMO, 1996; World Bank, 1996; GESAMP, 1996; Robadue, 1995.
	Identifying threats and risks (Impacts) to coastal resources on the short and long term, such as marine pollution. Identifying stakeholders and societal perceptions related to the identified issues.	Christie *et al*., 2006; Tortell, 2004; GEF/UNDP/IMO, 1996; GESAMP, 1996.

1.2.3. Timeline of ICZM Policy Development

The importance of coastal zones worldwide and the necessity to preserve and sustainably use of coastal resources are well established in the legal documents at the national, regional, and international levels. Figure 1.2 summarizes the timeline for the international agreements and initiatives that represent milestones which facilitated the development of ICZM.

The concept of ICZM was first introduced more than 40 years ago in the USA under the "*Coastal Zone Management Act*" issued in 1972 (UN, 1972a). The purpose of the Act was to encourage coastal states to develop coastal management plans for achieving an effective use, protection, and development of coastal resources. The plans should include participating states, the approved programs, allocated funds, a summary for the proposed activities, regulations, problems, and the research and training conducted with this regard. In the same year, "*the Report of the United Nation Conference on the Human Environment*", included Recommendations 91 and 92, focused on the marine and coastal management (UNEP, 1972b). Specifically, Recommendation 91 assured on the significance of the research, monitoring, dissemination of information for the purpose of managing the coastal areas, and highlighted the importance of collaboration of various international organizations for purpose of information exchange and dissemination of activities in the field of marine environment (UNEP, 1972b). The "*Regional Seas Program*" and the "*Mediterranean Action Plan*" were established in 1974 and 1975, respectively (Pavasovic, 1996) targeting both, Mediterranean and European countries and encouraged them to adopt a regional approach for the purpose of protecting the marine environment. Shortly after this, Jordan agreed on adopting suitable mitigation measures to prevent and reduce marine pollution, and so, conserving the environment of the Red Sea and the Gulf of Aden under the "R*egional convention for the conservation of the Red Sea and Gulf of Aden Environment*" (PERSGA, 1982).

The concept of integration in the coastal management started to shine after the "*United Nations Conference on Environment and Development*" in Rio de Janerio in 1992, the result of this conference was Agenda 21, a document that reflects a milestone and of particular importance for coastal management (Pavasovic, 1996). Agenda 21 involves assessing the progress to achieve a successful ICZM (Stojanovic *et al*., 2004). Specifically, Chapter 17 of Agenda 21 titled "*Protection of the Oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their* *living resources*" presents a mandate for the ICZM (Stojanovic *et al*., 2004). It identifies many objectives such as ensuring the integration in the decision-making, identifying various uses for the coastal zones, highlighting major issues to be tackled while implementing the coastal management, adopting mitigation measures while implementing new projects, adopting methods that can measure the change in the coastal resources values as a result of environmental damage, and lastly providing ease of access to information and strengthening the role of participation in the decision-making process (UNSD, 1992). Moreover, various activities were identified to reach those objectives including preparing and implementing appropriate policies in terms of land and water use, bringing to bear coastal management programs at different sectoral levels (e.g. industrial, ports, tourism, and fishing), establishing coastal profiles that clearly identify areas which require special management attention, implementing different environmental tools like EIA, environmental monitoring, and the regular assessment of potential negative impacts, and conserving critical habitats.

In order to progress in ICZM and provide recommendations to overcome potential challenges in its implementation, specifically along the European coastlines, the "*Commission's Demonstration Program*" was launched with the main purpose of gathering available technical information (Humphrey and Burbridge, 1999). This program comprised of 35 projects over 6 thematic studies: legal and regulatory bodies; participation; the role of technology; sectorial and territorial cooperation; EU policies; and the role of information. Based on the recommendations of this program, two significant documents for the development of ICZM were issued (EC, 2002). First, the "*European Commission (EC) Strategy for ICZM*" pursues to promote the sustainable use of coastal resources and pull-out the ICZM implementation from a project-based to strategic approach (Burbridge, 2004). It includes 38 actions to assist EC members in formulating strategic approaches for implementing ICZM (EC, 2000), which are grouped into six categories: (*i*) promoting ICZM with member states and regional states, through developing proposals for best management practices, regular participating in meetings, and using different financial instruments, (*ii*) enhancing compatibility between EU Policy and ICZM, through enforcement of EU legislations in implementing the integrated management and promoting internal coordination to attain consistency, (*iii*) promoting dialogue between European coastal stakeholders, through development of European coastal stakeholders forum, (*iv*) development of best ICZM practices, through supporting the development of practitioner's network, establishment of community framework for the promotion of sustainable urban development, and using various available financial instruments, (*v*) generating information and knowledge about coastal zone, by promoting beneficial research through the community research policy, and (v*i*) mobilizing information and raising public awareness, through ensuring that generated knowledge is reached to coastal zone planners and managers and development of appropriate tools for effective access to related data. Second, the "*Recommendations concerning implementation of ICZM in Europe*" (Pickaver *et al*., 2004; EC, 2002) is considered as a significant attempt to develop an ICZM framework in the European countries (Areizaga *et al*., 2012; Ballinger *et al*., 2010). EC members are obligated to formulate national strategies for best management practices with regard to ICZM along their coasts (EC, 2007). The most commonly cited tools for ICZM implementation (Reis *et al*., 2014; Areizaga *et al*., 2012; Ballinger *et al*., 2010) are the Eight ICZM principles that were identified within these EC recommendations including 1) the broad overall perspective, 2) long-term perspective, 3) adaptive management, 4) local specificity, 5) working with natural processes, 6) participation, 7) the involvement of stakeholders at different levels, and 8) using a combination of methods (EC, 2002).

Similar to the European countries, Mediterranean countries were seeking to protect their coastal zones and offering solutions to overcome the challenges along their coasts (UNEP/MAP/PAP, 2008). This was the purpose of the "*Conference of the Plenipotentiaries on the Integrated Coastal Zone Management*" that was held in Madrid in 2008 and resulted in the "*Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean*" (UNEP/MAP/PAP, 2008). This convention encompassed several protocols including the "*Protocol on Integrated Coastal Management (ICZM) for Mediterranean*" which represents the first supra-state legal tool developed specifically for the management of the coastal zones along the Mediterranean countries (Bille and Rochette 2015). Specifically, Article 5 stated the objectives of ICZM, which include ensuring the sustainable development of coastal zones for the contracting parties, taking into account environmental, social and economic aspects, and using coastal resources in a sustainable manner to safeguard the rights of the current and the future generations (UNEP/MAP/PAP, 2008).

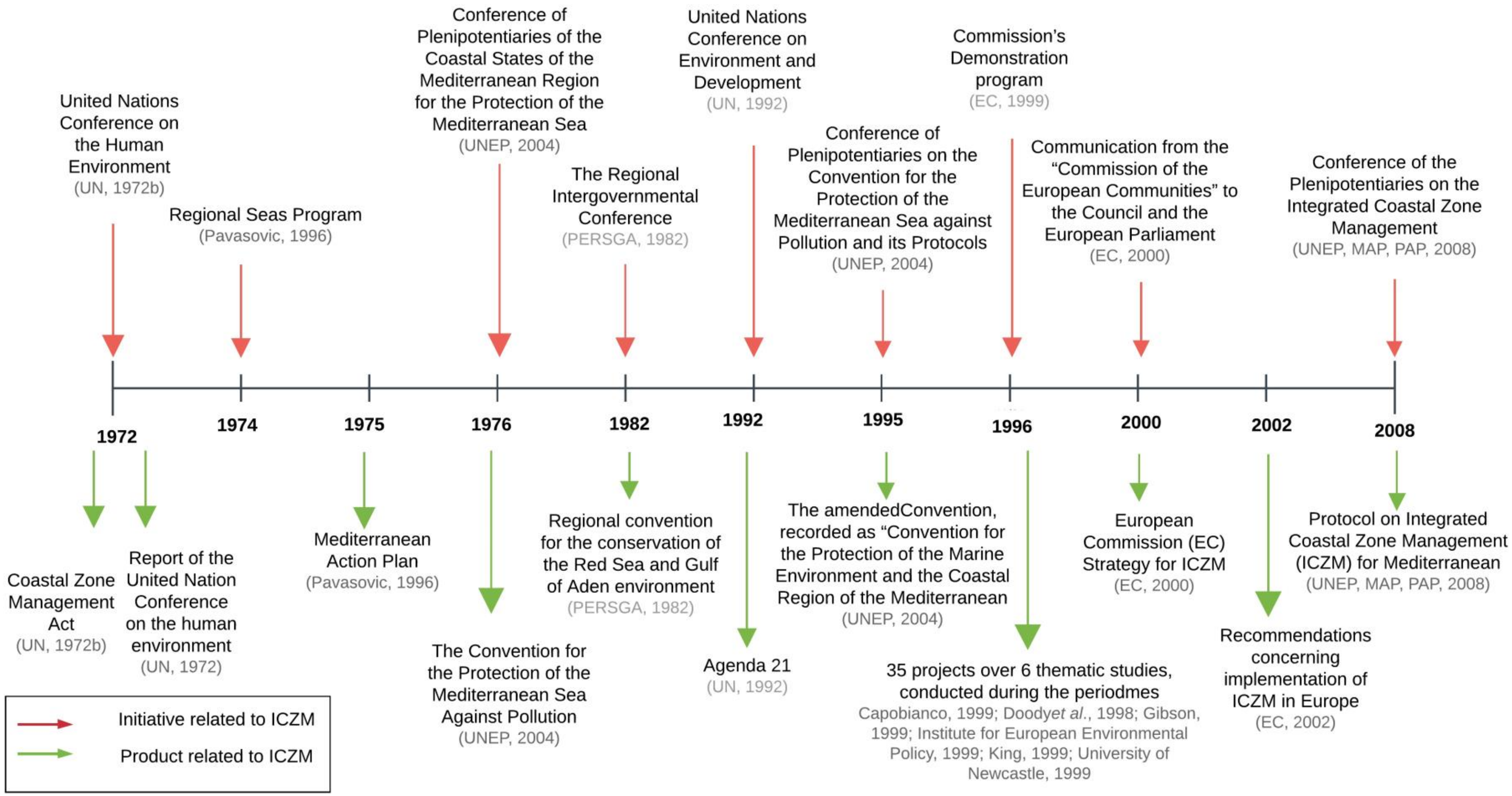


Figure 1.2: Legal international initiatives and agreements concerning coastal management and sustainable use of coastal resources that support ICZM implementation worldwide.

1.2.4. ICZM Implementation Challenges

There is a large and growing body of literature that evaluates the state of coast with regard to sustainable development and progress of ICZM implementation using different methodological approaches (e.g. Reis *et al*., 2014; Areizaga *et al*., 2012; Islam *et al*., 2009; González-Riancho *et al*., 2009; Pickaver *et al*., 2004; Burbridge, 2004; Van Elburg-Velinova *et al*., 1999; Burbridge, 1997). All these studies contribute to a better understanding of ICZM as an environmental policy mechanism for assuring the sustainability of coastal zones.

However, there are varying levels of progress in ICZM worldwide, and in many cases, the results do not meet the expectation from implementing the ICZM, especially in the developing countries (Pak and Majd, 2011; Farhan and Lim, 2010; Pavasovic, 1996). At the European level, the EC (2007) recognized that developed legislations and policies concerning coastal zones were based on a sectoral basis that leads to many conflicts and challenges in ICZM implementation. Reis *et al.* (2014) stated that ICZM implementation has achieved varying levels of success due to the complex and multidisciplinary issues in the ICZM. Nevertheless, evaluation of the progress is an important element in the ICZM and reflects a phase in its cycle (Figure 1.1) that allows learning from past experiences (Areizaga *et al*., 2012). For example, González-Riancho *et al*. (2009) focused on Mediterranean countries, including Albania, Algeria, Bosnia, Egypt, Jordan, Lebanon, Morocco, Mauritania, Palestine, Syria and Tunisia, and concluded that none of those countries have reached a full implementation of ICZM. They showed that those countries either have (a) lack of available funding, (b) absence of "State of coast" report, (c) weak implementation of sustainable development strategy, d) lack of human resources or e) weak transfer of information between stakeholders (González-Riancho *et al*., 2009). According to Le Tissier and Hills (2010), European countries (specifically Belgium, England, Malta, and Poland) are facing similar difficulties. Shipman (2007) more specifically argue that European countries challenges are 1) the complexity of responsibilities among official entities that prevent reaching a “joined-up” approach, 2) the adopted national policy, 3) information obstacles, and 4) bureaucracy. Farhan and Lim (2010) explored ICZM implementation in the Asia Pacific region, and concluded that 1) lack of ICZM legislations, 2) funding that supports the long-term implementation away from the project basis, 3) lack of “user need analysis”, in which the issues and the responses to them are formulated through the decision-makers, and 4) focusing on enhancing the economic development regardless of their consequences on the coastal environment are specific challenges in poor countries.

1.2.4.1. Lack of Coastal Knowledge and Difficulties in Monitoring the State of the Coast

Given the complexity in coastal management processes, knowledge is an essential element that is required from stage one of the IZCM cycle to develop the coastal profile (e.g. Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009). It can facilitate developing ICZM strategies. For example, the European countries are obliged to carry on a national stocktaking regarding the state of their coast and the progress of ICZM implementations along their coasts (EC, 2002). In addition, knowledge is required to develop adaptation strategies, especially in uncertain situations (e.g. climate change) (Santoro *et al*., 2013). Enough knowledge means the ability to describe the state of the coast and help in identifying the level of progress in ICZM implementation. For example, the UNDP recommended establishing a database to facilitate comparative analysis of the programs related to ICZM (Cicin *et al*., 2000). In addition, a coastal profile provides a baseline as a starting point to assess what has been achieved in regard to addressing coastal issues (Burbridge, 2004). Having enough knowledge related to stakeholders is an important factor in understanding their needs, which in turn, can help in tailoring the participatory process in ICZM implementation (Koutrakis *et al*., 2011).

However, lack of enough knowledge to support the ICZM process is well acknowledged in the literature as one of the main challenges facing the ICZM implementation (e.g. Reis *et al*., 2014; Pak and Majd, 2011; Koutrakis *et al*., 2011; Farhan and Lim, 2010; González-Riancho *et al*., 2009; EC, 2007; Burbridge, 2004). These may include 1) lack of knowledge about the coastal systems in general (Koutrakis *et al*., 2011; González-Riancho *et al*., 2009), 2) weak understanding for natural and anthropogenic pressures on coastal areas and their acceleration over time (Pak and Majd, 2011), 3) inconsistencies in the coastal terminologies and the understanding ICZM concepts and methodologies (Reis *et al*., 2014; Koutrakis *et al*., 2011; EC, 2007), 4) difficulties in defining territorial scale for proposed projects that is consistent with the administrative organizations (Duvat, 2011), and finally, 5) lack of knowledge regarding how to integrate the results from different methodologies and disciplines, such as the integration of both terrestrial and marine environment (Reis *et al*., 2014; Pak and Majd, 2011). Knowledge on the state of the coast is recognized to require more than having pure scientific criteria, as it entails different methodological frameworks and performance measures to assess the quality of complex coastal components (Pak and Majd, 2011; González-Riancho *et al*., 2009).

Over the years, various environmental management frameworks for ICZM indicators have been used, and choosing the best alternative to measure ICZM success was shown neither an easy task nor can be assessed based on the final product (Maccarrone *et al*., 2014; Pak and Majd, 2011; Burbridge, 2004). The PSR framework (Pressure – State – Response), Logical Framework Analysis (LFA) and analysis of stakeholders' perceptions are examples of those available frameworks (Pak and Majd, 2011; González-Riancho *et al*., 2009; Burbridge, 2004; Bowen and Riley, 2003). The PSR is a common framework designed to aid reporting about national sustainability in relation to Agenda 21 (Pak and Majd, 2011). It is used for environmental evaluation and simplifies the variables into cause and effect relationships. This framework highlights the necessity to focus the efforts on identifying the factors that influence the potential changes in the environment (Bowen and Riley, 2003). The LFA was designed specifically for the design, planning and assessment of the outputs of the projects (Pak and Majd, 2011; Burbridge, 2004). The analysis of stakeholder's perceptions is designed to assess the level of satisfaction among stakeholders regarding the project or the program under investigation. However, there are still shortcomings that may arise from using such frameworks, such as a) making the required linkage between coastal and socioeconomic systems b) interpreting the outputs from research into management information and c) reconciling indicators with the ICZM objectives (Maccarrone *et al*., 2014).

1.2.4.2. Weak Public Participation in the ICZM Decision-Making Process

ICZM involves comprehensive coordination among stakeholders (including the coastal resource users) to formulate shared environmental decision-making (Breen and Hynes, 2014). Therefore, public participation is one of the basic requirements to accomplish successful ICZM (e.g. Soriani *et al*., 2015; Breen and Hynes, 2014; Areizaga *et al*., 2012; Duvat, 2011; Koutrakis *et al*., 2011; Ballinger *et al*., 2010; ATKINS, 2004; Fletcher, 2003; EC, 2000). This takes into account the multiple players and the complexity and diversity of the coastal zone (Soriani *et al*., 2015). However, many studies found that public participation is one of the main challenges hindering the ICZM process (e.g. Reis *et al*., 2014; Areizaga *et al*., 2012; Pak and Majd, 2011; Duvat, 2011; Ballinger *et al*., 2010; Chaniotis and Stead, 2007). For example, Areizaga *et al*. (2012) evaluated the implementation of ICZM and the state of the coast of Cantabria in Spain, highlighting the role of public participation as the main component governing the ICZM process. In particular, public participation was evaluated through a questionnaire to stakeholders to assess their perceptions about the ICZM projects, and these authors found that availability of funding and public participation engagement were lacking. Ballinger *et al*. (2010) evaluate the progress of ICZM implementation in relation to the EC recommendations (EC, 2002), and show that although there were reasonable consultations in the ICZM process, the level of participation was significantly low. Chaniotis and Stead (2007) also found that the lack of participation in the East Riding Coast was a key factor hindering the full implementation of the ICZM process. Pak and Majd (2011) highlighted the low level of involvement for the private sector and Duvat (2011) indicated the difficulties of satisfying the public interest through reaching a long-term shared vision.

Taking the above mentioned as a starting point, participatory approaches can enhance communication and bridge the gaps between different actors, and integrate the perceived knowledge in a way that facilitates reaching comprehensive perspective for complex and multidisciplinary issues such as the ones faced within the ICZM process.

1.3. Participatory Approaches

1.3.1. Participatory Approaches – Conceptual Background

A participatory approach is '*the system wherein authority and responsibility for local resources is shared between government and local resource users and/or their communities*' (Close, 2003, p. 19). Thus, participatory approaches work on integrating the perceptions of all relevant stakeholders such as the coastal resource users in the ICZM decision-making process (EC, 2002). The importance of involving coastal resource users from the early stage of ICZM has been widely acknowledged in the literature that stems from 1) the crucial knowledge they have as they rely on the coast, 2) the importance of gaining support of coastal users to ensure the success of the process as it will be more legitimate, 3) allowing an equitable and transparent ICZM process, 4) help in reducing the conflicts among the coastal users, 5) the necessity to assure public-private partnership to reach the management goals of the governments, and 6) help in identifying the real issues on the ground (e.g. EC, 2002; Cicin-Sain and Knecht, 1998; Dahl, 1997).

Adopting a participatory approach that engages a wide range of actors also affects the legitimacy, credibility, and salience (LCS) attributes of the scenarios that are developed in the decision-making process(Volkery *et al*., 2008; Anuchiracheeva *et al*., 2003; EEA, 2001). A scenario is considered legitimate if it is seen by users as being acceptable and fair. The salience relates to a scenario's relevance and ability to address user concerns. The credibility of the scenario refers to its believability from a technical or a scientific standpoint (EEA, 2001). Fletcher (2003) argued that adopting a participatory approach can also increase the legitimacy of the decisions, and give an opportunity for the local knowledge (LK) to be involved in the decision-making process (Fletcher, 2003).

Public participation was an important prerequisite for the successful ICZM implementation in the international and national legal documents as well. For example, public participation is one of the key principles of the EC ICZM recommendations, emphasising the need of adequate and timely participation in a transparent decision-making process by local populations and stakeholders (EC, 2002). Paragraph 23.2 from Agenda 21 focused on the importance of public participation within the decision-making process for achieving sustainable development, particularly for those decisions which potentially affect the communities in which they live and work and have or are likely to have a significant impact on the environment (UNSD, 1992, P. 270).

An effective public participation approach implies a clearly understood process that represents all the affected parties operating in a transparent way and using relevant techniques and sufficient resources (King, 2003). As stated by Volkery *et al*. (2008), it is crucial to decide who are participating, their roles, and their capabilities, and so, shaping the legitimacy, credibility, and salience of the final decisions for coastal zone management. The process depends therefore on the a) availability of data, b) level of complexity of data analysis, c) adequacy of legal framework, and d) ability to integrate all the components of the ICZM based projects, and finally, e) facilitation of accessible information between decision-makers and users (through e.g. surveys, awareness raising activities, and information tools) (Soriani *et al*., 2015; Duvat, 2011; Chaniotis and Stead, 2007; King, 2003; EC, 2002). In addition, there are specific factors that relate directly to stakeholders including 1) their willingness to participate, which may require extensive efforts (e.g. through campaigns) and convincing specific stakeholders in participating in the process (EC, 2002), 2) seeking their consensus through understanding their perceptions, knowledge, and behaviours (e.g. through field surveys) (Koutrakis *et al*., 2011), and 3) acceptability, which could be achieved by tackling local needs and tailoring the proposed participatory approach to local characteristics (Koutrakis *et al*., 2011).

Given that participation of stakeholders is possible and beneficial, a participatory method and the level of intensity and involvement must be defined (Soriani *et al*., 2015). The level of public involvement in the decision-making process can vary widely according to the purpose of participation (Soriani *et al*., 2015; Volkery *et al*., 2008; Hare *et al*., 2002; Arnstein, cited in Carver 2001; Arnstein, cited in Dahl 1996). Soriani *et al*. (2015) classified public participation into four levels; the first level is "information provision", where stakeholders provide information but are not asked to give feedback that can support knowledge and current understanding of issues at stake. The second level is similar to information provision but stakeholders are asked for their feedback. In the third level "Involvement and consultation", stakeholders are involved in identifying issues under study through formal and informal meetings. While in the highest level of participation, "Extended Involvement", stakeholders are participating in formulating plans and proposals, and directly involved in the decision-making. An alternative classification was presented in Volkery *et al*. (2008) and Hare *et al*. (2002), where stakeholders participate by either: 1) receiving the developed knowledge, or 2) giving comments and some information, 3) participating in the process design, 4) participating in the analysis and preparing the recommendations, or finally 5) take the full responsibility of the process design, analysis, recommendations and action plans. Similarly, Arnstein, cited in Carver (2001) described the level of public participation in seven stages; 1) "public right to know", 2) "informing the public", 3) "public right to object", 4) "restricted participation", 5) "public participation in defining interests, actors, and determining agendas", 6) "public participation in assessing risks and recommending solutions", and 7) "public participation in final decision". King (2003) differentiated between consultation and participation. The role of locals in "consultation" includes information giving (e.g. through newsletters and media) and gathering (e.g. through questionnaires). Yet, the consultation in this context was stated by Dahl, 1997 (after Arnstein, 1997, p. 219) as "*a shame since it offers no assurance that citizen concerns and ideas will be taken into account*". On the other hand, their role in "participation" implies joint working (e.g. through community mapping), shared decision-making (e.g. through committees), and local empowerment (e.g. through conflicts resolution and capacity building) (King, 2003). Therefore, it is important to engage local communities in the decision-making process and to capture their local knowledge (LK), however, locals need to see that their participation is not only for information provisioning, and that they have a real participation in this process (Ramirez-Gomez *et al*., 2017).

In this process, selecting the best approach for public participation depends on many factors such as the local and regional geography, the complexity of the issues, available resources, the status of local institutions, potential for the sustainability of the process, and the general attitudes toward the participation (King, 2003). Moreover, participation embraces some limitations. The process can be time-consuming and costly (Soriani *et al.*, 2015; Dahl, 1997) and in some cases, if not well-managed can result in new conflicts or increase current conflicts (Soriani *et al*., 2015). Participation may also negatively impact the decision-making process if participants do not fully understand the concerns, do not have enough information to make decisions, or underestimate the views of other stakeholders who did not participate in the process (Fletcher, 2003). For example, focusing on the individual actor “one man show” can hinder the overall performance and acts against the concept of integration between different stakeholders (Storbjörk and Hedrén, 2011). Failure to make the required integration can result in complicating the implementation of the proposed coastal management in the long-term (Duvat, 2011; Pak and Majd, 2011).

1.3.2. Participatory Approaches and Local Knowledge (LK)

There are different expressions to reflect the knowledge inherited by locals, such as the Traditional Ecological Knowledge (TEK) as in Berkes *et al*. (2000), Traditional Knowledge (TK) as in Halim *et al*. (2013), and Indigenous Knowledge (IK) as in Nakashima and Roue (2002). Those expressions share the fact that local community is the main source of this knowledge, which basically consists of practices, believes and values, generated from the experiences and traditions, and are transferred through generations. LK is therefore context-bound, specific to the community, and not systematized (Canagarajah, 2002) .In this research, the term Local Knowledge (LK) will be used as in Lah *et al.* (2015) and Close, (2003) to reflect the inherited knowledge that is gathered from ICZM stakeholders, and specifically the coastal resource users. In particular, LK is defined by Lah *et al*. (2015, p. 2), as ‘*the knowledge that people in a given community have developed over time, and continues to develop, through practices and based on experiences’.*

Scientific knowledge (SK), on the other hand, is generated through a formalised process, and defined as ‘*any systematic recorded knowledge or practice*’ (Raymond *et al*., 2010, p. 1768). This means that SK is generated through scientific methods and relies on principles such as reliability and validity. Decision-makers usually rely on scientific knowledge for resource management, even though it may not completely fulfil the requirements for the decision-process (Close, 2003). Scientific data may be solid and have high levels of credibility, however, the difficulties associated with gathering and analysing scientific data can still lead to gaps in the available information. Therefore, local knowledge can potentially be used to fill those gaps (Hall and Close, 2007; Tobias 2000).

In the past, the common thought was to consider LK as subjective and lacking in scientific rigor (Close and Hall, 2006; Close, 2003). Therefore, even in those cases where good accumulated LK resources existed, it was not being incorporated in the management process itself, and the importance of LK was lower at higher levels of decision-making (Anuchiracheeva *et al*., 2003). Nowadays, LK is more commonly used and have been shown to have the same level of importance as SK, and consequently, it should be considered as a complementary knowledge (Close and Hall, 2006; Close, 2003). However, LK must be systematized and visualized to be more useful, in particular, spatial knowledge (Hall and Close, 2007; Anuchiracheeva, 2003).

With reference to the above classification for the level of public participation, integrating LK can be either in the last three roles ranging between co-designing to decision role (Volkery *et al*., 2008; Hare *et al*., 2002), or between "public participation in defining interests and actors" to "participating in the final decision" (Arnstein, cited in Carver 2001). However, it is advisable to decide the roles and responsibilities of the stakeholders in the early stage of the decision-making process (Volkery *et al*., 2008; Scholz *et al*., 2004; Hare *et al*., 2002). Note that within the context of this thesis, this integration of LK would be at the first phase of the ICZM cycle.

It is important also to highlight that there are some limitations on the potential usage of LK. For example, if the LK is in conflict with the financial interests of the industries under consideration (e.g. fisheries), the developed LK is ignored or denied (Hall *et al*., 2009; Volkery *et al*., 2008). When formulating a participatory process for any scenario development, conflicts can happen between the knowledge of the stakeholders (either scientists or locals) and other interests, views, and hidden agendas for the decision-makers. According to Volkery *et al*., (2008) this situation can be represented by one of the two types of dilemma: "Advocacy – Discourse Dilemma", and "Science – Policy Dilemma". "Advocacy – Discourse Dilemma" occurs when there are conflicts between the stakeholders' knowledge and the interests of the decision-makers, which in turn, can lead to politicizing the process and therefore losing its credibility and legitimacy. The selection of stakeholders who are able to discuss different perspectives can be a useful strategy to overcome this dilemma (Volkery *et al*., 2008). The "Science – Policy Dilemma" reflects conflicts between scientists and stakeholders, who have different perspectives on the weights of credibility, salience and legitimacy. Stakeholders (other than scientists) are often more concerned with the salience of the exercise under study; while scientists on the other hand are more concerned with the credibility. This may end up in losing the legitimacy of the scenario (Hall *et al*., 2009; Volkery *et al*., 2008). To overcome this dilemma, it was recommended that the reasons behind stakeholder participation are identified at the beginning of the process (Volkery *et al*., 2008).

Different tools have been used to acquire LK within a participatory process that can facilitate discussion with the local community and increase their level of self-confidence regarding the analysis of the issues under consideration. These include visualization and sharing (walking through the village with some discussion), ranking (comparing and grouping units, such as households), historical recall (such as recounting life stories), calendars (to discuss changes along time), and mapping. In participatory mapping, the tool chosen in this research, many factors such as the purpose, targeted quality to be achieved, type of respondents, and the available resources can influence the use of different approaches which can range from simple (e.g. drawing on the sand by sticks, drawing on hard copy maps) to advanced techniques (e.g. using tables and websites) (Emami and Ghorbani, 2013).

1.3.3. Participatory Geographic Information Systems (PGIS) – A Theoretical Framework

In the context of this research, acquiring the LK about coastal zones is characterized by its variety and complexity; therefore computerized systems can best fit in handling and analysing a large amount of data to be processed. Geographic Information Systems (GIS) are designed to deal with various types of data, specifically when the geographic location is an important element such as in the case of coastal management (Fabbri, 1998). Common approaches that integrate participatory mapping with the power of GIS are Participatory Geographic Information System (PGIS) and Public Participatory Geographic Information System (PPGIS). Both are well-suited to target the empowerment of marginalised or underrepresented communities (Brown and Kytta, 2014). Therefore, participatory mapping will be used together with GIS to produce georeferenced spatial local knowledge. Yet, there are some factors that define the most appropriate participatory GIS mapping approach for the case under study.

PGIS is basically a combination of participatory approaches including face to face (e.g. traditional meetings) and distributed (e.g. online) together with mapping processes using GIS technologies. It is a process of mapping themes under investigation by stakeholder groups on a map in order to capture local knowledge that is spatially identified (Jankowski, 2009) and democratized (Brown and Fagerholm, 2014). PGIS has been defined as:

> '*A set of methodologies designed to legitimize non-official stakeholders' knowledge of particular concerns. They are designed to make the stakeholder knowledge comparable with official spatial datasets and communicates information more directly and successfully to policy-makers*'
> (Cinderby and Pott, 2007, p. 347).

The acquired knowledge on the maps can then be processed within the GIS in order to generate spatially referenced data, ready for further spatial analysis. Carver *et al*. (2001) highlighted the benefits of PGIS as a platform for locals to be engaged in the decision-making process through participating in the public debates using GIS, which can also reduce the criticism of the GIS as an "elitist technology". Efficient public participation and locals' empowerment are the main motivations for the development of the PGIS (McBride *et al*., 2016; Jankowski 2009; Sieber, 2006; Weiner *et al*., 2002). The evolution of PGIS emerged from the (i) notion that people who are affected by the decision should have a say in the decision-making process (from democratic perspective); (ii) criticism of GIS as "privileged" knowledge of experts, together with the concern about the expensive costs related to the GIS hardware, software, data, and the high technical requirements (Elwood, 2008; Abbott *et al.*, 1998); and (iii) difficulty of including the LK in the traditional GIS (Musungu, 2015). Moreover, the PGIS was developed from the necessity to stimulate the traditional ways (e.g. public meetings and hearing) for public participation in decision-making processes (Jankowski, 2009). Moreover, the power of the PGIS evolves around its capability of integrating different views into one dialog, in a way to inform processes and relationships (Abbot *et al.,* 1998), and sharing ideas by bringing everyone to discuss their knowledge and concerns (Alcorn 2000; Abbot *et al*., 1998) especially the locals (Zolakfi *et al*., 2017), and so, promoting intra-community cooperation (Alcorn, 2000). Therefore, the mapping is recognised as a critical tool for discussions among different groups (Young and Gilmore, 2017; Fox *et al*., 2003).

The use of GIS applications for coastal management in the PGIS process has many advantages. GIS is usually used to deal with quantitative data stemming from scientific knowledge, however, it also has the potential of integrating various types of data (i.e. quantitative and qualitative data together) for more effective results (Close, 2003). This means that GIS can analyse quantitative scientific data and also be used to visualize qualitative data on maps (Hall and Close, 2007). Moreover, participatory mapping using the GIS provides a representational framework for spatial local knowledge. It allows storage, analysis and dialogue between different types of knowledge, which can lead to better understanding of complex systems. It can help in producing common notions (e.g. key resources) that can lead different stakeholder groups, as officials, researchers, and locals (Young and Gilmore, 2017). PGIS also provides an opportunity to utilize the GIS in combination with the communities' needs and capabilities (Abbot *et al*., 1998); and give an opportunity to enhance public involvement by engaging the communities in developing place-based local knowledge (Brown and Fagerholm, 2015). Consequently, the generated place-based local knowledge (spatial LK) can then be used to strengthen the debates of the local community for decision-making (Harrison, 2002), and can also be compared to, and/or, combined with other types of spatial knowledge (Hall and Close 2007; Hall *et al*., 2009; Cinderby 1999).

There is a large and growing body of work on the usage of the PGIS in the decision-making process within a variety of fields, such as ecosystem and resource management, land-use planning, conflict resolution, policy change, empowering marginalized communities through territorial claims and preserving their rights, increasing the level of awareness, and managing the expansion of development. (e.g. Ramirez-Gomez *et al*., 2017; Young and Gilmore, 2017; Zolakfi *et al*., 2017; Jankowski, 2009; Dunn, 2007; Rambaldi *et al*., 2006; Fox *et al*., 2003; Carton 2002; Alcorn, 2000; Abbot *et al*., 1998; Denniston, 1994).

In the field of resources management, using the acquired spatial information from PGIS can facilitate the management of communities' resources including their distribution and usage allocation (Zolkafi *et al*., 2017; Jankowski, 2009; Rambaldi *et al*., 2006; Fox *et al*., 2003; Carton 2002; Alcorn, 2000). PGIS can also be a good tool for conflict resolution (Ramirez-Gomez *et al*., 2017; Fox *et al*., 2003; Alcorn, 2000; Abbot *et al*., 1998). Such participatory GIS can be an opportunity to solve the conflicts over, for example, land-use, through supporting land tenure claims and the legitimate participation of locals (Ramirez-Gomez *et al*., 2017). The produced maps can be best fit in areas with high conflicts, and where rights and responsibilities are cloudy (Alcorn, 2000; Abbot *et al.,* 1998).

In addition, mapping can assure the existence of locals on the maps (Fox *et al*., 2003) against for example, the expansion of development activities (Alcorn, 2000) and so, helping in preserving the territories of the locals against land-use activities (e.g. construction), and supporting locals in claiming their rights in the land tenure (Ramirez-Gomez *et al*., 2017; Alcorn, 2000). Colonial ignorance of the indigenous people is still occurring. Denniston (1994) clarified that indigenous people used to lose their lands because they were not able to prove their ownership, and suggested that producing participatory maps can help these groups to defend their rights against the intrusions of new groups. Successful examples of using participatory mapping can lead to a demarcation of land claims including adopting treaties, compensation for lost properties, and developing indigenous territories (Fox *et al*., 2003). Such participatory approach can result in more inclusive and cohesive political processes, it also provides the opportunity for the marginalized groups to be recognized and empowered through counter mapping (Young and Gilmore, 2017). Moreover, PGIS can provide an opportunity to decrease the distrust of marginalized groups towards outsiders in the land-use planning, especially in data scarce context (Ramirez-Gomez *et al*., 2017). This motivated many indigenous communities to adopt PGIS for the sake of visualizing their local knowledge digitally (Young and Gilmore, 2017).

In both, PPGIS and PGIS, the place-based thoughts and feelings identified by the participants do not always fit well with the space-based points, lines, and polygons being mapped (Huck *et al*., 2014). This means that there is imprecision while reflecting the place values because of their fuzzy boundaries that are difficult to capture using traditional maps (Carver *et al*., 2009). Waters and Evans (2003) approached this limitation by referring to feelings and thoughts of people about the space as "vernacular geographical terms", examples include terms such as "downtown" or "high crime areas" (Carver *et al*., 2009). In addition, Huck *et al*. (2017) referred to the fuzzy nature of mapped thoughts by people as "vagueness". Recent research aims at mapping vernacular geography in order to capture fuzzy location through utilising web-based mapping websites, such as web-based spraycan PPGIS, Volunteered Geographic Information (VGI), and Paper-2-GIS (Dunning, 2016; Huck *et al*., 2014; Huck *et al*., 2013; Carver *et al*., 2009; Evans and Waters, 2007; Goodchild, 2007; Waters and Evans, 2003).

Web-based Spraycan PPGIS can be used without restricting the acquired spatial knowledge into primitives (e.g. points, lines, and polygons) (Huck *et al*., 2015, 2014, 2013; Waters and Evans, 2003). Huck *et al*. (2014) used Spraycan tools to identify the preferred areas as fuzzy locations for wind farm developments in Lancashire, UK. A similar approach is used in Waters and Evans (2003) to locate high crime areas in Leeds, UK. Fuzzy locations reflect those that are difficult to delineate either due to their indifference (e.g. boundary is of little concern), continuousness (e.g. boundary is difficult to identify) or averaging characteristics (e.g. boundary is an average of variable boundaries) (Huck *et al*, 2013; Waters, and Evans, 2003). Sparycan is a similar tool to those used in graphics packages (e.g. Microsoft Paint) that uses airbrush-style user-interface with the Google Maps as the base map (Huck *et al*., 2014), allowing participants to tag information into fuzzy areas of varying densities (Waters and Evans, 2003). Sparycan can be utilized in the PPGIS approach for advantages such as 1) avoiding the vagueness associated with mapping points, lines, and polygons and enable mapping diffuse boundaries, 2) the possibility of using it by non-professionals, and 3) the fact that the platform is freely available through Map-Me website (http://map-me.org), allowing the users to create their online surveys using the spraycan tool (Huck *et al*., 2014; Huck *et al*., 2013; Waters and Evans, 2003).

Alternatively, Goodchild (2007) used the term Volunteered Geographic Information (VGI) to reflect the phenomenon for widespread engagement of people who are untrained with a low level of qualifications in the GIS in voluntary actions to develop geographic information using, for example, the GPS, to create maps while walking, cycling, or driving. Examples of VGI includes the Wikimapia (similar to Wikipedia but focusing on presenting geographic information), Flickr (a website that allows users to upload images), OpenStreetMap (a free source of map data that allows representing the Earth's surface), Google Earth (that allows the usage of GIS functions for public). All of the above reflect online mapping services that facilitated the participation of individuals in mapping, because they do not require familiarity with GIS (Huck *et al*., 2014).

Although web-based mapping systems can facilitate mapping feelings and thoughts of participants without the necessity to restrict them into the GIS primitives, it also entails some limitations. Some specific limitations to the web-based spraycan PPGIS are 1) the considerable efforts required for the data storage, transfer, and processing within the system (Huck *et al*., 2014; Waters and Evans, 2003), 2) reliance on the knowledge stemming from hearsay, media attention, and the way people feel about the area (e.g. using random sampling) (Huck *et al*., 2014; Waters and Evans, 2003), 3) the system does not allow storing, extracting and analysing data flexibly (Huck *et al*., 2014) and the technical competence for setting-up the software (Carver *et al*., 2009). Limitations of VGI approaches include the issue that the content lacks the citation, references, or other authority for the creator (Goodchild, 2007).

A major concern of web-based mapping systems is that they create what is called the "digital divide" between those who have digital access and are digitally competent and those who are not (Huck *et al*., 2017; Dunning, 2016; Huck *et al*., 2014; Goodchild, 2007). The digital divide was defined by Huck *et al*. (2014, p. 230) as '*the gap between those who have computers, computer skills, internet access, suitable language skills (normally English), or fast broadband connections; and those who either do not, or choose not to have*'. Thus, the digital divide includes three main limitations: 1) internet access, although, most of the developed countries have internet access, this is not the case in the majority of other countries (Goodchild, 2007), even if the internet is available, it should be a high connection capacity that enables proceeding the mapping process; 2) good computer skills; and 3) language and alphabet. Goodchild (2007) stated that many VGI servers only support English and Roman alphabet. Even though, much can also be done using the mobile phones which usually have internet access, supports the desired language, and have the function of capturing images; yet, they are not well exploited to serve such purposes (Huck *et al*., 2014; Huck *et al*., 2013; Goodchild, 2007).

A novel prototype PPGIS software was recently presented by Dunning in (2016) and well explained by Huck *et al*. (2017). Note that this was after the fieldwork of this thesis was carried out (which started late in 2014). Dunning (2016) used "Paper-2-GIS" software in an attempt to avoid the issues of the fuzzy boundaries and the digital divide. The Paper-2-GIS approach was applied in Ladakhi region in North India with locals to identify their most valued areas in a way to protect them from urbanization. It basically allows the locals to map their thoughts on paper maps to avoid the digital divide, which is then, digitized automatically through the Paper-2-GIS software. This removes the potential error or bias and saves time compared with manual digitizing (Huck *et al*., 2017). Although the software managed to avoid the digital divide successfully. Dunning (2016) acknowledge that it does not combat vagueness associated with fuzzy boundaries and that uncertainties still persist in the highlighted places.

For this thesis, the researcher employs PGIS because of its ability to facilitate community involvement and empowerment, key factors when using participatory approaches. PGIS is also commonly used in developing countries. The above review shows that two important elements should be taken into consideration while selecting and implementing participatory mapping approaches; vagueness (or the fuzzy nature of boundaries) and the digital divide; and that trade-off exists between those two issues. Web-based mapping systems improve the vagueness issue, but still face the problem of the digital divide; while paper-2-GIS improve the digital divide issue, but does not combat the vagueness issue. The digital divide was of concern for this research, stemming from its main focus on the locals, therefore, web-based mapping systems were not considered here. However, the researcher acknowledges that the vagueness will be an issue in this research. Based on that, the PGIS is used in this research as it fits within the context of the study area and the aims, using hard copy maps, which are then, uploaded and manually digitized using GIS software. As clarified by Zolkafi *et al*. (2017), the knowledge acquired through PGIS can be more structured and place-specific compared to that gained from other participatory approaches, which makes the final integration of gained knowledge easier (e.g. collecting comments).

1.4. The DPSIR Framework

This thesis will structure and link the acquired knowledge on the state of the coast from the PGIS in terms of problems, their causes and consequences using the DPSIR (Driver – Pressure – State – Impact – Response) framework. It was selected because of its ability to link the causes and the consequences of environmental problems in a simple way. This section provides a theoretical background for the framework.

The DPSIR framework has been used to help in structuring complex coastal problems, gaining a comprehensive understanding of such problems, and unifying multiple terminologies, which can lead to enhanced decision-making process (Lewison *et al*., 2016; Bi *et al*., 2014; Azevedo *et al*., 2013; Atkins *et al*., 2011; Ness *et al*., 2010). DPSIR is an extension of the PSR (Pressure – State – Response) framework (Figure 1.3), which was developed as a stress – response model in 1980s by the Organization for Economic Cooperation and Development (OECD) and published in early 1990s (Lewison *et al*., 2016; Sekovski *et al*., 2012; OECD, 1994). DPSIR was then adopted by the European Environmental Agency (EEA) by adding two components (driver and impact) to link human activities with the state of the environment (Bi *et al*., 2014, Sekovski *et al*., 2012; Atkins *et al*., 2011; Ness *et al*., 2010;). Since then, DPSIR has been widely used in the environmental and coastal management as a tool to link social, economic, and natural system in a single framework for detailed analysis that can lead to more options for managing the coast (Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010).

DPSIR has the ability to present and organize data about the cause-consequence links between the human activities (anthropogenic) and the environmental processes in a simple way within a system (Azevedo *et al*., 2013; Atkins *et al*., 2011). Atkins *et al*. (2011) argued that it is important to identify the boundaries of the area containing the system to be modelled through DPSIR and that applying DPSIR to understand a system means that other systems shall be included as well. For example, applying DPSIR framework on fishery sector (as a system) means that this system is nested within other DPSIR cycles (many other sectors) such as the aquaculture sector.

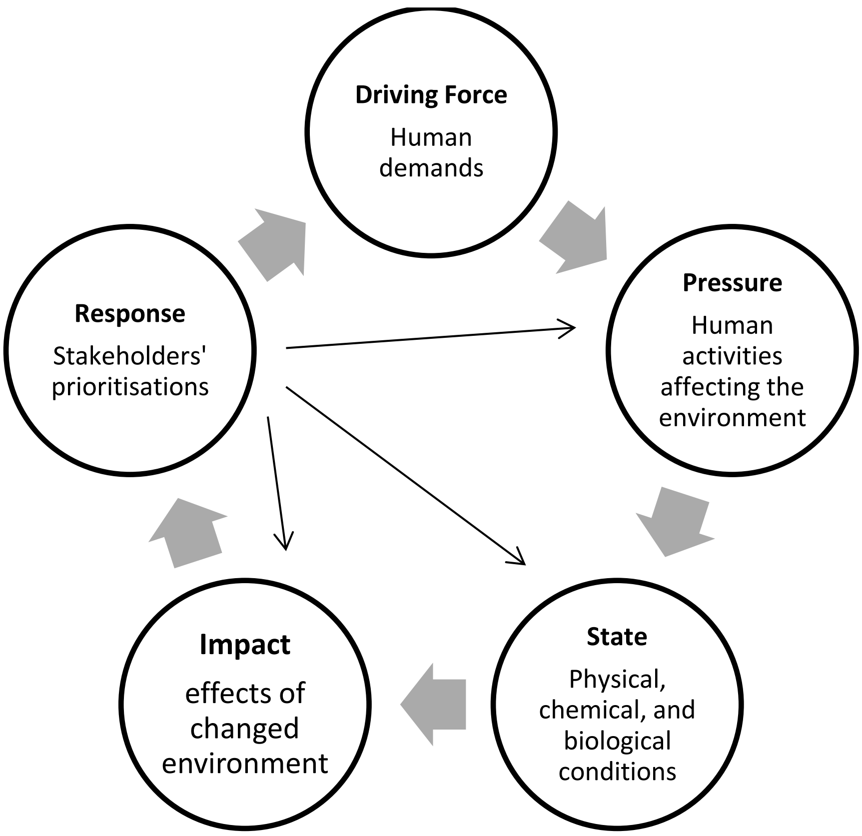


Figure 1.3: The DPSIR Framework (Sekovski *et al*., 2012).

In the context of coastal environment, "Driver" or the "driving force" is defined as: '*the independent, external causes (or forces) that underlie movement toward or away from desired targets*' (Ness *et al*., 2010, p. 480), it reflects coastal activities (e.g. fisheries) that fulfil primary human needs (e.g. food, water, energy) (Sekovski *et al*., 2012; Atkins *et al*., 2011) and secondary human needs (e.g. entertainment and culture) (Sekovski *et al*., 2012). Examples for coastal driving forces are urbanization due to population growth, and demographic change, economic and industrial development; energy consumption and power generation, urban and maritime transport, food production (e.g. maximization in agriculture and fisheries), water consumption, and tourism (Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010).

These drivers pose "Pressure/s" on the coastal environment. Pressure is defined as '*the consequence of the driving force*', it can be either positive or negative (in most cases negative) (Ness *et al*., 2010, p. 480) and result from production (e.g. wastewater discharge, air emissions, and solid waste generation) and consumption (e.g. exploitation of fisheries) (Sekovski *et al*., 2012; Ness *et al*., 2010). Examples for pressures on coastal zones are: generation of waste (solid, liquid, and oil spills), gas emissions, and pressures on groundwater resources, coastal and marine habitats loss, and pressure on fish stock (Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010). Atkins *et al*. (2011) clarified that the pressure on the system (in our case, the coastal zone) can either be endogenic or exogenic. The former pressure come from inside the system and it is locally manageable (e.g. fisheries), which means that the causes and the consequences can be managed and so, it can be called (managed pressure). The latter is pressure from outside the system (e.g. climate change) and it is not manageable locally, either due to insufficient knowledge or because we can do nothing about the pressure (called unmanaged pressure). However, in the case of exogenic pressure, the response can target the consequences of the pressure (not the pressure itself) (Atkins *et al*., 2011).

These pressures, in turn, results in a "State", '*the condition, or observable changes in the system following the pressure*' (Ness *et al*., 2010, p. 480). A state reflects the level of environmental quality (physical, chemical, and biological conditions) (Sekovski *et al*., 2012). For example, air quality, water quality in water bodies (surface and groundwater), potable water quality, and the coastal vegetation coverage (Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010).

While the "Impact", the '*measurable damages to the environment or human health*' (Ness *et al*., 2010, p. 480), or in other words, the change on the state (altering the conditions) (Sekovski *et al*., 2012; Atkins *et al*., 2011) that results in environmental (ecosystem services) and economic (human) impacts. Examples for Impacts on coastal zones include coastal erosion, diminishing fish stock, altering the biodiversity, changing the ecosystem functions, decreasing fishing revenues, environmental degradation, water pollution, degradation of historical heritage, and global warming (Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010; González-Riancho *et al*., 2009).

Responses are the '*defined societal (decision-making) measures to correct the problems of the previous phases'* (Ness *et al*., 2010, p. 480). Their aim is to reduce the negative impacts through altering part of the chain (Driver, Pressure, State, or Impact) (Sekovski *et al*., 2012; Atkins *et al*., 2011). Responses can either be adaptive or mitigative (EEA, 1999). The main aim of DPSIR is to recognize policy options reflected by the responses such as changes in policy, legislations, enforcement, and governance measures (e.g. polluters pay, quantity restrictions), new pricing strategies (e.g. taxes and fees), institutional strengthening, behavioural change (e.g. clean up campaign), technological improvements (e.g. leakage detection and shift in fuel usage), and conducting further research (Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010). Moreover, a response has to meet the seven tenets for environmental management (Atkins *et al*., 2011); whereby the adopted management should be '*environmentally/ecologically sustainable; technologically feasible; economically viable; socially desirable/tolerable; legally permissible; administratively achievable and politically expedient*' (Elliott and Cutts, cited in Elliott *et al*. 2006, p. 469).

1.5. Empirical Background: Case Study Area

Aqaba is a prime example of an ICZM case study; it is the only coastal city in Jordan with a limited coastline of just 27 km (Al-Rousan *et al*., 2011). Aqaba experienced a transition phase by becoming a tax-free zone in 2001, with a strategic goal of enhancing development. Therefore, it lies in one of the most important economic districts in Jordan, and faces accelerating developments, especially during the last few years (Khalaf *et al*., 2012). As a tax-free coastal zone, Aqaba offers special benefits to investors, but conversely trigger extra ICZM challenges compared to the common challenges facing other coastal zones (Pak and Majd, 2011). In addition, the Gulf of Aqaba is important for Egypt, Jordan, and Saudi Arabia for economic activities and transportation (Manasrah *et al.*, 2004). The transition phase is still posing constraints on the ICZM development in this city. The total population in Aqaba was 62,773 in 1994 (Department of Statistic, 1994) and reached 193,400 in 2016 (Department of Statistics, 2016). This significant increase is due to immigration to the city after the establishment of ASEZA which facilitated good employment opportunities. The city is also a touristic destination for the local residents and for tourists coming from abroad, it is also important for industrial and port activities. The Aqaba coastal zone hosts a wide variety of marine coastal resources such as coral reefs, fish, and seagrasses. For example, Aqaba's reefs is designated as a World Wide Fund for Nature globe 200 eco-region due to its unique biodiversity , considered as the northernmost latitude reefs in the Western Indo-Pacific that host more than 158 species of hard corals, and amongst the greatest in the world (Kotb *et al*., 2015; Alhorani *et al*., 2006; Al-rousan *et al.*, 2005). However, such unique resources are highly impacted by various coastal activities such as fishing, touristic, ports, and industrial activities (Al-Saqarat, 2017; Khalaf *et al*., 2012). The fact that Aqaba is located within a semi-enclosed water body, means that such activities have a major influence on the coastal ecosystems (Burbridge, 2004), and being a small coastal zone, implies that the negative environmental impacts are more immediate due to the limited resources and environmental vulnerability (Pak and Majd, 2011).

The Red Sea is a semi-enclosed, narrow water body connecting northeast Africa with the Arabian Peninsula, with a total length of 1932 km, a width of 280 km, depth of 491 m, and a total area of around 437,970 km^2. The sea is shared by Jordan, Palestine, Saudi Arabia, Yemen, Ethiopia, Sudan, and Egypt (Figure 1.4). The Red Sea includes two gulfs, the Gulf of Aqaba and the Gulf of Suez. Both are characterised by their unique biological diversity and economic importance (Manasrah *et al.*, 2004).

In particular, the study area is the Jordan coastline within the Gulf of Aqaba (Figure 1.4). The Gulf of Aqaba is located between 28-29 degrees N and 34-35 degrees E within the sub-tropical arid zone (Manasrah *et al.*, 2004). The entire gulf is 180 km long, 8 km wide (maximum width reaches 25 km), and an average of 1355 m deep (maximum depth of 1833m) (Manasrah *et al.*, 2004). In Jordan, Aqaba is characterized by its arid lands, high temperature, high evaporation rate (400 cm/yr.) and low level of precipitation. The sea surface temperature range is 20.5-27.3^{o}C (Reiss and Hottinger, cited in Khalaf, 2004) with an average of 23.5 ^{o}C while the upper water salinity is around 40.4 to 40.6% (Al-Rousan *et al*., 2007).

The uniqueness of Aqaba as a coastal zone and the specific problem of lack of information on the progress of ICZM implementation in Aqaba has stimulated this thesis. In Aqaba, some tools have been used within the context of ICZM such as the Environmental Impact Assessment, environmental audit, and environmental inspection. Yet, far too little attention has been paid to describe the state of the coast or to evaluate the implementation of the ICZM. Therefore, a stakeholder analysis explained in chapter two was conducted to explore the state of the coast and progress of the ICZM implementation. The remaining chapters focus on developing a coastal profile using the participatory GIS to overcome some of the highlighted challenges in the ICZM implementation in Aqaba.

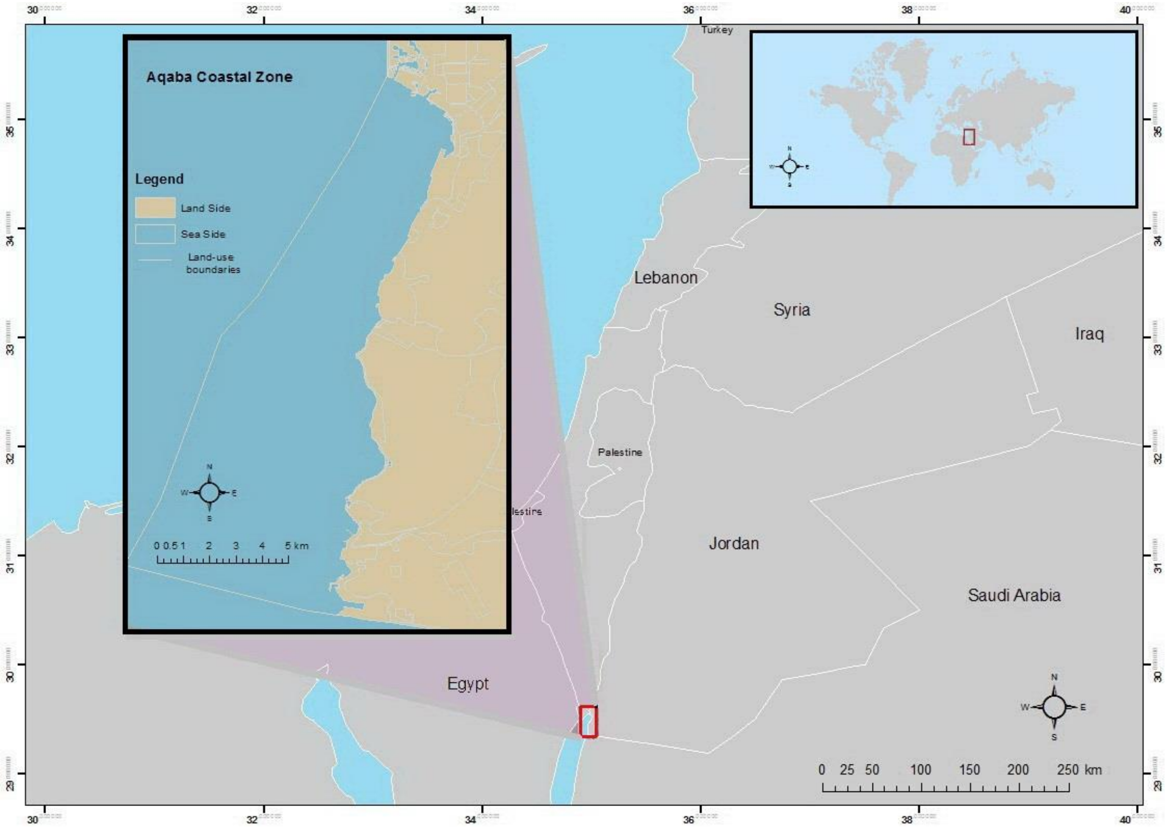


Figure 1.4: Demonstration map for Aqaba, (a) on the regional level, (b) on the local level, and (C) on the zone level.

1.6. Conclusion and Thesis structure

This thesis was motivated by the increasing consensus on the importance of evaluating the progress of ICZM implementation worldwide, with the special focus on the first phase of the ICZM cycle "Issue Identification and Assessment". This Chapter has shown that key challenges identified in the literature that hinder the successful ICZM implementation are the lack of enough coastal knowledge and difficulties in monitoring the state of the coast, and weak public participation in the ICZM decision-making process. This thesis investigates ICZM challenges within the case study context of the coast of Aqaba using a stakeholder analysis (chapter 2) and evaluates the usefulness of Participatory Geographic Information Systems (PGIS) as an approach to overcome those challenges in the first stage of an IZCM cycle (chapters 3-7).

This thesis includes seven further chapters. Chapter Two presents results from the first fieldwork in Aqaba using semi-structured interviews with the main actors from different institutions governing the management of the environmental, social and economic aspects along the coast in Aqaba. The motivation underlying this work was the need for an initial diagnosis for the status and management challenges along the coast in Aqaba. This chapter was based on the European Commission recommendations for the implementation of ICZM in Europe (EC, 2002), which stated that member states for the sake of assessing their state of coast and progress of ICZM implementation should '*conduct or update an overall stocktaking to analyse which major actors, laws, and institutions influence the management of their coastal zone*' (EC, 2002, p. 26). Therefore, chapter two can thus be framed within the first phase, the "Diagnosis", of the ICZM cycle. More specifically, information was collected on actors' perceptions and knowledge on (*i*) environmental coastal resources (corals and fish), (*ii*) socioeconomic developments that can pose pressure on the environmental coastal resources (touristic, ports, and industrial); (*iii*) types of pressure on the environmental coastal resources from the socioeconomic developments (pollution and coastal ecosystems degradation). Moreover, it gathered information on the progress of ICZM implementation in Aqaba which can be framed in the first phase, "Gap analysis" of the ICZM cycle, collecting information on the actors and institutions in charge of managing the coast in Aqaba, 2) the regulatory framework governing the coastal management, 3) elaborating tackled initiatives in the ICZM policy, and 4) assessing various challenges hindering successful ICZM implementation. Two key challenges highlighted by the interviewed actors formed the basis and the motivation for selecting the PGIS for assessing its potential to overcome them. First ICZM actors recognised lack of knowledge on legislative knowledge, coastal resources and the state of the coast, especially spatial knowledge. The management of the coast is a place-based process (e.g. EC, 2007; Anuchiracheeva *et al*., 2003), which relies on spatial information. PGIS offers an effective way to fill the gaps in data-poor areas (Hall *et al*., 2009; Volkery *et al*., 2008; Anuchiracheeva *et al*., 2003), and was used in the context of this research to collect spatial information about various coastal resources, human coastal activities and different types of pressures on the natural resources. Second, the lack of participatory approaches in the decision-making process between the ICZM actors, in particular, the weak role of the local community was another main challenge mentioned. The use of PGIS is evaluated in this research as a tool to give an opportunity for local resource users (local community along the coast) to be part of the data gathering process and so be part of the planning process for the integrated management of the coastal zone.

Chapter Three provides information on the Participatory GIS methodological approach implemented by a second fieldwork exercise in Aqaba, and involved gathering local knowledge from coastal resource users and stakeholders in order to develop a coastal profile that can be used in the first phase of the ICZM cycle "Issue identification and assessment", and highlight areas which require higher management attention (priority areas) in the future planning process within the ICZM cycle in Aqaba. Figure 1.5 illustrates how the development of the coastal profile as the PGIS' output from the first ICZM stage can facilitate the way to reach the following stages in the cycle.

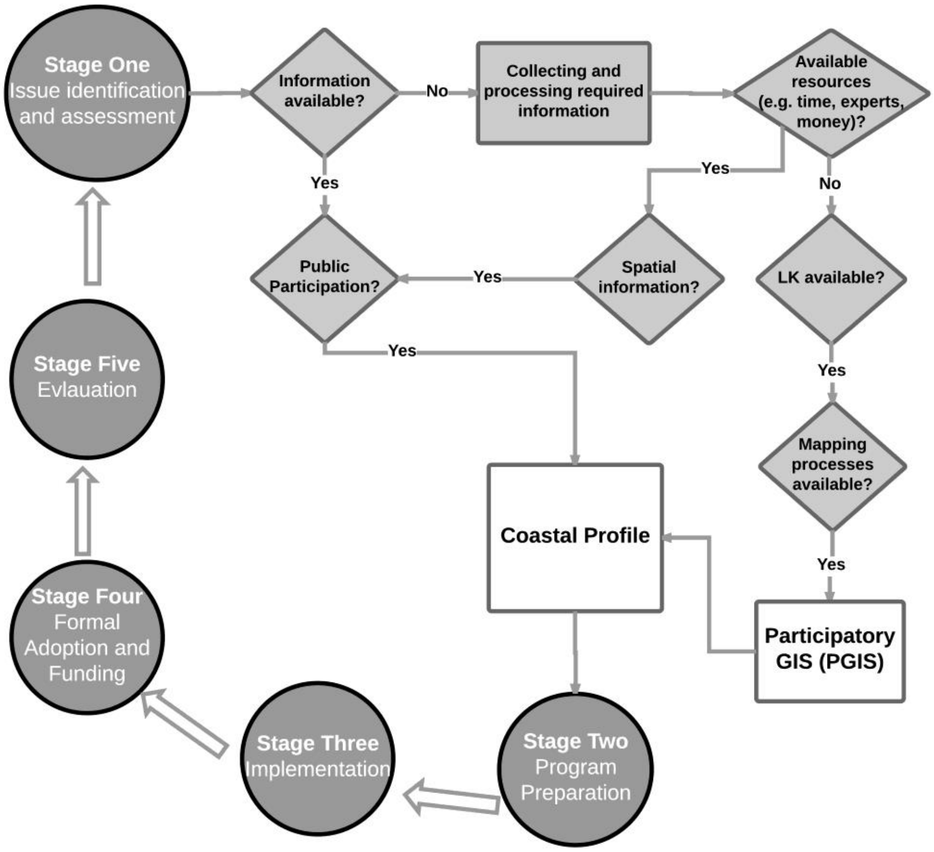


Figure 1.5: Illustration for the conditional usage of the PGIS within the ICZM cycle (adapted from GESAMP, 1996).

The results from the PGIS interviews are presented in the Chapters 4, 5, 6, and 7. Chapter four presents the land-based and marine-based coastal activities profile in Aqaba. Land-based coastal activities are touristic, ports and industrial activities, and marine coastal resources are diving, boating, and fishing. The chapter provides the acquired qualitative knowledge as well as their spatial locations based on the perception of the PGIS participants. Chapter five describes the coastal resources along the coastline in Aqaba and their coverage areas based on the consensus of respondents who mapped the resources. Identified coastal resources are corals, fish, seagrass, sandy bottoms and others (Eels and sponges). Results in chapter six show the pressures, their consequent negative impacts, and their drivers, on the coastline of Aqaba as being identified by the PGIS respondents, providing their spatial distribution along the coast. The main impacts are pollution and coastal ecosystems degradation that results from the pressures posed by various coastal activities, mainly land-based (touristic, ports, and industrial). Chapter seven presents the coastal-use conflicts based on the perception of the PGIS respondents. Finally, Chapter eight offers the conclusion of this thesis and the contribution and policy recommendations of this work to Aqaba ICZM.

2. Chapter Two: State of Coast and Progress of ICZM Implementation in Aqaba

2.1. Introduction

The coastal zone, as an interface between marine and terrestrial environments, encompasses complex processes and the multiple interests of users from the government, private sector, research institutions and the local community (Dauvin *et al*., 2004). They face accelerating demands to be protected and well managed environmentally, economically and socially (e.g. Sale *et al*., 2014; Pickaver *et al.*, 2004; EC, 2002; GESAMP, 1996).

Although there has been an increasing understanding of the main challenges facing coastal zones in the last decade, implementation of Integrated Coastal Zone Management (ICZM) is still lacking globally (Dauvin *et al*., 2004), due to its complex and dynamic nature, involving a wide range of actors with different but also overlapping objectives (Bracken and Oughton, 2013). In the ICZM cycle, collecting and processing information (stage one) and developing a long-term management plan (stage two) are both crucial steps in ensuring successful implementation of the coastal management program (Pickaver *et al*., 2004; Olsen, 1999; GESAMP, 1996). Moreover, involving all stakeholders for 1) developing an effective management plan, and 2) identifying different alternatives, which in turn, allow multiple analysis and discussions to arrive at the best solutions, is crucial (GESAMP, 1996). In the context of the strategic approach for the management of the coast (Pickaver *et al*., 2004), EC recommended starting the process by conducting a “stocktaking”. This involves defining the main sectors, stakeholders’ institutions and their roles, developing a stock for the applicable policies and legislative measures along the coast and identifying the concerns of ICZM stakeholders (EC, 2002).

The main aim of this Chapter is to carry out such stocktaking for the Aqaba coastline through identifying:

1. The main sectors along the coast (environmental and socioeconomic) and the pressures they pose on the coastal ecosystems;
2. ICZM stakeholders, their roles, and the regulatory framework governing their work;

3. Adopted initiatives as well as challenges toward a successful ICZM implementation, as perceived by the stakeholders.

This stocktaking will provide an initial understanding of the state of the coast, and the perceptions on progress proposed solution that enhances ICZM implementation in Aqaba which will guide further research in this thesis.

This Chapter is structured as follows. Section 2, defines the methodological approach. Section 3 presents the key coastal activities (sectors), their pressures and impacts on the coast. Section 4 identifies the stakeholders' institutions in the ICZM process, their roles and the governing legislations. Section 5 elaborates the progress of ICZM implementation by spotlighting the initiatives and challenges hindering successful ICZM implementation. Finally, section 6 and 7 discuss the findings and draw some conclusions, respectively.

2.2. Methodological approach

The Aqaba stocktaking was mainly based on semi-structured interviews, which were used to understand the viewpoints of key stakeholders on the state of coast and progress of ICZM in Aqaba. Semi-structure interviews include both open and closed ended questions, allowing for a less constrained interview that (*i*) help to understand the complexity of coastal issues; (*ii*) provide better knowledge of stakeholders' consciousness regarding the coastal zone, (*iii*) have the potential to provide both open-ended and structured data, thus enhancing the evaluation of the results, and (*iv*) allow new ideas to be highlighted and discussed (Ramsey *et al*., 2015; Soriani *et al*., 2015; Chaniotis and Stead, 2007). Even though, semi-structure interviews can lead to difficulties in defining the spatial scale for the coastal zone under study and in the complexity of the acquired data (Soriani *et al*., 2015), they have been extensively used in the literature. For example, in Chaniotis and Stead (2007), which evaluates ICZM role in achieving good coastal governance in the UK; Abelshausen *et al*. (2015), which assesses the applicability of the participatory approaches for the integrated management of coastal zones in Thua Thien Hue in Vietnam; Soriani *et al*. (2015), which identifies priority environmental issues along the coastal zone in Bouches-du-Rhône County (south-east France); and Ramsey *et al*. (2015), which analyses social perceptions on coastal management in Antigua and Barbuda islands.

2.2.1. The Guiding Questions

A set of open-ended questions were used to orient the meetings and obtain the required qualitative knowledge (Table 2.1). The interviews included first, a set of questions addressing general issues about the current coastal sectors (environmental, social, and economic), and pressures facing the environmental coastal resources. Secondly, respondents were asked to list the ICZM stakeholder institutions, their scope of work and their governing legislations. Thirdly, the interviews included more in-depth questions about types of coordination between ICZM institutions and level of enforcement of the governing regulations. Moreover, the interviews included a disclosure question on stakeholders' views on potential recommendations that can improve the ICZM process in Aqaba.

Table 2.1: The Guiding questions for the semi-structured interviews.

Questions Categories	The Question
First Set: General questions about the environmental situation in Aqaba	- What are the coastal resources in Aqaba? - What are the main economic and social activities in Aqaba that are related directly or indirectly to the environmental resources? - What are the main implemented and proposed mega projects in Aqaba? - How such activities (social, economic, or mega projects) can impact the coastal resources?
Second Set: Questions about the stakeholder institutions	- Describe your work, and how much it is related to the ICZM? - What are the reference environmental legislations in your work?
Third Set: Questions related to the Integrated Coastal Zone Management (ICZM)	- What are the main environmental problems in Aqaba (which are related to your work within the context of ICZM)? - Who are main stakeholders (governmental, researchers, the private sector, and local community) related to your work? - What is the basic role of those stakeholders in relation to your work? - Is there any kind of coordination with other ICZM actors, if yes, how? And if no, why? - What is the level of enforcement for the above-mentioned legislations?
Disclosure question	- From your experience, what are your recommendations to enhance the coastal status in Aqaba?

Note that the acquired data from the guiding questions, specifically, the first questions' set can be framed within DPSIR framework (as described in Chapter One). Questions related to activities and projects can reflect the "Pressure", while questions about coastal problems reflect the "Impact".

2.2.2. Selection Criteria and Selection Process for the Respondents

Respondents were selected as ICZM players in Aqaba whose scope of work is directly or indirectly related to the coastal management. Accordingly, semi-structured interviews were conducted with the following:

1. Officials working on the planning, management, inspection, and monitoring of the coastal zone, mainly from various directorates within Aqaba Special Economic Zone Authority (ASEZA),
2. Researchers working on coastal issues and/ or teaching at the Faculty of Marine Science at the University of Jordan – Aqaba branch,
3. NGOs, dealing with coastal management, and
4. Funded projects targeting coastal issues.

The respondent selection process was based on personal connections and contacts, recommendations, and snowball sampling. All the respondents were initially contacted via phone calls that included introducing the researcher, briefly explaining the research and arranging follow on meetings. No incentives were provided to the respondents.

2.2.3. Data Collection

Thirteen personal interviews were held in Aqaba and five in Amman (the capital city of Jordan) during the period between August and September 2013. Table 2.2 shows the eighteen ICZM actors who participated in this research with codes (R1, R2, R3 etc.) used to ensure their anonymity. The duration of the meetings varied between 0.5–2 hours depending on the flow of the discussion and the amount of knowledge the respondents presented. The meetings started by presenting a brief about the research, the objective of the interview, and an introduction about the ICZM (in case the concept is not clear for the respondents). During the meetings, permission was asked to record the interview.

Table 2.2: Details for the Respondents of the Conducted Semi-structured Interviews to develop the Aqaba stocktaking.

Respondent	Institution	ICZM Stakeholders Group
1	Environmental studies and monitoring division / ASEZA	Officials
2	UNDP Project	Locals
3	Aqaba Marine Park – ASEZA	Officials
4	The Royal Marine Conservation Society of Jordan	Locals
5	The Royal Marine Conservation Society of Jordan	Locals
6	USAID Project	Locals

Respondent	Institution	ICZM Stakeholders Group
7	Architecture and Physical Planning Directorate/ ASEZA	Officials
8	Geographic Information Systems Directorate / ASEZA	Officials
9	Architecture and Physical Planning Directorate/ ASEZA	Officials
10	Permitting and EIA Division/ ASEZA	Officials
11	Environmental Inspection Division/ ASEZA	Officials
12	Water Division/ ASEZA	Officials
13	USAID Project	Locals
14	Private Sector	Locals
15	Marine Science Station/ University of Jordan	Researchers
16	Marine Science Station/ University of Jordan	Researchers
17	Marine Science Station/ University of Jordan	Researchers
18	Marine Science Station/ University of Jordan	Researchers

2.2.4. Data Processing and Analysing

Following the meetings, the "verbal data" acquired from recordings were transcribed, and then, translated from Arabic (the official language in Jordan) to English for the analysis. The research used the thematic analysis described by Braun and Clarke (2006) which consist of six basic phases as shown in Figure 2.1

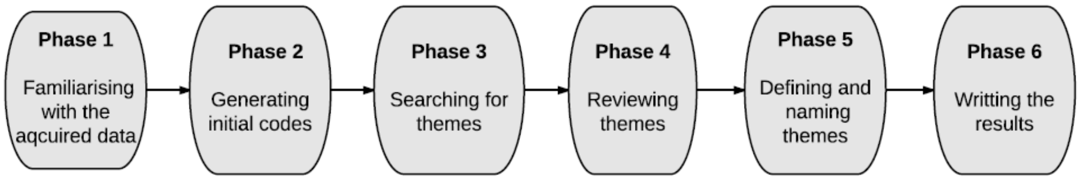


Figure 2.1: Phases of thematic analysis (adapted from Braun and Clarke, 2006).

Applying the above method to this case, in phase one, transcripts were initially read and notes were taken, followed by deep and repetitive readings in order to familiarise the researcher with the transcripts. The notes and ideas generated at this stage helped in identifying possible patterns of meanings or the potential interests in the data, in other words, potential themes. During the second phase, initial codes were produced from the data. Code is '*the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon*' (Boyatzis, cited in Braun and Clarke 2006, p. 18). Following Braun and Clarke (2006) theory driven coding was applied, in which emerged themes rely on the components of the stocktaking referred to in the ICZM literature. The coding process was applied to the entire data set manually through writing notes on the texts to identify the patterns, identifying initially the codes, followed by matching similar extracted texts. These codes were sorted into potential themes and sub-themes in phase three, with texts for the codes collated to produce the content of each potential theme. During phase four, potential themes were reviewed to ensure they appear in a coherent pattern; and if potential themes were similar, they were merged, while a potential theme was split when it seemed to accommodate different patterns. These were followed by refined and defined theme process during phase five, which included identifying the essence and the aspects of each theme, as well as its relation to the overall context and the aims of this study.

Figure 2.2 shows the three final themes 1) state of Aqaba coast, 2) stakeholders' institutions and 3) progress of ICZM implementation, as well as sub-themes and codes. Detailed description for each final theme is presented in the following sections below. Policy documents, reports, and legislation, are used to support the narrative of the themes and be referred to accordingly. Note that the DPSIR framework is followed in the analysis of sub-theme of 'coastal pressures and impacts'.

2.3. The state of Aqaba coast

The coastline is divided into four main zones as stated by 7 respondents (R1, R7, R8, R10, R15, R17, and R18) (Figure 2.3):

1) Northern coastline, which includes most of the touristic activities like hotels and mega touristic projects. Termed in this thesis "Touristic zone",

2) Middle coastline, which accommodates port activities like the main port, Aqaba Containers' Terminal (ACT), and Passengers' port. Termed in this thesis, "Port zone",

3) Protected coastline, where the Aqaba Marine Park (AMP) is located. Termed in this thesis "AMP zone",

4) Southern coastline, divided into two parts. The first part, where some land-based touristic and military activities are located, termed in this thesis "special zone". The second part, where all the industrial activities and some port activities are located, termed in this thesis "Industrial zone".

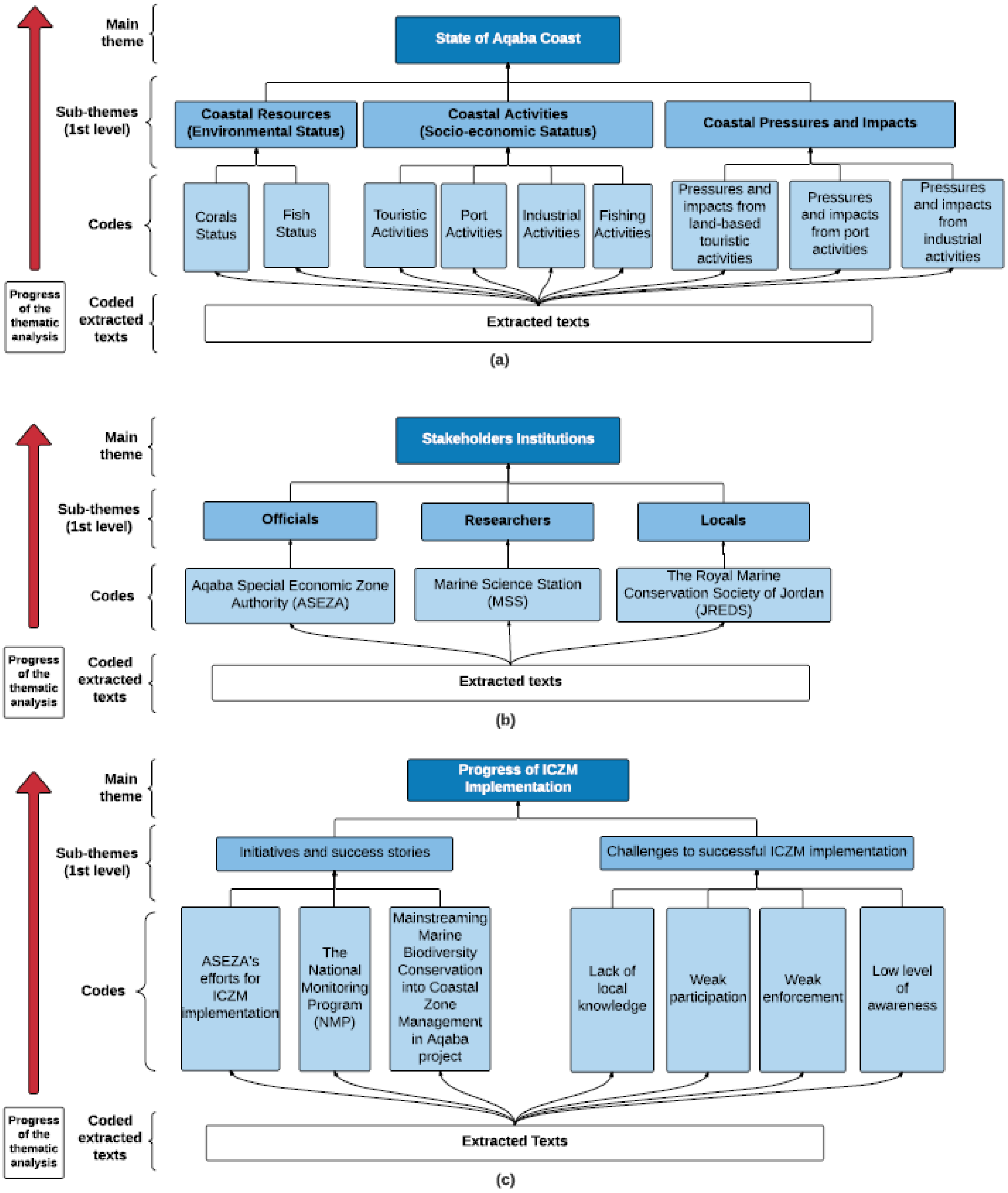


Figure 2.2: Emerged main themes and their related sub-themes and codes based on the stakeholders' semi-structured interviews, (a) first main theme – state of Aqaba coast, (b) second main theme – stakeholder institutions, (c) third main theme - progress of ICZM implementation.

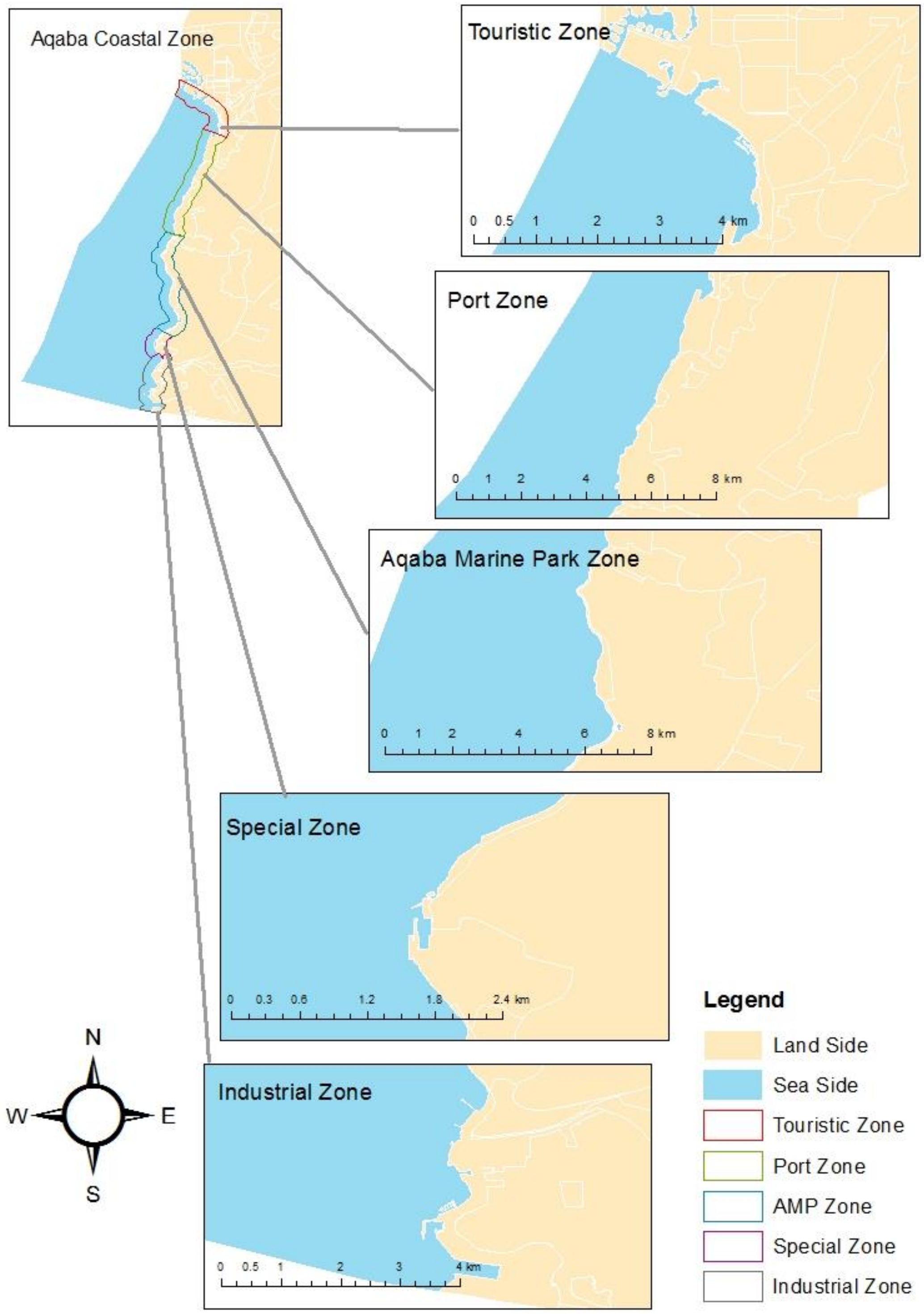


Figure 2.3: Zoning system along Aqaba coastline as perceived by the respondents.

2.3.1. Environmental Status in Aqaba

Table 2.3 shows the coastal resources recognized by the stakeholders. Both corals (mentioned by 67% of respondents) and fish (mentioned by 44%) are discussed in detail below.

Table 2.3: Coastal resources and percentage of interviewed stakeholders who mentioned them. The gradient in the blue colour reflect the response rate, darker colour means a higher response rate. Total number of respondents, 18.

Coastal Resources	Response Rate
Corals	67%
Fish	44%
Others*	
Seagrass	33%
Artificial coastline	17%
Sediments	11%
Soil	6%
Mineral resources	6%
Water quality (as resource)	6%
Air quality (as resource)	6%

Response Rate %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

*** Others: detailed description for the coastal resource is not included in the section, either because it has low response rate or because there was no enough data to support it.**

2.3.1.1. Corals Status

According to an expert researcher in benthic habitats (R18), there are two types of corals in Aqaba: deep and shallow. Deep corals can be found all along the coastline, while shallow corals may be found in the port and AMP zones and to a lesser extent in the touristic zone. The same respondent clarified that vertically, the highest cover percentage and diversity for corals can be found at depths between 15 – 20 m. Depths for the coral's surveys can extend up to 100 m depending on the purpose of diving (recreational, research, business). Thus, diving for recreational purposes can occur at depths of up to 40 m, while for the National Monitoring Program: reef flat 0 m, 9 m, and 18 m, and for business, it is usually around 30 m. Horizontally, the coral's coverage is low along the touristic zone due to natural factors (i.e. flooding), and so, the predominant environment in such areas are sandy or seagrass. Scattered corals can be found along the public beach in the touristic zone (Figure 2.3). The intensity of the corals increases going to the south starting from the phosphate loading berth up to the Kingdom of Saudi Arabia border, where the best corals can be found.

Corals in Aqaba have both natural and anthropogenic threats. Natural threats include: 1) flooding - sediments from flooding can significantly impact the shallow corals along the touristic zone; 2) exposure of corals to sunlight -resulting from unusual low tides, which can cause coral bleaching or even coral death if this exposure extends for a long time; 3) increasing levels of UV radiation - impacting shallow corals; and 4) coral diseases (R18).

2.3.1.2. Fish Status

There are around 507 fish species along the Aqaba coastline, which represents half the total number of fish species in the Red Sea (R1). This high fish diversity is associated with the diverse soft and hard corals (R1). However, fish are not abundant enough for commercial production due to natural and anthropogenic factors (R2, R18). Primary productivity (mainly affected by the sea water temperature) is a key factor controlling fish stock abundance, as it is not enough to support fish proliferation in significant amounts due to low levels of nutrients. In fact, fish stock increases in late winter and early spring due to increasing the primary productivity (R18).

2.3.2. Socioeconomic Status in Aqaba

Table 2.4 describes stakeholders' perceptions on the coastal activities. There are four main types of coastal activities, based on the response rate, which are touristic, ports, industrial, and fishing.

Table 2.4: Coastal activities and percentage of interviewed stakeholders that mentioned them. The gradient in the blue colour reflect the response rate, darker colour means a higher response rate. Total number of respondents, 18.

Socio-economic Status	Response Rate
Touristic activities	56%
Port activities	56%
Industrial activities	56%
Fishing	22%
Others*	
Diving activities	11%
Boating activities	11%
Other aqua sports (e.g. jet ski)	6%
Social activities (e.g. campaigns)	6%
Security activities	6%
Birds watching	6%

Response Rate %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

*** Others: detailed description for the coastal activity is not included in the section, either because it has low response rate or because there was no enough data to support it.**

2.3.2.1. Touristic Activities

Aqaba is a major touristic destination for both local and international tourists. Generally, touristic activities are concentrated in two areas: at the touristic zone in the north coast and at the AMP in the south coast (Figure 2.3). The port zone includes a proposed mega touristic project "Marsa Zayed". The touristic zone is characterised by two mega touristic projects; Ayla and Saraya, in addition to the Royal Palace, five stars hotels, Royal Yacht Club (RYC) and the public beach (Ghandoor) (R1, R2, R3, and R5) (See Appendix 1).

2.3.2.2. Port Activities

The main port, phosphate port, Mo'tah port, Collective Terminal, Aqaba Containers' Terminal (ACT), and Passengers' port are located in the port zone. The phosphate port is being used as a hub for receiving phosphate from the Al-Hasa area by trains and trucks, and then stored in the silos to be loaded later to the ships for exporting. During the phosphate handling process, large quantities of phosphate dust are generated, significantly impacting both water and air quality (R1, R5, R7, R16, and R18).

2.3.2.3. Industrial Activities

The industrial zone contains the Aqaba Petrol Company, the Central Electricity Generating Company (CEGCO), the phosphate company, and two gas companies. In addition, the industrial zone hosts jetties for miscellaneous liquids. There is also an industrial complex which accommodates a range of industrial business, mainly chemicals and fertilizers companies. This includes Solvochem (suppliers of chemicals), Aqaba Bulk Chemicals, Jordan Petroleum Refinery Company, Jordan Bromine Company, Red Sea Timber Factory, Manaseer Concrete, Aqaba Desalination Plant, Jordan India Fertilizers Company (JIFCO), Arab Potash Company, Arab Fertilizers and Chemical Industries (KEMAPCO), and the logistic Centre (R1, R3, R5, R15, R17, and R18). Note that the oil export port, Liquid Petroleum Gas Port (LPG), and Liquid Natural Gas Port (LNG) are also located in the industrial zone (R1, R3, and R5).

2.3.2.4. Fishing

Fishing is permitted by licenses issued through AMP. The regulation of this activity used to be the responsibility of the Ministry of Agriculture, but was transferred to AMP in 2005 (R3). Even though, fishing was not considered as an economically feasible in Aqaba (R2, R18), there are around 200 licenses for both permanent and seasonal fishermen, and about 70 families, with an average size of 4 – 5 people, relying on fishing as their main source of income. For many other families, fishing is a secondary source of income (R2, R3). A researcher expressed his concern about current underestimation of the socioeconomic importance of fishing in Aqaba and the lack of support for the development of fishing as an industry (R15). All fishermen are looking for alternative sources of income (R2, R3). In addition to the natural threats described in the environmental status section above; respondents mentioned the following specific anthropogenic threats to fish stock and fishing activities:

1. Construction activities and the accompanying waste and noise pollution (R15, R18).
2. Mass tourism and the associated touristic activities, like boat traffic (R2, R7, and R18).
3. Overfishing, this is considered the main reason for the decrease in fish stock,

consequently weakening fishing as an industry. This may be due to the low level of awareness among fishermen and the use of some traditional fishing technique such as “Al-Hawakeer”. This involves throwing large nets into the sea and collecting fish catches after two or three months. Many fish die and decompose in the nets, which causes changes in the water quality, increasing the nutrients concentration (eutrophication), and leading to a high abundance of algae. ASEZA prohibited this type of fishing technique recently(R18).

Historically, fishermen were allowed to fish beyond the territorial water and fishing trips may extend for a month (called Sarha). They could land along the Egyptian or the Saudi Arabian coast. Long fishing trips were prohibited during the 70s to 80s when fishermen were also forced to get licenses. The number of fishermen decreased as they started to find alternative sources of income (R3, R18). Different suggestions to sustain the current fish stock and improve the fishing activities were mentioned by the interviewed stakeholders:

- Conducting rehabilitation programs or capacity building project targeting fishermen, to introduce the benefits of modern fishing techniques like the use of gears that are more compatible with maintaining a sustainable fish stock (R18)
- Imposing temporal restrictions like seasonal fishing, and/or concentrating fishing on specific sites to allow fish breeding in other sites (R15, R18).
- Introducing (fish farming) which was labelled by (R15, R18) as environmental friendly and is been applied in the Marine Science Station (MSS) for research purposes only.
- Examining the possibility of deep sea fishing (400 – 800 m depth) using modern fishing techniques (R18).
- Establishing specialised fishing companies that can fish beyond the territorial waters, by signing agreements with neighbouring countries (R18).

2.3.3. Coastal pressures and impacts on the coastal zone

Table 2.5 shows the main sources of coastal pressure and consequent environmental impacts. This table follows the DPSIR framework, linking the “Driving force” which is posing a “Pressure”, and causing a change in the “State” that results in an “Impact”. This framework is used in the following sections to help in structuring the content of this section in relation to coastal pressures and impacts.

Table 2.5: Coastal pressures and impacts in relation to their driving force and state following DPSIR framework, and percentage of respondents who mentioned these pressures and impacts. The gradient in the blue colour reflect the response rate, darker colour means a higher response rate. Total number of respondents, 18.

Driving Force
Port activities
Industrial activities
Fishing activities
Visitors
Others
Diving activities
Boating activities
Marine Sports

Coastal Pressure	Response Rate
Intensive port activities like the construction activities accompanied with oil pollution and generation of phosphate dust.	50%
Intensive industrial activities such as the construction activities, chemical industries, oil pollution and emissions of pollutants like ammonia.	44%
Due to low fish stock, difficulties in finding alternative source of income for fishermen, difficulties in rehabilitation the fishermen's port, using the traditional techniques for fishing, overfishing, pressure on fishing from construction activities, limited areas for fishing, weak fishing societies, low level of awareness among fishermen and lack of scientific research about fishing.	28%
High number of visitors accompanied with the generated solid waste.	28%
Others*	
Intensive diving activities.	11%
Intensive boat activities and potential leakage of oil.	6%
Intensive marine sports (e.g. jet ski)	6%

State
Coastal ecosystems
Water quality
Public beaches
Air quality
Aesthetic value/ water quality

Impact	Response Rate
Coastal ecosystems degradation	50%
Water Pollution	39%
Pressure on public beaches	39%
Air pollution	22%
Solid waste pollution	11%
Flooding	11%

**** Other coastal pressures: detailed description for the coastal pressure is not included in the section, either because it has low response rate or because there was no enough data to support it**

2.3.3.1. Pressure and impacts on the coastal zone from touristic activities

As the only coastal city in Jordan, and due to its strategic location regionally, Aqaba hosts many tourists. Although the intense touristic activities are a crucial contributor to the Jordanian economy, it has negative impacts on the marine environment, if not appropriately regulated (R4, R17). Generated solid waste from touristic activities can be a pressure to the coastal resources, especially with the inefficient solid waste management in Aqaba (R2, R3, and R7). Beaches suffer from high quantities of litter, which is clearly noticed in the public beaches (Ghandoor and AMP), and it is worse during weekends and holidays (R3, R17). Most of the litter accumulates on the sea floor or over the corals and badly impacts benthic habitats especially corals (R1, R2, R3, R7, R15, and R16). In addition, touristic construction activities and the associated generated waste and dust are sources of pressures that negatively impact sea water by increasing the water turbidity and changing the water quality, which in turn, impacts also on coastal resources, especially corals (R1. R2, R3, R15, R16, R17). Intense diving activities can also pose pressure on the corals, especially at the diving sites in AMP. For example, the “shipwreck” diving site is extensively visited by divers (R1, R2, R3, R4, R7, and R16). There are also intense boating activities (especially in AMP and the marinas of both RYC and Tala Bay), which can impact coastal resources. Corals, for example, can be badly impacted because boaters’ trips are mainly in coral abundant areas, causing water pollution while fuelling or washing the boats, or by dumping solid waste in the sea (R2, R3, and R16).

2.3.3.2. Pressure and impacts on the coastal zone from port activities

Even though port activities are very important for the country’s economy, they pose direct and indirect negative pressures on the marine ecosystems (R2, R3, R5, R16, and R18). Water pollution is one of their main negative impacts, affecting especially corals (R1, R3, R15, and R16). For example, corals in the fishermen’s port were destroyed due to pollution (R2).

Port activities include unloading and loading of imported and exported goods, leading to dumping of waste (R1, R3) or accidental oil spillages (R1, R3, R7, and R16). Oil pollution can have significant negative impacts on corals and fish, and there are up to 2 accidents occurring annually. Corals can also be damaged from the pressure caused by ship traffic (R3, R7, and R16). AMP as a reserved zone is suffering from port-caused pollution, because it is surrounded by the ACT and passengers’ port (to the north), and the industrial zone (to the south) (R3). Many respondents mentioned the negative environmental impacts caused by phosphate dust pollution as large quantities of phosphate dust are generated while handling and loading raw phosphate for exports (R1, R7, R16, and R18). In addition, construction of new ports, demolition, and expansion of current ports can result in the generation of high quantities of solid waste (R16).

Moreover, the current relocation of the main port to the industrial zone (Dirrah Bay) negatively impacted large areas of corals along Dirrah Bay. Some corals were moved from Dirrah Bay and transplanted within AMP, but the majority areas of corals in the Dirrah Bay have deteriorated (R5, R16).

Further negative impacts from the port activities are associated with prohibiting access to beaches. For example, diving is not allowed anymore within the industrial zone because of the expansion of the port activities in this zone, which in turn increases the pressure on the other diving sites within AMP (R4, R11).

2.3.3.3. Pressure and impacts on the coastal zone from industrial activities

Industrial activities include storing and handling, loading and unloading of chemicals and fertilizers for both exporting and importing purposes (R1, R3, R7, and R18), which can lead to similar pollution impacts to the ones described in the previous section. Pollution poses pressure on both corals and fish stocks by negatively impacting water quality, e.g. by discharging different types of chemicals like potash and phosphate dust (R1, R7). Respondents also mentioned air pollution resulting from the emission of high quantities of ammonia and sulphur when handling chemicals and fertilizers (R1, R4, and R7). Note that the use of sea water by the thermal power station for cooling purposes is thought not to pose significant impacts on the sea water quality since water is being discharged to the sea with the same quality except the change in temperature (R1).

2.4. Stakeholder Institutions

This section summarise stakeholders' perceptions on the ICZM main actors in Aqaba (Table 2.6) and their scope of work. ICZM actors include ASEZA, reflecting the main official institution, Marine Science Station (MSS) reflecting the main research institution, and the Royal Marine Conservation Society of Jordan (JREDS) reflecting the main NGO.

Table 2.6: Stakeholders' institutions and percentage of respondents who mentioned them. The gradient in the blue colour reflect the response rate, darker colour means a higher response rate. Total number of respondents, 18.

Stakeholder institutions	Response Rate
ASEZA	100%
MSS	56%
JREDS	56%
Others*	
Glass boat society	17%
Aqaba Development Company	17%
Hotel sector	11%
Fishers Society	11%
Ministry of environment	11%
Environmental rangers	6%
Royal Jordanian Navy	6%
Jordan Maritime Authority	6%
Aqaba Ports Cooperation	6%
Diving Centres	6%
Ministry of labour	6%
Jordan Environment Society	6%
Royal scientific society	6%

Response Rate %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

*** Others: detailed description for the stakeholder institution is not included in the section, either because it has low response rate or because there was no enough data to support it.**

2.4.1. Aqaba Special Economic Zone Authority (ASEZA)

The city of Aqaba is located within the Aqaba Special Economic Zone (ASEZ) - a duty-free, low tax development zone launched in 2001 covering an area of 375 km^2. ASEZ is governed by (ASEZA) established under the ASEZA law No (32) for the year 2000 and its amendments. ASEZA is the main ICZM stakeholder in Aqaba (response rate = 100%) (Table 2.6). ASEZA is a financially and administratively independent executive statutory institution that is responsible for the regulatory, administrative and financial issues of ASEZ (ASEZA, 2006). Under its organizational structure (Figure 2.4), ASEZA consists of five commissions (ASEZA, 2006);

1. Economic Development and Investment Affairs Commission,
2. Environmental Affairs Commission,
3. Administration and Financial Affairs Commission,
4. Customs and Revenue Commission, and
5. Infrastructure and Services Affairs Commission.

According to ASEZA's Strategic Plan for 2007–2010, the goals are: to enhance the national economy by encouraging investments; update continuously the legislative framework for ASEZ; enhance the social and economic levels of the local community; represent Aqaba as an example of good management practices; increase the touristic attraction; and develop appropriate infrastructure for future growth (ASEZA, 2006).

Aqaba is governed by a regulatory framework, encompassing a set of national and local laws, regulations, instructions and standards (R1, R2, R3, R4, R7, R8, R10, R11, and R12) as listed in Appendix 2. In addition, ASEZA has adopted policies to enhance environmental protection in areas of water, energy conservation, and discharge. This regulatory framework can play a crucial role in the integrated management for Aqaba, and represents a rigid reference for the best management practices environmentally, economically, and socially. The Commission of Environmental Affairs within ASEZA is responsible for the protection of the coastal and marine environment (2001 Regulation No. 21: "Regulation for Protection of the Environment in Aqaba Special Economic Zone") (R1, R2, R10, R11). Respondents mentioned the three ICZM related entities as part of this commission: The environment directorate, Ben Hayyan laboratories, and AMP.

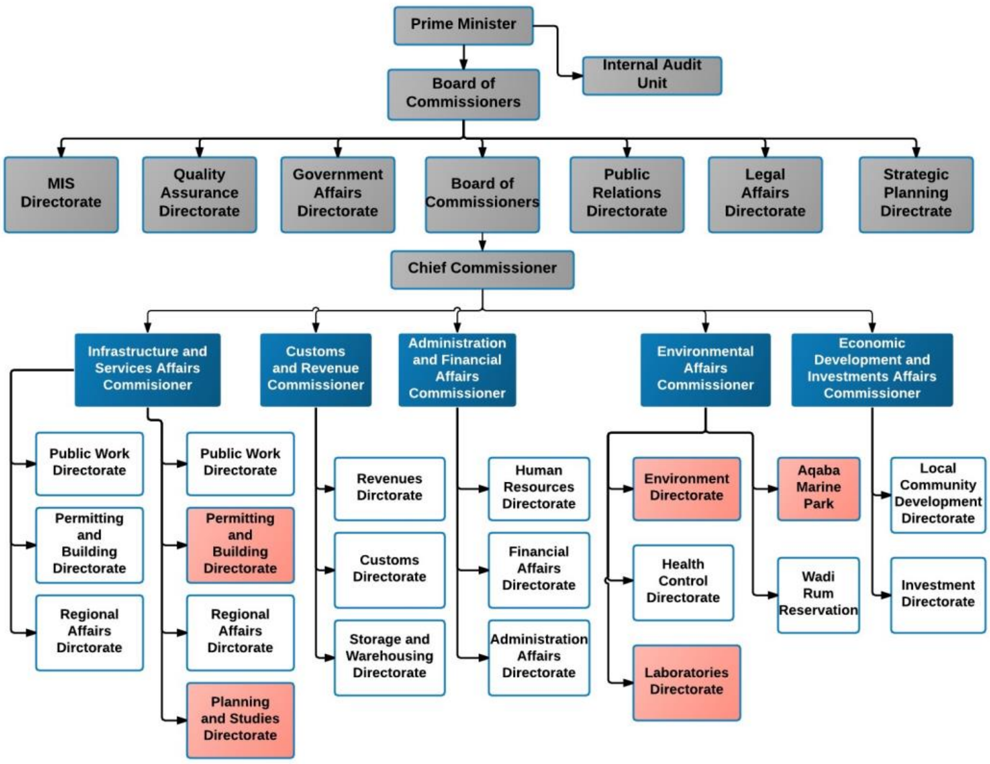


Figure 2.4: Organizational Structure for ASEZA.

Source: ASEZA, 2006

2.4.1.1. Environment Directorate

The “Regulation for the Protection of the Environment in the Aqaba Special Economic Zone”, mentioned above, identifies the best management practices to protect the environment, describing the required procedures for both Environmental Impact Assessment (EIA) and Environmental Audit (EA), and management for air protection and marine environment protection (R1) (R1, R2, R10, R11).

The directorate’s work is performed within three divisions: 1) environmental studies division; 2) environmental impact assessment/auditing division; and 3) the environmental permission division. Figure 2.5 summarizes the information on existing coordination between the environment directorate in ASEZA and other ICZM actors based on the stakeholders’ perceptions.

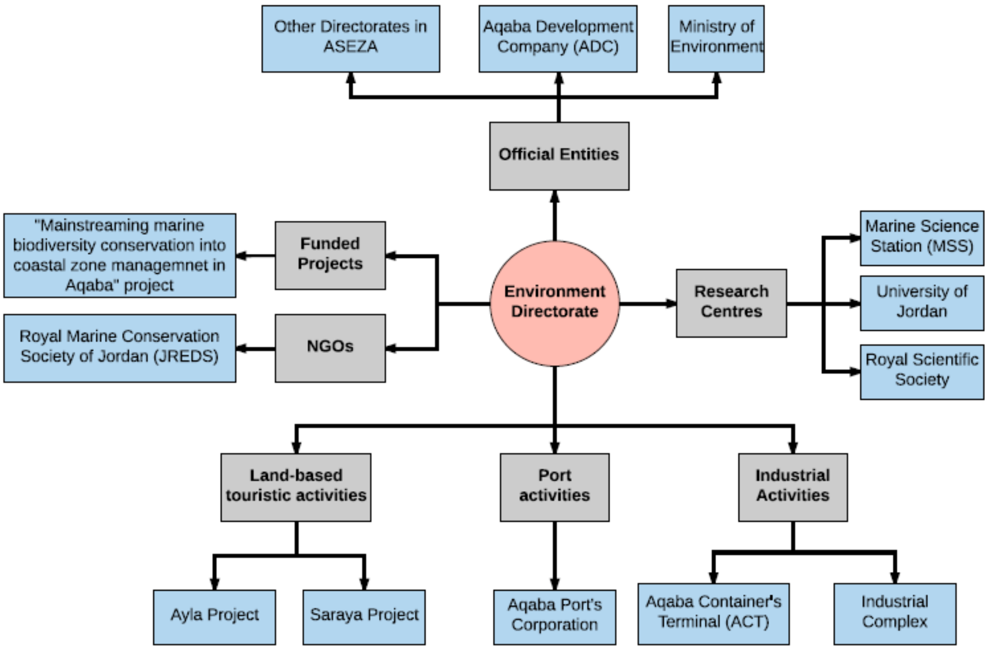


Figure 2.5: Coordination between the environment directorate in ASEZA and other ICZM actors in Aqaba.

1- Environmental Studies Division

This division is responsible for monitoring the marine environment (water quality and benthic habitats) according to the National Monitoring Program (NMP). ASEZA has signed a contract with MSS for sampling, conducting the analysis, and reporting back to the division on the quality of the marine environment along Aqaba coastline. The division is also responsible for reviewing and updating the issued reports by MSS (R1). Self-monitoring programs for the water quality of the lagoons of the private projects are also conducted under the supervision of the division. Examples of this include Ayla and Royal Yacht Club

(RYC) in the touristic zone, and Tala Bay in AMP zone. Also, the lagoons of Saraya will be monitored once the construction is finished (R1).

Other entities cooperate with the division to monitor the marine environment. For example, Aqaba Ports Corporation monitors the coast within its premises and submits periodic reports to the division. The Aqaba Container Terminal (ACT) is obliged to send periodic reports on water and air quality to be reviewed by the division (R1).

2- Environmental Impact Assessment and Environmental Auditing Division

EIA and environmental audit are crucial tools for effective coastal management (R10). The environmental protection regulation specifies all the requirements for both, EIA and environmental audit. Moreover, ASEZ master plan 2013 (Appendix 3) is also considered a reference document for the division. The "planning and studies" directorate within the "infrastructure and services affairs" commission (Figure 2.4) informs the "Environmental Impact Assessment and Environmental Auditing" division about the allowed activities based on the master plan before issuing the environmental approval (R10).

The Head of the division (R10) indicated that the division coordinates the EIA process through the land sale activities, which can be under either ASEZA or Aqaba Development Company (ADC) jurisdiction. For ASEZA supervised land, a representative from the division sits on the land property selling committee to identify EIA needs. For lands under the ADC jurisdiction, a specific agreement forces any investor to get the necessary environmental approvals (including checking with the division if an EIA is required) before buying or renting land. Subsequently, ASEZA follows up with the investor till the end of the EIA process and monitors the project's activities during its construction and operation phases.

The division also coordinates with other directorates within ASEZA to ensure that any proposed or current investments comply with environmental requirements, including the following cases:

1. For Small-Medium size lands sold through ASEZA, potential investors are required to specify the nature of land use and the division representative in the Land Sales committee directs the application form to the EIA division in order to check the requirement of "full" or "preliminary" EIA, a similar procedure is followed when the investor asks for a change in the nature of an existing project (R10).

2. For large investments, EIA referrals to the division are made by a higher level committee overseen by the planning and studies directorate with the membership of the environment commissioner and the environment director. (R10).

3. The division is also electronically connected with the infrastructure and services affairs commission (Figure 2.4) through the "permitting entities" system for proposed projects that enable ASEZA to implement a one-stop shop concept (R10).

As ASEZA is responsible for environmental protection in ASEZ (Aqaba Special Economic Zone), while the Ministry of Environment (MOE) is responsible for it in the rest of the kingdom, joint EIA studies are conducted for projects that span across the jurisdiction of both entities. An example of this is the Egyptian gas project, which includes a gas pipeline connecting Taba in Egypt to Rihab in the north of Jordan passing through ASEZ (R10).

Highlight that ASEZA and MOE have different EIA procedures. The head of the EIA division in ASEZA (R10) stated that the role of local participation in ASEZA is higher compared to MOE, which is achieved through holding two scoping sessions for the EIA study compared to one session for MOE. Moreover, ASEZA shares an executive summary for the proposed project with all the stakeholders including locals prior to the sessions allowing them to provide comments on the project twice. Furthermore, ASEZA presents a preliminary TOR (prepared by the consultant carrying out the EIA) in the first scoping session and solicits input from participating stakeholders to arrive to the final TOR, while in MOE case, the TOR is presented in the scoping session for information purposes only (R10).

3- Environmental Permission Division

This division is responsible for conducting the environmental inspection on facilities under construction and operation to assure their compliance with environmental requirements, it also coordinates with MOE issues related to dangerous waste, where a joint committee is established to oversee the inspection, packing, and loading of this type of waste (R11).

2.4.1.2. Bin Hayyan Laboratories

Bin Hayyan laboratories are connected to the Environmental Affairs commission (Figure 2.4) and supervised by the Environmental Studies Division. They conduct both compulsory and self-air monitoring activities (R7).

Compulsory air quality monitoring is done using two fixed stations: one located near the downtown residential area, and the other between AMP and the industrial zones. Allowable levels for emissions are set by the Jordanian National Ambient Air Quality Standards (JS 1140/2006). Pollutants monitored include: sulphur dioxide (SO_2), nitrogen oxides (NO_2), carbon monoxide (CO), ground-level ozone (O_3), volatile organic compounds (VOCs), particulates (PM_{10}), ammonia (NH_3), and hydrogen sulphide (H_2S). Self-monitoring of point emission sources (R1) mainly for the industrial facilities, with reference to the Jordanian Point Sources Emission Standards (JS 1189/2006) includes monitoring air pollutants such as SO_x and NO_x (R1).

2.4.1.3. Aqaba Marine Park (AMP)

AMP was established in 1992 with the main objective of protecting the marine environment, preventing coral damage, and regulating the fishing and diving activities within its borders (R3). It is a marine natural reserve which extends along 7 km on the south coast of Aqaba, with a width of 400 m. The border starts from the MSS in the north and Tala Bay in the south (R3). The park is governed by Regulation No. (22) For the Year 2001 “Regulation for AMP” and its amendments issued by virtue of Article (56) of ASEZA Law No (32) for the Year 2000 and its amendments. Consequently, designated instructions were issued by the article (14) of AMP regulations to cope with this special zone as listed in Appendix 2. However, if there are cases that cannot be resolved by the regulations of AMP, the reference regulation would be “the environmental protection regulation” of ASEZA (R3).

As a Marine Protected Area (MPA), the park’s tasks include protecting and monitoring sea water quality and diving sites within the park, public awareness, outreach and environmental education (e.g. visits, lectures, films, marine activities, and/or joint clean-up campaigns in the coast and deep sea). The park cooperates with many entities including the Royal Marine Conservation Society of Jordan (JREDS), Divers Society, divers and glass boats community (R3) (Figure2.6). More specifically, AMP coordinates with:

1) MSS and university of Jordan (Aqaba branch) in conducting marine research and studies. Researchers from those research entities are invited to consultation sessions and meetings in ASEZA (R3),

2) The Royal Jordanian Navy on boat traffic and marine security (R3),

3) The Jordanian Maritime Authority on boat licensing, marine sites identification, maritime activities, tourism marine transportation, and aqua fishing activities (R3),

4) Hotels within the park's borders on awareness issues such as the signage system along the coast, activities within the swimming sites and parking of boats (R3),

5) NGOs such as the glass bottom boat society, fishermen society, and JREDS on boating activities, awareness, and "Clean up the World" campaign (R3), and

6) Aqaba Ports Corporation (APC) and MSS on "Valuating Environmental Damage" which is done through a committee tasked to document the damage and transferring relevant cases to authorities (R2).

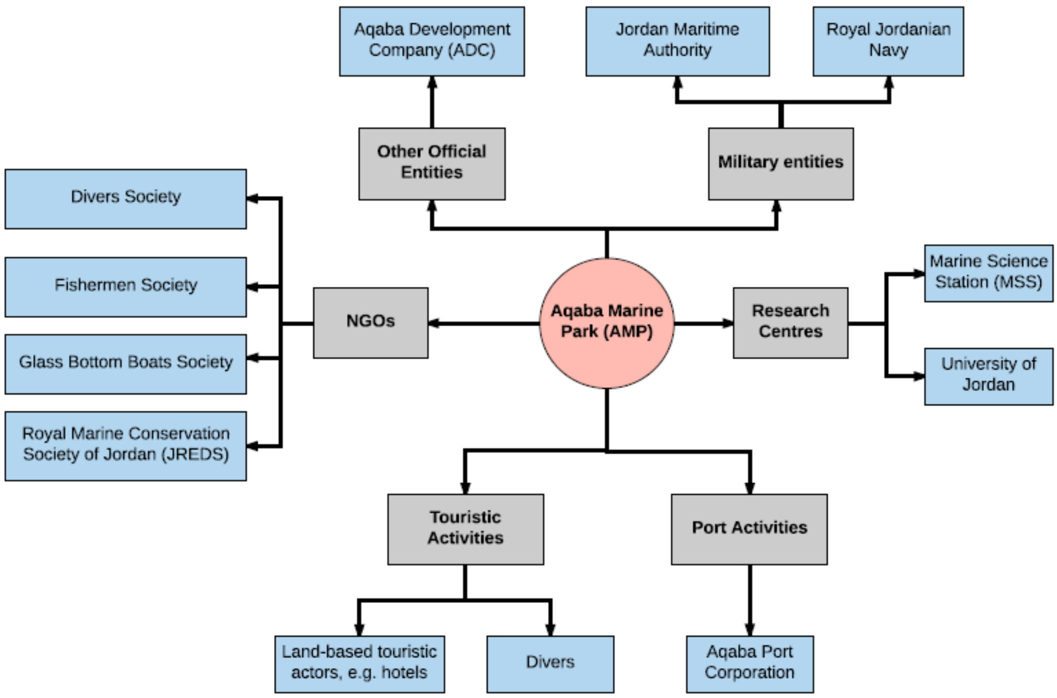


Figure 2.6: Coordination between AMP and other ICZM Actors in Aqaba.

2.4.2. Marine Science Station (MSS)

The Marine Science Station was established to promote marine and coastal research; and hosts researchers and students from the University of Jordan – Aqaba branch and the Yarmouk University in Irbid (a city in the north of Jordan). MSS also implements the National Monitoring Program (NMP) – More details on this program are presented in section 1.5.1.2 (R15, R16, R17, and R18).

MSS also serves as a consultative and information centre that provides services to various stakeholders such as ASEZA, Bin Hayyan laboratories, and the Royal Society for Conservation of Nature (RSCN) (R1, R15, and R17). Figure 2.7 shows the coordination links between MSS and other ICZM actors.

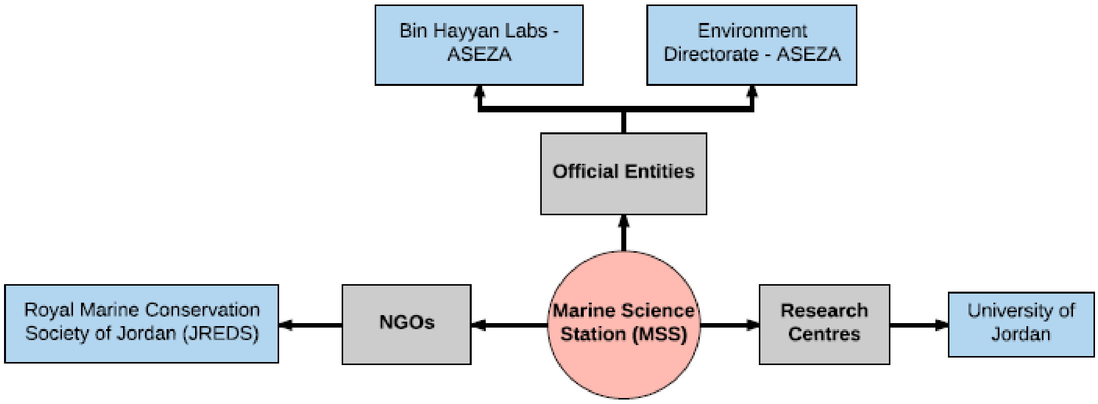


Figure 2.7: Coordination between MSS and other ICZM actors in Aqaba.

2.4.3. The Royal Marine Conservation Society of Jordan (JREDS)

JREDS is a local NGO established in 1993 as an active environmental society dealing with marine and coastal protection (R5). JREDS also represents Jordan in the Foundation of Environmental Education (FEE) since 2008. The FEE manages several marine and coastal management programs such as the "Blue Flag," Green Key", and "Eco School" (R4, R5). JREDS coordinates with military entities like Jordan Maritime Authority in issues related to public safety and security purposes along the coast (R5) as shown in Figure 2.8.

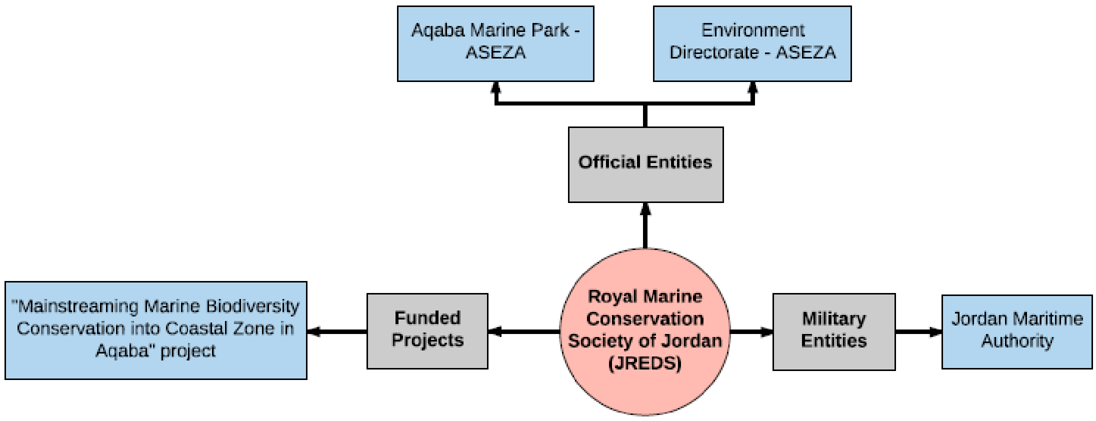


Figure 2.8: Coordination between JREDS and other ICZM actors in Aqaba.

2.5. Progress of ICZM Implementation in Aqaba

ASEZA's mission is to encourage the economic development activities and investment in Aqaba. In doing so, the challenge has been to achieve a balance between the economic, social, and environmental status along the short coastline, while utilizing coastal resources in a sustainable manner (R7). There is a high turnover in top management positions, specifically in ASEZA, which adds to the challenges of ICZM implantation, as it results in changing priorities and approaches in handling coastal issues (R3, R7).

2.5.1. Initiatives and success stories toward ICZM implementation

Despite the lack of legal and institutional frameworks for ICZM in ASEZA; ICZM is being implemented to some extent by ASEZA's commissions, especially through the environmental affairs commission (Figure 2.4). ICZM initiatives reflect the first sub-theme for the third main theme presented in Figure 2.2. This section describes initiatives and success stories towards enhancing the state of the coast based on the semi-structured interviews,

2.5.1.1. ASEZA Efforts for ICZM Implementation

ASEZA attempts as a "regulator" to decrease negative impacts and mainstream all efforts for enhancing the quality of Aqaba coastline through environmental protection, coastal zoning and planning (R7).

ASEZA adopted a zero discharge policy since 2001, which prevents dumping any solid or liquid that may affect the seawater quality. The only exception to this policy is the water discharged from the thermal power station in the industrial zone. In addition, ASEZA attempts to protect the coastal environment through requiring environmental impact assessments and environmental audits before granting approvals to development projects (R7).

ASEZA has also updated the land use master plan in 2013 to improve coastal zoning and planning (Appendix 3). This plan recognized "coastal zones" and "beach protected areas" and defined coastal zone seaside to be 50 m away from the highest tide point (R7).

ASEZA conducts monthly monitoring of biological parameters like Enterococci and E-coli for bathing water along public beaches and takes the appropriate action in case those parameters exceeds the allowable limits (R12).

2.5.1.2. The National Monitoring Program (NMP)

The NMP monitors: a) sea water quality (physical and chemical parameters), b) sediment quality, c) fish, and d) benthic habitats. Details of these four components are listed in Appendix 4. The NMP is run by MSS, with information reported annually to ASEZA. There are 12 monitoring sites categorized within four zones (R7, R16, and R18) as follows:

1. The touristic zone (Ayla, Saraya, and Ghandoor beach).
2. The port zone (fishermen's port, phosphate port, and cement port).
3. The AMP zone (MSS, national campsite, Tala Bay – Inside, and Tala Bay - outside).
4. The industrial zone (thermal power station, Arab Fertilizers and Chemical Industries Company KEMAPCO).

The parameters related to physical conditions, chemical properties, and biological quality of sea water are monitored on monthly basis (see Appendix 4), while the parameters related to corals and fish are monitored on annual basis and along seven sites only (R15).

2.5.1.3. Mainstreaming Marine Biodiversity Conservation into Coastal Zone Management in Aqaba project

This UNDP funded project aims to enhance the level of awareness on integrated management with reference to some international conventions like CBD (Convention on Biological Diversity) (R2). The project addresses issues about knowledge management, institutional capacity building, establishing GIS databases, coral translocation, and ecotourism (R2).

2.5.2. Challenges to Successful Implementation of ICZM in Aqaba

Table 2.7 describes the stakeholders' perceptions on the main challenges. More than 70% and 60% of the respondents mentioned issues related to 'Lack of local knowledge' and 'Weak participation', respectively. The most common challenges as perceived by respondents include lack of local knowledge, weak participation, weak enforcement, and low level of awareness.

Table 2.7: ICZM challenges and percentage of respondents who mentioned these challenges. The gradient in the blue colour reflect the response rate, darker colour means a higher response rate. Total number of respondents, 18.

ICZM Challenge	Response Rate	Description
Lack of local knowledge	72%	Examples include 1) weak understanding for the ICZM concept and the marine environment. 2) Unclear definition for the coastal zone and coastline. 3) Lack of: coastal profile, sea use plan, fish statistics, GIS maps for environmental resources, sea water quality for the entire coastline, valuation methods for evaluating the environmental damage, satellite images for the sea, baseline studies about corals and fish.
Weak participation	61%	Lack of participatory approach, and weak participating for NGOs, researchers, private sector, and other officials (than ASEZA representatives).
Weak enforcement	39%	Due to 1) lack of capacities to enforce the law, 2) economic, political and social issues, 3) conflicts between legislations.
Low level of awareness	17%	Examples include the level of awareness among boaters, industrial touristic actors, in addition to inefficient environmental campaigns.
Others*		
Conflict of Interests	28%	Examples include conflicts among officials and between officials and NGOs.
Non-Integrated management	11%	For example, ICZM is not institutionalized within ASEZA, and implementing ICZM on project base.
Rehabilitation for Al-Hafayer	11%	NA
Difficulties in implementing environmental solutions	6%	Due to high costs associated with the environmental mitigation measures
Establishment of ASEZA	6%	NA
Weakness in encouraging tourism	6%	Weakness is the result of the low level of awareness and the weak role of media.

Response Rate %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

*** Others: detailed description for the stakeholder institution is not included in the section, either because it has low response rate or because there was no enough data to support it.**

2.5.2.1. Lack of local knowledge

Thirteen respondents discussed issues related to lack of knowledge including 1) weak understanding for the ICZM concept, 2) lack of scientific knowledge, 3) lack of legislative knowledge, and 4) lack of resources. Those categories are illustrated in the following examples.

a) Weak understanding for the ICZM concept

Weak understanding for the ICZM as a challenge was reported by 5 respondents (R1, R2, R10, R15, and R18), including one respondent in top management position (R10). This category involves issues related to basic definitions of the coastal zone (R1, R10) and the requirements for the coastal management (R1). For example, one respondent stated that some of the ICZM actors are not able to distinguish between the marine and the coastal environment (R2).

b) Lack of scientific knowledge

Lack of scientific knowledge was raised by 61% of respondents (R1, R2, R3, R5, R7, R8, R10, R15, R16, R17, and R18), including the following examples:

1- Two researchers stated that data about sea water quality is not available for the whole coastline, and that the only available data is produced through the NMP for only specific monitoring sites (R1, R2). The MSS Director (R17) mentioned that there was no scientific reference for selecting the locations for the monitoring sites.

2- There is a lack of studies about corals status in Aqaba (R3, R5, R16, and R18), and the few available are not updated to reflect the current corals status. For example, the last coral sensitivity map was prepared at the end of the 90s by a French company (R3, R7).

3- Respondents reported the lack of studies about existing fish stock (R3, R5, R16, and R18). A researcher (R16) highlighted that there are no comprehensive studies that identify quantities and types of available fish or that evaluate the status of fishing activities (e.g. catches) in Aqaba.

4- The spatial distribution of coastal resources, which is crucial for the coastal management is lacking in Aqaba. Many respondents agreed on the lack of GIS maps for the marine resources including corals, fish, and seagrass (R3, R5, R7, R8, R10, R15, R16, R17, and R18). These maps, if they existed, could be used to evaluate if there is a correlation between the location of the marine resources and specific parameters like the water quality (R15). A researcher stated that the only comprehensive survey for corals was conducted in the industrial zone with the only purpose of informing the main port translocation (R15). However, the same respondent added that there is no coral map showing the current coral baseline conditions after the translocation from the industrial zone or the transplanted corals in the AMP zone (R15) which was also confirmed by the manager of AMP (R7). It was also mentioned that there are no processed satellite images for marine resources in Aqaba (R8).

c) Lack of Legislative knowledge

Even though ASEZA is being governed by the land use master plan updated in 2013 (Appendix 3), there is no sea use plan for Aqaba that organizes the touristic, ports, industrial and fishing activities along the coast (R2, R7, R9, and R10). Moreover, there is a lack of legislative reference for conducting economic valuation studies of the environmental damage that can inform decision-making (R11, R16).

d) Lack of Resources

The lack of resources was reflected by the need for an international expert to carry out the transplant of a small area of corals in the AMP due to lack of local expertise in this field (R2). Moreover, 7 respondents discussed difficulties in accessing the available studies (R3, R5, R7, R11, R15, R17, and R18) especially with the ones in the governmental entities represented by ASEZA, which seems to be a challenge even for officials in ASEZA themselves (R3).

2.5.2.2. Weak Participation

One of the major challenges in ICZM implementation in Aqaba is the weak participation of stakeholders. Two researchers (R15 and R16) and one official (R3) indicated that their knowledge and perceptions are not considered within the decision-making process. A researcher said: "*ASEZA is not doing its best in engaging all stakeholder institutions in managing the coastal zone*" (R15). This challenge was expressed by more than 60% of respondents (R1, R2, R3, R5, R7, R11, R12, R14, R15, R16, and R18) including the following examples facing officials, researchers, locals, and private sector:

1- Weak participation between officials in ASEZA and officials of institutions outside Aqaba borders, such as the case of Ministry of Labour, when carrying on environmental inspection on facilities (R11 & R12).

2- One researcher (an expert in the benthic habitats especially corals) stated that the scientific knowledge was not taken into account in the decision and process of translocating corals from the industrial zone due to construction of the new main port (R16). Researchers are not involved in adding to the limited available knowledge about fish and fishing activities (PR15).

3- Low level of local community (represented by NGOs) engagement with AMP (R1, R3). The only type of participation is done through conducting environmental campaigns or by attending AMP workshops (R1). In addition, participation of local community and NGOs in the ICZM process has been limited to an invitation to attend the scoping sessions within an EIA processes (R2, R5, and R11).

4- Although the UNDP project was tackling ICZM issues, research centres and NGOs have not been adequately involved in its activities (R16).

5- A consultant from the private sector reported that weak coordination between the private sector and ASEZA characterise the implementation of the CDM project of Aqaba Electricity Company (R14).

2.5.2.3. Weak enforcement

Due to various economic, political and social issues, enforcement is a challenge in Aqaba (R3, R15). In some cases, ASEZA has many cross cuttings issues with various institutions, so their mandate is not that clear (R2). Stakeholders mentioned different examples including:

1- The illegal construction of Tala Bay resort on the beach (R4).

2- The illegal inaccessibility of beaches opposite to the hotels for locals, as hotels are closing these beaches and not allowing access to them without paying entrance fees (R7).

3- The low amount of compensation for damaged corals in the new main port area, which violates the amount stated by law (4000 JD compensation per damaged meter square of corals, 1 JD is approximately equals to 1 pound) (PR16).

2.5.2.4. Low level of environmental awareness

There is a low level of environmental awareness among the ICZM actors (R2, R13, and R15). One respondent (R2) said that environmental management awareness is all about printing brochures and posters, and in his opinion, this is inefficient and not enough. Another respondent stated that although tourism is the main source of income in Aqaba, too little attention has been done to enhance the level of awareness among locals with respect to interaction with tourists in their use of the coast (R15). In another example, the respondent (R13) mentioned that there is a low level of awareness among the industrial facilities in Aqaba regarding energy efficiency issues (R13).

2.6. Discussion

This Chapter presents the results of stocktaking carried out in Aqaba, identifying the main coastal sectors, stakeholder institutions, relevant legal references, and the challenges hindering successful ICZM implementation based on the input of Aqaba ICZM actors. The components of the stocktaking mentioned above were recommended in the literature (González-Riancho *et al*., 2009; Pickaver *et al*., 2004; EC, 2002; World Bank, 1996; GESAMP, 1996) in order to evaluate the state of the coast and the progress of ICZM implementation along the coastal zone under study.

The Chapter showed that the use of semi-structured interviews was a suitable approach for developing the stocktaking of Aqaba coastline. Consistently with the literature (Ramsey *et al*., 2015; Soriani *et al*., 2015; Chaniotis and Stead, 2007), it helped in providing better knowledge about the stakeholders' consciousness on coastal status, with the open-ended questions allowing new ideas to be highlighted. The use of the DPSIR framework helped in the thematic analysis through structuring and linking the pressures caused by specific coastal activities with the associated negative environmental impacts on the coastal resources.

The literature shows that worldwide coastal resources include vegetation cover such as mangroves and seagrass (e.g. Das and Mandal, 2016; Lagbas and Habito, 2016; Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010; Agardy *et al*., 2005; World Bank, 1996), marine habitats such as fish, prawn, crabs, molluscs (e.g. Das and Mandal, 2016; EC, 2009; World Bank, 1996), coral reefs (e.g. Lagbas and Habito, 2016; Alhorani *et al*., 2006; Agardy *et al*., 2005), and beaches and dunes (e.g. Agardy *et al*., 2005). The findings of this Chapter show that some of those resources exist in Aqaba, with stakeholders being particularly aware of corals, fish, seagrass, and sediments. The presence of corals is important because coral areas are considered high productivity areas (Lagbas and Habito, 2016). For example, the mean net primary productivity (kg/m^2/year) for the corals is 2.5, compared with tropical rain forest (2.2), swamp and marsh (2.2), and estuaries (1.5) (Agardy *et al*., 2005). Corals along with seagrass in Aqaba provide the food and shelter for 507 fish species that belongs to 109 families (Khalaf, 2004) which is consistent with the statement of one of the respondents. However, only one respondent, an expert in benthic habitats, managed to provide some details about corals types and distribution in Aqaba, showing a lack of detailed knowledge about this resource across ICZM actors.

Fishing was thought to be not economically viable due to low fish stock in Aqaba. This contrasts with the fact that this activity seems to support the livelihood of local fishing communities. Therefore, suggests a lack of knowledge on the status of the fish stock in Aqaba; and the need to include fishermen in further research on the development of the coastal profile for ICZM implementation. In addition, fishermen seem to use traditional simple fishing gears to accomplish their work. Commonly used fishing gears in Aqaba include gillnets, with depth (width) of 10 m and length of 60 m (for commercial fishing), hand-lines and hand-reels (e.g. to catch surface swimming tuna), monofilament longline (e.g. to catch mackerels and bonitos), and traps or "the cages" made from wire mesh, (e.g. used for catching all fish species) (Abu-Hilal and Al-Najjar, 2009). The last type was mentioned by the fishermen during the interviews (See Appendix 5). Seagrass, although barely mentioned by stakeholders, have been reported as abundant along the Gulf of Aqaba (Kochzius, 2002).

Aqaba hosts diverse activities operating within five zones along its coastline: touristic, ports, AMP, the special, and the industrial zones are designated following the NMP and the common knowledge among the stakeholders. Land-based touristic activities and fishing activities are located primarily within the touristic and AMP zones; port activities are within the port zone and to a lesser extent within the industrial zone; and finally, industrial activities are clustered within the southern industrial zone. These findings show that there are no unique coastal activities in Aqaba compared to other coastal cities worldwide (Papageorgiou *et al*., 2017; Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010; EC, 2009; González-Riancho *et al*., 2009; EC, 2002; World Bank, 1996) and that other activities, such as agriculture, aquaculture, energy related activities (e.g. power generation) often described in the literature (Papageorgiou *et al*., 2017; Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010; EC, 2009; González-Riancho *et al*., 2009; EC, 2002) are not common in Aqaba. The geography of the area being confined between rocky mountains (Al-Khlaifata and Al-Khashman, 2007), and its arid lands with limited fresh water availability (Al-Rousan *et al*., 2007) limits the development of agricultural activities in Aqaba. There is also low precipitation rate, less than 2 cm/year (Yehudai *et al*., 2017), and a high evaporation rate, 200 – 265 cm/year (Manasrah *et al*., 2006). In addition, Jordan is considered one of the poorest countries in fresh water resources (Al-Omari *et al*., 2009). Solar and wind energy activities, although lacking in Aqaba, this sector has a great potential (Anagreha and Bataineh, 2011; Anagreh *et al*., 2010), because there is an urgent need to find an alternative source of energy due to lack of conventional energy resources in Jordan (Hrayshat, 2008).

The expansion of human-related activities operating along fragile coastal ecosystems significantly impacted the productivity and the functioning of their resources (e.g. Agardy *et al*., 2005, MA, 2003). The findings of this work show that Aqaba ICZM actors are concerned about the anthropogenic pressures on the coastal ecosystems derived mainly from land-based touristic activities and port activities. Aqaba is a major touristic destination for local and international tourists due to many reasons: the strategic location, warm weather and sandy beaches, nearby famous touristic destination "Petra", the unstable political conditions in the surrounding countries, and the vision of ASEZA that encourage the touristic sector.

All of the above resulted in an expansion in the touristic sector and the pressures caused by those activities were mentioned by half of the stakeholders interviewed in this study. Such pressures include construction activities, the artificial lagoons, and the high number of visitors, oil leakage, and solid waste generation. This is consistent with Kochzius (2002) who stated that tourism in Aqaba is generating significant pressure on the natural resources on the coast through discharging of sewage, generation of solid waste, and the various conducted recreational activities. Port activities are economically important in Aqaba as it is the only marine outlet for the kingdom (Al-Rousan *et al*., 2016). Pressures resulting from port activities were also of concern by stakeholders interviewed, who mentioned construction activities, oil leakage, and solid waste generation, consistently with previous studies (Alhorani *et al*., 2006; Kochzius, 2002). Note that fishing activities and their pressures were only mentioned by just a few respondents; even though they are acknowledged in the literature. For example, Alhorani *et al*. (2006) show how destructive fishing methods have impacted the corals in Aqaba. The lack of representation for local fishermen in this analysis can justify this result.

Results show that stakeholders agreed that touristic, ports and industrial activities are causing habitats degradation (especially on corals), as the major negative impact along the coast; followed by water and air pollution. Kochzius (2002) also concluded that corals in Aqaba are threatened by the human pressures, mainly tourism, industrial pollution, as well as shipping and port activities. Kotb *et al*. (2015) stated that corals in Aqaba are considered the most threatened in the Red Sea because they are mostly shallow, easily accessible and is located nearby urban developments.

Through its efforts to conserve the coastal resources, ASEZA adopted the regulation for the protection of the environment, followed the Jordanian national air quality standards, and adopted the zero discharge policy. However, stakeholders expressed their concerns about the current and future impacts of pollution, caused by land and marine coastal activities. Touristic and industrial activities are the main source of land-based pollution, while port activities are the main source of marine pollution. As the second largest point for phosphate export worldwide (Al-Rousan *et al*., 2016), the pollution resulting from phosphate related activities in Aqaba can be a major coastal pressure. The phosphate powder generated during handling find its way to the water and air, and is considered one of the major environmental pressures in Aqaba, highlighted by the stakeholders, and recognised in the literature (Al-Rousan *et al*., 2016; Al-Sawalmih, 2016; Abu Hilal and Al-Najjar, 2009). The impacts of such sediments can significantly reduce light, impact the primary productivity, and affect the growth of corals, which impact other marine habitats (Al-Rousan *et al*., 2016). A possible explanation for the environmental impact is the insufficient legislation to conserve the coastal resources and the weak level of enforcement in Aqaba. Another explanation is the weak monitoring during the construction and the operation phases of the phosphate port, although they are requirements stated within the EIA procedure.

The city of Aqaba was designated as a special zone with its own regulatory framework for the strategic goal of encouraging economic development and investments. As stated by respondents, ASEZA is tasked to pursue this goal while trying to conserve the environment through implementing EIAs, environmental audits, inspection and monitoring, regular monitoring of the marine environment through the NMP. A combination of instruments like those used by ASEZA is considered crucial for successful ICZM implementation (EC, 2000). In addition, there is the zoning system and an updated land-use master plan, tools that are developed to ensure conserving the coastal zone, yet, they actually originated from the planning directorate and have been converted into ICZM tools, following similar processes in the Atlantic coastal region (International Ocean Institute, 2006). In addition, ICZM is not institutionalized within the structure of ASEZA. There is no single unit responsible for managing and monitoring the state of the coast. Moreover, ASEZA’s high turnover of top management positions leads to inconsistent implementation and prioritization of the integrated management. There is no ICZM strategy and what were described are only fragmented tools to address coastal issues. Furthermore, the development of an ICZM strategy for Aqaba would require professionals and capacities, as well as conflicting interests' resolution between the stakeholders (International Ocean Institute, 2006).

Finally, this Chapter shows that the most widely recognised ICZM challenges according to the stakeholders interviewed are lack of knowledge, particularly, spatial knowledge, and lack of public participation of the local community in ICZM decision-making. These are major factors for successful ICZM implementation worldwide (Soriani *et al*., 2015; Breen and Hynes, 2014; Areizaga *et al*., 2012; Fletcher, 2003; EC, 2002; GESAMP, 1996). Other identified challenges from the interviews are weak enforcement, conflict of interests among ICZM actors, and low levels of awareness. Similar ICZM challenges found in the literature include (*i*) monitoring the state of the coast (Pak and Majd, 2011); (*ii*) legal and political issues such as inadequate legislation and lack of adapting coastal policies (Areizaga *et al.*, 2012; Chaniotis and Stead, 2007; Dauvin *et al*., 2004; World Bank, 1996); and (iii) increasing conflicts among coastal users (Papageorgiou, 2017; International Ocean Institute, 2006; World bank, 1996). Areizaga *et al*. (2012), González-Riancho *et al*. (2009), and EC (2007) identified funding, as an additional key challenge, which was not found an issue in Aqaba.

2.7. Conclusion

This Chapter concludes that more effort is needed in terms of integrating all the ICZM stakeholders to sustain the coastal zone and its resources. It is crucial to enhance the level of involvement of the local community to develop the coastal profile needed in the first stage with the ICZM cycle. In the absence of a participatory approach that involves all the ICZM stakeholders and the required knowledge to understand the wider picture for this complex zone, the ICZM process is still in its early stages in Aqaba. Actions are needed to acquire knowledge and begin a participatory planning process. Work is also required to enhance the level of coordination and awareness amongst the various coastal resource users in order to have a successful ICZM. The following Chapters provide a step in this direction.

3. Chapter Three: Methodology – Participatory Geographic Information System (PGIS)

3.1. Introduction

Chapter Two showed that ICZM stakeholders recognised a lack of knowledge, especially spatial knowledge, about coastal resources, as well as weak participation of non-official stakeholders in the decision-making process, as significant challenges to the effective implementation of ICZM in Aqaba

This Chapter explains the theory behind, and implementation of the PGIS methodology, which is used in this thesis for:

1- Developing a coastal profile for coastal activities and resources;
2- Identifying coastal pressures and impacts and their spatial distribution;
3- Identifying coastal conflicts among ICZM actors; and
4- Identifying priority areas that require special management attention.

The use of this methodology allows the researcher to (*i*) fill the gap in current knowledge based on the input from a broad set of ICZM actors, officials, researchers, and locals, (*ii*) engage all stakeholders in the ICZM cycle from its first stage, (iii) begin to enhance public participation in the decision-making process. The locals represent the direct and the primary users of coastal resources. Participatory GIS (PGIS) can contribute to community empowerment, social learning, and the creation of social capital in Aqaba, with the additional benefit of the production of maps (Brown and Kytta, 2014; Brown, 2012a).

PGIS is a socially engaging tool (Ramirez-Gomez *et al*., 2017), and consequently, the produced PGIS maps differ from traditional maps as the actual mapping process and the time spent for interviews, provide meaningful discussions that increase the social equity and legitimacy of the final results (Ramirez-Gomez *et al*., 2017; Wilson and Howarth, 2002). The process can, therefore, enhance the end users' capacity to be able to effectively participate in the decision-making process through 1) legitimizing the local knowledge, 2) enabling ownership, and 3) enhancing the capabilities of the locals in assessing the changes to their environment (Sayer *et al*., 2013; Jankowski, 2009; Rambaldi *et al*., 2006; McCall and Minang, 2005; Talen, 2000).

As mentioned in Chapter one, the first step in implementing the ICZM program is to combine all the required information in terms of environmental, socioeconomic, institutional, and regulatory aspects about the coastal zone under investigation (Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009; Christie *et al*., 2006; ATKINS, 2004; Tortell, 2004; GEF/UNDP/IMO, 1996; World Bank, 1996; GESAMP, 1996; Robadue, 1995). The coastal profile which is a basic requirement for efficient ICZM implementation is missing in Aqaba following the semi-structured interviews. In fact, those interviews revealed that lack of knowledge, especially spatial knowledge as one of the main challenges facing Aqaba ICZM implementation. The interviews also revealed an agreement among the respondents about the weak role of public participation in the ICZM decision-making process. This Chapter describes the methodology used, PGIS, as a way to fill the gaps in current spatial knowledge on the coast in Aqaba, and presenting a way to enhance the role of non-official stakeholders in the decision-making process.

A PGIS mapping process was conducted in parallel with semi-structured interviews with input from Aqaba coastal resource users and ICZM actors. PGIS integrates both a participatory approach and a mapping process, in order to generate GIS maps fed by the LK. Participants were asked open-ended questions about coastal activities, resources, pressures, impacts, and conflicts. Then, their perceptions were translated as drawings on the maps which were later digitized and spatially analysed using the GIS. The methodology enabled the development of a coastal profile for the coastal activities and resources. It also helped in defining the coastal pressures and impacts as well as conflicts and their spatial distribution. This, in turn, aided in highlighting priority areas along the Aqaba coastline which require special management attention for the coming ICZM programmes. Through this process, the researcher also compared the perceptions of the three participating groups; officials, researchers, and locals, to assess their level of agreement and disagreement, and to evaluate the usefulness of the acquired local knowledge in comparison with the officials and researchers knowledge.

3.2. Research Design

3.2.1. Guiding Questions

Following the literature (e.g. Ramirez-Gomez *et al*., 2017; Alcorn, 2000), a set of key guiding questions was developed in advance to encourage discussion during meetings, allowing the facilitator (knowledge collector) to start the meeting by asking respondents to identify the most essential features, but with the flexibility to acquire additional information depending on the type of respondents. The guiding questions addressed issues on the coastal resources and its users, coastal activities, coastal pressures and impacts, and conflicts along Aqaba coast (Table 3.1).

The first guiding questions included basic information on gender, age, the level of education, years of experience, institutions, and scope of work collected from coastal resource users and/or the ICZM actors (Table 3.1). This allowed the characterisation of the players within different sectors (e.g. tourism and recreation), while also helping in the understanding of the institutional framework for ICZM (actors and institutions). Close and Hall (2006) argued that the level of education is an important factor to simplify and/or guide the presentation of further questions in PGIS meetings; and level of experience is a key factor in diving deeper into the issues under consideration, as more years of experience means better opportunity to acquire more detailed local knowledge. Information on the institution and the scope of work is also helpful to orient further questions during the meetings, for example, if the respondent was from the environment directorate within ASEZA, more details were asked about the EIA process in relation to existing anthropogenic impacts on the coastal resources.

Table 3.1: Guiding questions asked during the PGIS meetings.

Question set # 1: Basic information about the coastal resource users/ ICZM actors being interviewed	
Basic information about the coastal resource user	What is your name?
	What is your gender?
	What is your age?
	What is your level of education?
Scope of work for the coastal resource user	What is your Institution/ department?
	What is your scope of work in relation to coastal resources (job title)?
	How many years of experience do you have?
Question set # 2: Statistics about the coastal resource users	
What is the number of fishermen (commercial and recreational)?	
What is the number of divers (commercial/ recreational)?	
What is the number of visitors (local, regional, and international)?	
Questions set #3: Coastal activities and resources	
Coastal activities	What are the existing coastal activities (land and marine-based)? What are their spatial distributions?
Coastal resources	What are the existing coastal resources in Aqaba? Who are the users for such resources? What are their spatial distributions?
What are the areas with high cultural importance? What are their spatial locations?	
Questions set #4 Coastal pressures, impacts, and responses	
Coastal environmental impacts and pressures	List the negative environmental impacts along the coast (environmental problems) and spatially identify them What are the causes of the identified impacts (pressures) and what are their spatial distributions?
Coastal conflicts	Is there any kind of conflicts among ICZM actors along the coast? What are those conflicts? Who are the conflicting parties? And what are their spatial locations?
List your recommendations to overcome the above mentioned environmental impacts	

Secondly, there were questions about perceptions on the numbers of coastal resource users (Table 3.1) to get information on the dominant coastal activities and to get an indication of the type of pressure that those activities may be posing on coastal resources.

Third, respondents were asked to describe and spatially identify land and marine-based coastal activities (Table 3.1). Respondents were also asked about the abundance of coastal resources, their spatial distribution (physical environment and species), and their users. Respondents were also asked to identify areas of cultural importance. Such questions were asked in order to understand the environmental and socioeconomic aspects along the coast, aiding the development of the coastal profile.

Fourth, there were questions related to the impacts on the identified resources, the pressures causing them, and issues related to conflicts among coastal resource users (Table 3.1). This was considered a crucial part of the meetings in order to identify priority areas which may require special management attention. This research classifies priority area as the ones facing high pressures and significant negative environmental impacts, as well as those with the highest conflict among users.

To be able to answer the above questions, the researcher assumes the following:

(i) Respondents either have access to the required information or their scope of work implies interaction with other groups (e.g. fishermen, divers, and boaters). For example, officials working within AMP, the responsible authority for issuing fishing licenses, can help in providing information about the fishing industry and the current numbers of fishermen;

(ii) Aqaba is a small city, which implies that any changes on the state of the coast can be recognized. For example, driving forces causing pressures on the corals, the valuable coastal resources in Aqaba;

(iii) Coastal users groups are small and there is a relative stability in terms of their number, which means that it is easy to recognize individuals who wish to join or leave the group.

(iv) Questions that contained scientific language and terminologies were explained to respondents in a simple and easy to understand manner.

Some questions were consistent for all respondents as presented in Table 3.1, while other questions were designed specifically for specific groups (Alcorn, 2000). For example, specific questions were asked to the fishermen regarding fish stock, fishing sites, and challenges facing the fisheries industry; to divers about corals distribution, diving sites, and diving challenges; and to boaters regarding their trip routes, landing sites, and their challenges. Moreover, following Cinderby (2009) and Carver (2001), local respondents (divers, boaters, and fishermen), whose work is related to the availability of clients, were asked short and straightforward questions in order to utilize their time efficiently and without delaying their work. Group PGIS meetings were held for some respondents, mainly from the locals' groups, due to their limited availability and some difficulties in approaching them - the hard to reach people (Cinderby, 2010). As the literature recognises, this approach encourage respondents to think together, share their knowledge, and enhance the debates and discussion about the issue under investigation based on the knowledge from their daily life, which in turn, increase the legitimacy of the process (Ramirez-Gomez *et al*., 2017; Cinderby *et al*., 2008; Cinderby and Forrester, 2005; Alcorn, 2000). PGIS offers the anonymity of participating respondents, and so, respondents can feel free to reflect their opinions (Zolkalfi *et al*., 2017).

3.2.2. Sampling Design

3.2.2.1. Definition of the Respondents

In this research, respondents represent coastal resource users and/ or ICZM actors in Aqaba. Based on Ramirez-Gomez *et al*. (2017), PGIS stakeholders can be classified as internal (those living in the study area and can be affected by management decisions) and external (those who can affect decisions that impact the internal stakeholders), respondents of this research are defined as any person:

1- Who can be impacted by any changes to the state of the coast and whose source of income depends on coastal resource, "internal stakeholders" using the classification of Ramirez-Gomez *et al*. (2017).
2- Whose scope of work is directly/ indirectly related to coastal management, external stakeholders *sensu* Ramirez-Gomez *et al*. (2017).

3.2.2.2. Selection Criteria and Process

Eligibility criteria required PGIS respondents to have experience about the state of the coast, and challenges in Aqaba (reflected by the years of experience and recommendations from stakeholders' questions). By doing so, the researcher assured that participants had the ability to explain in depth, the coastal resources and pressures and impacts to be mapped. In addition, respondents were selected from various coastal resource user groups in order to capture their various collective knowledge, challenges, and interests.

Respondents were selected through purposive sampling because this approach facilitates the targeting of specific stakeholders (Brown and Kytta, 2014; Brown, 2012b). Personal connections and contacts, recommendations and a snowball process were used to target specific respondents who meet the above selection criteria. All respondents were contacted via phone calls to arrange meetings. During the phone calls, the researcher introduced herself, explained, in brief, the research and nature of the meeting, and an oral consent was obtained from each respondent as recommended by Ramirez-Gomez *et al*. (2017). It is crucial to explain that the meeting would include a mapping process in order to assure the respondent's willingness to draw on the maps and to allocate a proper time and place for the meeting. Note that, respondents were informed that no experience in mapping was required to participate in the PGIS interviews, and no incentives were provided to the respondents for their participation.

3.2.2.3. The PGIS Respondents

The conducted PGIS interviews were carried out with representatives from the following (see Chapter Two for details about the institutions and projects cited).

- Officials, working on the planning, management, inspection and monitoring of the coastal zone

Respondents were representatives from the following directorates in ASEZA (regulatory and executive body for Aqaba): Environment Department, Architecture and Planning Directorate, Geographic Information System Directorate. Respondents from AMP and Ben Hayyan - Aqaba International Labs were also included; both institutions work under the umbrella of ASEZA.

- Researchers, doing their research and/ or teaching on coastal issues.

Respondents were (*i*) from the departments of coastal management and marine biology at the Faculty of Marine Science in the University of Jordan, which has taught programmes on coastal topics; (ii) and MSS (Marine Science Station).

- NGOs dealing with coastal management.

Two representatives from the environmental NGO in Aqaba, Royal Marine Conservation Society of Jordan (JREDS) were included in the local stakeholder group.

- Funded projects targeting coastal issues.

Project manager of a funded project by UNDP titled “Mainstreaming Marine Biodiversity Conservation into Coastal Management in Aqaba”, as part of the local stakeholder group.

- Divers.

This includes divers, whose job is to conduct surveys like coral surveys, and those that offer recreational diving for tourists. All the selected divers were active members in the diving community in Aqaba, and rely on diving as their main source of income. Participants included the president of the diving society in Aqaba.

- Fishermen.

All the fishermen, who participated in the PGIS meetings, rely on fishing as their main source of income, and are active members in the fishing community in Aqaba, and included the president of the fishermen society in Aqaba.

- Boaters.

Boaters are respondents who derive their main source of income from providing recreational trips on glass bottom boats to tourists in order to show coastal resources, specifically corals.

3.2.3. Sketch Base Map for PGIS

PGIS can be applied using one or a combination of methods and tools, which includes ephemeral maps by drawing on the ground (e.g. using sticks or gravels - e.g. Rambaldi *et al*., 2006; Abbot *et al*., 1998); sketch mapping by drawing on papers using pencils, vines or leaves (e.g. Cinderby, 2010; Hall *et al*., 2009; Close and Hall, 2006; Fox *et al*., 2006; Rambaldi *et al*., 2006; Cinderby and Forrester, 2005; Alcorn, 2000; Abbot *et al*., 1998); scale mapping (using georeferenced data) (e.g. Rambaldi *et al*., 2006); PGIS spatial analysis (using GIS) (e.g. Rambaldi *et al*., 2006; Alcorn, 2000); participatory 3-Dimensional Modelling (P3DM) (e.g. Ramirez-Gomez *et al.,* 2017; Rambaldi *et al*., 2006; Fox *et al*., 2006; Alcorn, 2000) which is useful when the topographic aspects are important factors (Alcorn, 2000); photomaps (geometrically corrected aerial photographs) (e.g. Rambaldi *et al*., 2006; Abbot *et al*., 1998); mobile devices (e.g. PDA and GPS) (e.g. Rambaldi *et al*., 2006), and web-based maps (e.g. Carver *et al*., 2001; Kingston *et al*., 2000).

For this research, sketch mapping was adopted to acquire the LK (Local Knowledge) from stakeholders, which was later processed by the spatial analysis tools offered through GIS. Sketch mapping was selected because it is a simple way that suits rural areas in a developing country context (Brown and Kytta, 2014). As mentioned by Fox *et al*. (2006, p. 103), '*sketch mapping and 3D maps are easier to understand and are effective in engaging even illiterate villagers in conversations regarding natural resource management'.* Other methods like mobile devices (PDA and GPS) and web-based PGIS were not used because many PGIS interviews were conducted along the beach where there was no access to the internet; and many of the respondents are not familiar with smart technology, and so it was more comfortable for them to draw directly on the maps.

The base map was an aerial photo provided by the GIS directorate within ASEZA. The researcher asked the directorate to add a grid system on the seaside of the map (500 m x 500 m) in order to facilitate mapping themes under investigation along the coast (Figure 3.1). Respondents were informed about the grid system at the beginning of the mapping process to identify more accurately locations of marine-based activities and coastal resources. For example, fishing is allowed at a distance of 350 m from the shore along AMP (Aqaba Marine Park), and so, knowing about the grid system helped the fishermen in carrying-out the mapping. Other examples of the advantages of the grid system in facilitating the mapping process were related to the mapping of the boating trips, diving sites, and abundance of corals and seagrass.

The final printed map for the interviews was A0 (84 cm X 119 cm) with a scale of 1:20000 (similar Plieninger *et al*., 2013; Close and Hall, 2006) (Figure 3.1). Using one large size map (compared to several small maps) reduced the potential for confusion while mapping and was also easy to carry during the fieldwork.

This scale was large enough to show the main features and details (e.g. ports and mega-projects) and enable respondents to map the themes under investigation (e.g. 1:20000 or less) (Cinderby, 2010; Close and Hall, 2006). Although PGIS is subject to less scientific standards compared to PPGIS (Brown and Kytta, 2014; Brown, 2012a), the scale provided enough accuracy in identifying locations (Anuchiracheeva *et al*., 2003). It also enabled illiterate participants or those with low levels of education to draw easily on the map (Cinderby, 2010; Close and Hall, 2006; Fox *et al*., 2006; Cinderby and Forrester, 2005).

The scale was small enough to show the whole 27 km coastline in one map. It allowed the maximum number of respondents in each interview to fit around the map (Ramirez-Gomez *et al*., 2017; Rambaldi and Callosa-Tarr, 2001). Using aerial photographs allowed increased accuracy of representation of the spatial dimensions (Ramirez-Gomez *et al*., 2017; Fagerholm *et al*., 2012) and clearly showed easily recognizable landscape features (e.g. compared to drawing on poster board (Young and Gilmore, 2017).

One hard copy base map was printed to be used for all respondents, but each respondent was provided with an A0 transparent paper. This transparent paper was placed over the coloured hard copy map, so respondents were able to draw their own maps.

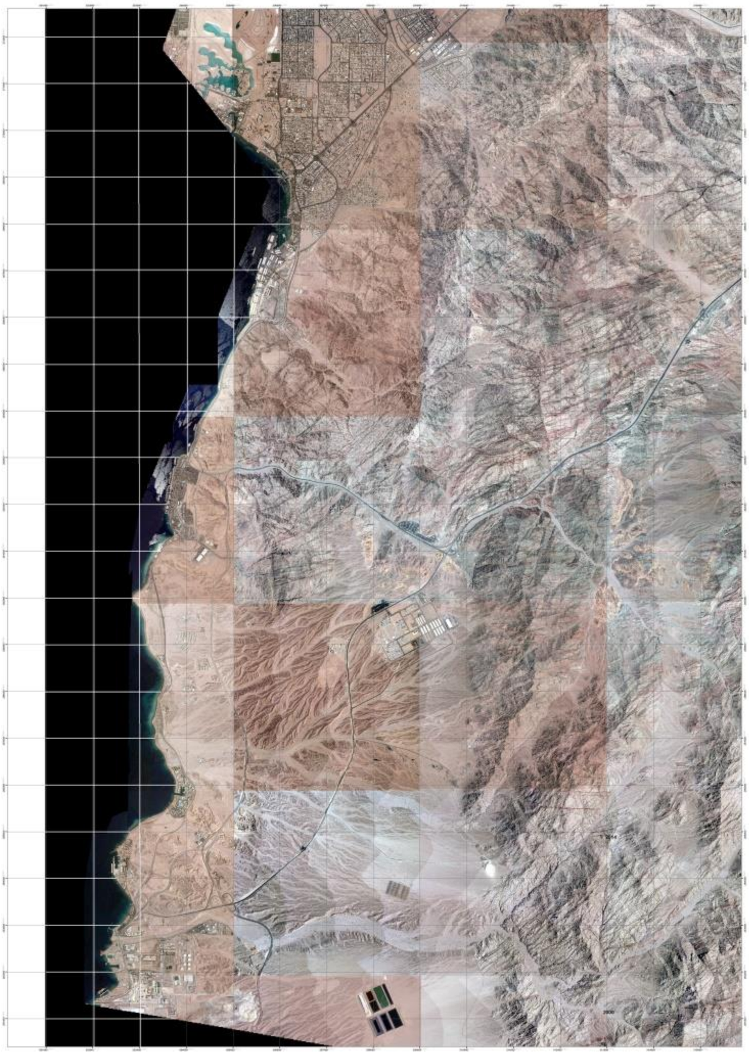


Figure 3.1: Air photography base map for the PGIS, with the grid system.

3.3. Ethical Arrangements and Consent Forms

The consent of respondents was required before data could be collected for the research. Ramirez-Gomez *et al*. (2017) clarified that two consents are required for this process; an oral consent during the phone calls setting up meetings and a written informed consent prior to the meeting. In addition to that, the PGIS facilitator should clearly discuss with locals the purpose of acquiring their knowledge and to agree with them on the knowledge type that will be mapped prior to the mapping process. In some cases, it is important to clarify to the locals the consequences of recording their spatial knowledge (Fox *et al*., 2006).

Therefore, participant written consent and basic information were collected on the forms presented in Appendices 6 and 7. An information sheet about the research was also handed to respondents prior the meetings (Appendix 8). In addition, university ethics approval was received at the beginning of January 2015.

3.4. Aqaba PGIS Meetings

3.4.1. PGIS meeting's venue and time

In this research, PGIS meetings were conducted in Aqaba, Jordan during January – February 2015. Some meetings were held in the respondents' offices and during specific times. This was the case mainly for officials and researchers. Figure 3.2 shows some photos taken during the PGIS meetings with individuals in their offices.

The traditional public meetings setting can weaken the voice of locals (Carver, 2001). Such meetings can limit the number of locals who attend because they are usually carried out in a formal context, including 1) specific locations, which may be far from the locals' working environment, and 2) specific times, which may not be convenient for them, which in turn, decrease the level of locals' empowerment in the participatory process.

While holding PGIS meetings in the locals' working environment is useful because (Young and Gilmore, 2017; Carver, 2001; Cinderby, 2010): (*i*) participants do not have to do any kind of arrangements to participate; (*ii*) they do not have to allocate a long time, since no time is required to travel to the meeting's venue and they have the flexibility to leave anytime; (*iii*) they can feel less stressful and more confident in providing and mapping their LK; (iv) such meetings can attract a large number of participants; and finally (*v*) in some cases, having the features under study visible, can aid participants to point- them out directly. This helps those who may have some difficulties in translating and marking, for example, it was easier for fishermen in the study to point-out directly on specific sites along the beach where the meetings were held.

In this research, the flexibility of PGIS meetings to be carried out anywhere was used, because this facilitates the participation of “hard-to-reach” groups, such as people with low-income level (Cinderby, 2010). Meetings, specifically with locals including divers, fishermen, and boaters were held on the beach (where respondents’ working activities are based). Figure 3.3 shows some photos taken for group meetings on beaches. In addition, Appendix 9 shows more photos for the mapping process by the respondents.

Figure 3.2: Photos from the PGIS interviews with respondents participating as individuals, in the respondents' offices.

Figure 3.3: Photos from the PGIS interviews with local respondents participating as a group in public spaces.

3.4.2. Facilitating the Meeting

Following the literature (e.g. Ramirez-Gomez *et al.*, 2017; Fox *et al.*, 2006; Cinderby and Forrester, 2005), at the beginning of the PGIS meeting, the researcher, introduced herself, gave a brief outline of the research, clarified the main objective of the PGIS meeting and the purpose of acquiring their LK, and agreed with respondents on the LK that will be spatially recorded. The researcher also reminded the respondents about the necessity to record the meeting, explained to participants the consequences of recording. Then, the maps were placed on an appropriate table, accessible from all sides to enable respondents to mark comfortably.

Participants were provided with highlighters, thick and fine, with different colours to enable mapping (Figure 3.4). Features mapped consisted of points, lines, and polygons. Literature suggests that these can be represented either through highlighters, flags, or meta-cards, often a colour coded system is used to differentiate between them (Ramirez-Gomez *et al.*, 2017; Cinderby and Forrester, 2005; Carver, 2001). For example, in Carver (2001), participating locals wrote their notes on flags, which had different colours to represent different issues, and placed them on a hard copy map or a three-dimensional model. Here, the researcher followed Cinderby and Forrester (2005) in using coloured, thick and fine highlighters.

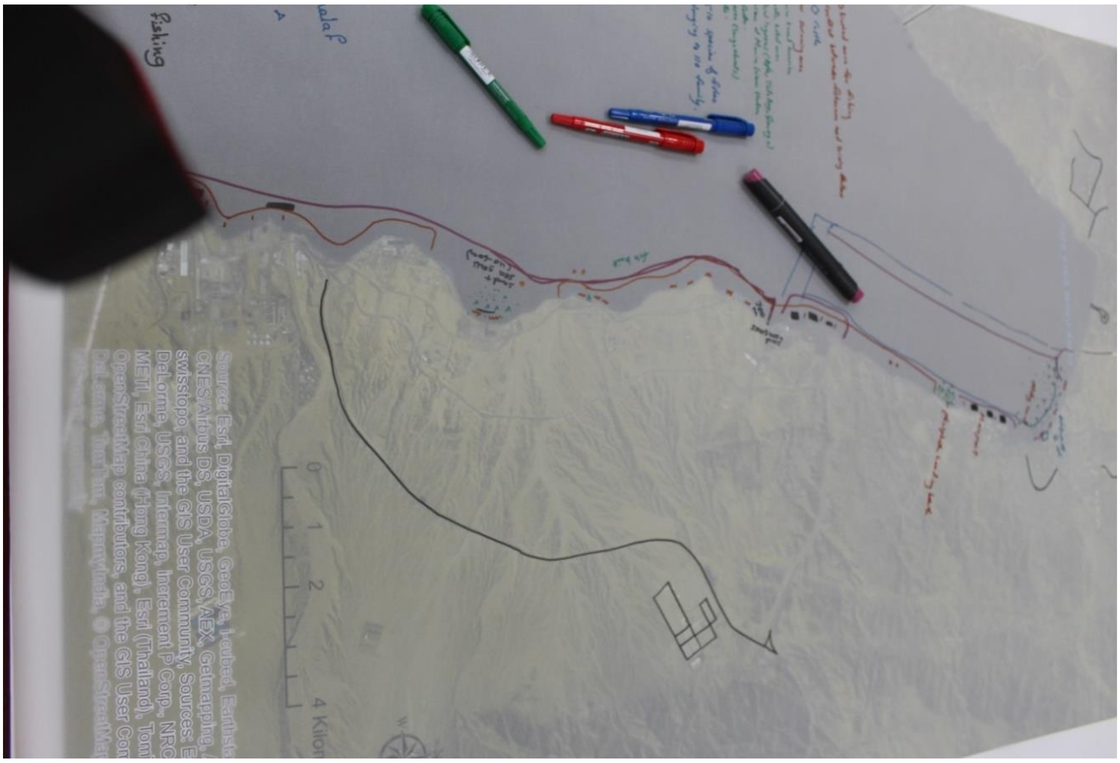


Figure 3.4: The mapping process using thick and fine highlighters with different colours.

3.4.3. The Mapping Process

In order to help respondents in mapping the themes under study and to increase the accuracy of identifying locations, the mapping process started by identifying the main features along the map with respondents (Young and Gilmore, 2017; Cinderby, 2010; Close and Hall, 2006; Anuchiracheeva *et al*., 2003). In this case, the mega projects (e.g. Ayla, and Saraya), ports (e.g. the old main port, and passengers port), or industrial activities (e.g. industrial complex) were included. Even though the identification of borders is often recommended at the beginning of the mapping process, in order to increase the map legitimacy (Alcorn, 2000), in this research, the study covered the entire coastline, and the land use master plan (Appendix 3) and the borders with the neighbouring countries were used to solve the issue of identifying the borders of the study area.

Once respondents became familiar with the map, they were invited to start marking issues under investigation. During the meetings, respondents were usually describing what they want to draw to the facilitator before drawing., respondents were encouraged to discuss what they know about the issues while mapping, to facilitate acquiring additional LK (Cinderby *et al*., 2008; Cinderby Forrester, 2005). Based on Ramirez-Gomez *et al*. (2017), Rambaldi *et al*. (2006), and Close and Hall (2006), respondents were free to use their own symbols (points, lines, or polygons), but it was assured that only one colour and one symbol were being used to draw one feature, which was important for the digitizing phase later. Examples of mapping are given in Figures 3.5 and 3.6. In addition, more examples for the PGIS hard copy maps highlighting the hand drawings and notes are presented in Appendix 10.

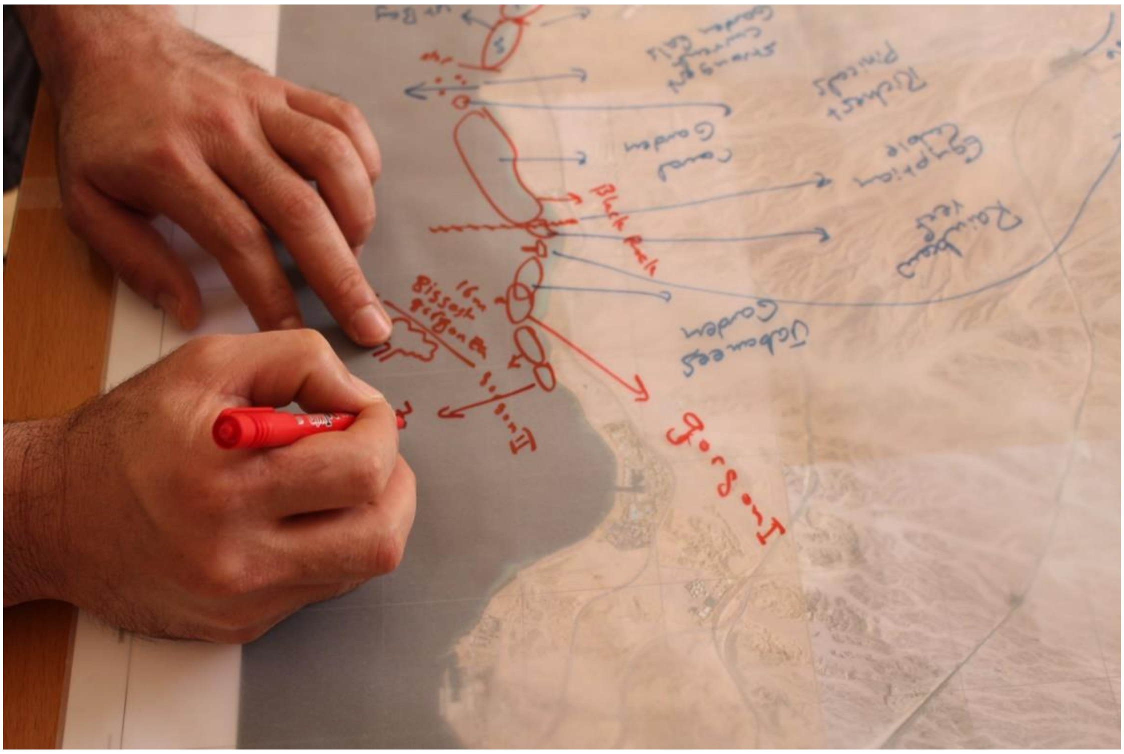


Figure 3.5: A diver mapping diving sites along the south coast using polygons; he used the blue colour to identify the names of the diving sites, and the red colour to add notes.

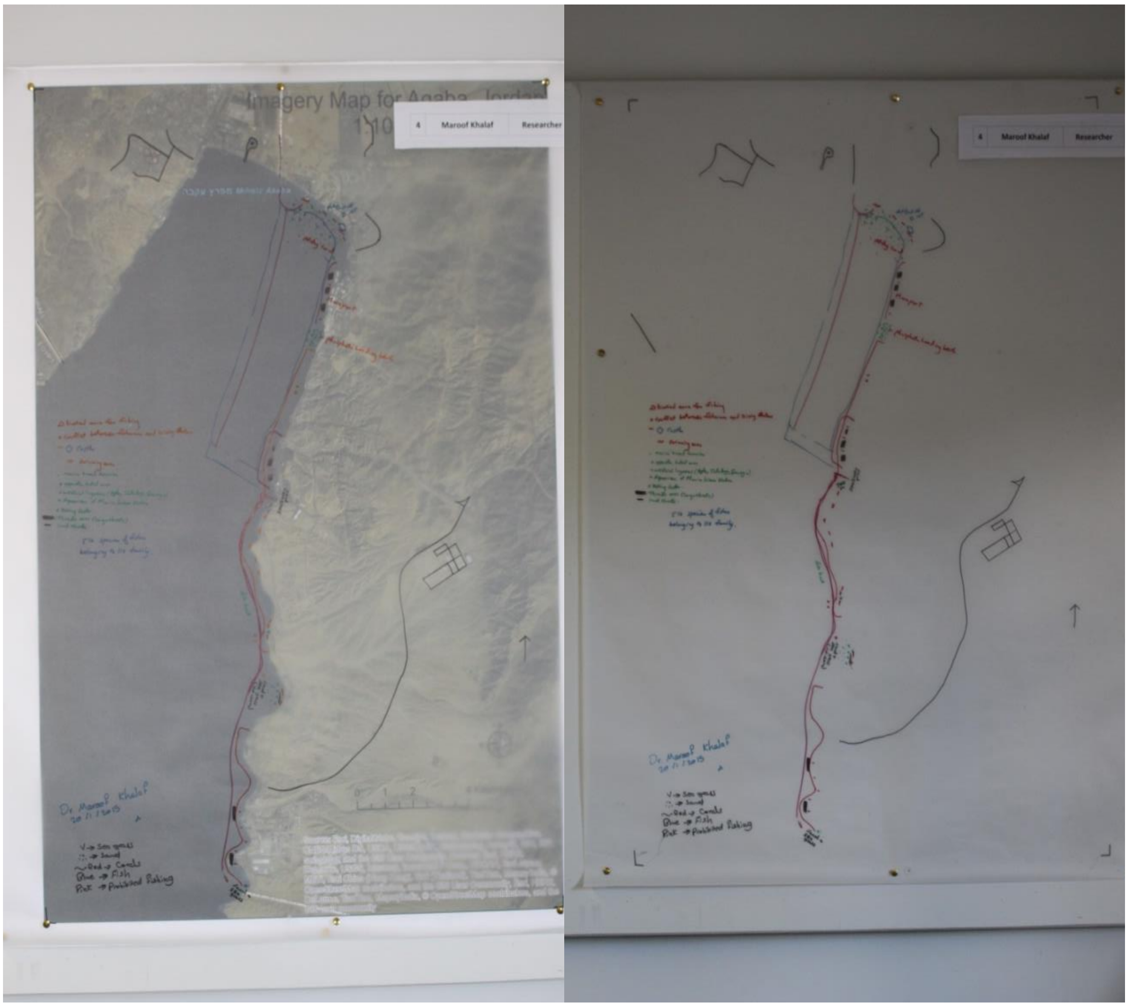


Figure 3.6: The left photo shows the transparent paper being used for the mapping, while it was placed over the aerial base map during the PGIS meetings. The right photo shows the points, lines, polygon, and their related descriptions on the transparent paper.

In general, during the group meetings, each respondent took his/ her turn to map their LK, and respondents were encouraged to think and share their ideas which it is argued to enrich the discussions and acquired spatial and qualitative LK (Young and Gilmore, 2017; Ramirez-Gomez *et al*., 2017; Alcorn, 2000). For example, in Young and Gilmore (2017,) group PGIS meetings were shown to enable respondents to classify their important sites in fine detail, presenting their expert knowledge with an indication of their long historical connection with the studied area. In order to avoid a dominant respondent controlling the mapping process, all respondents within the group were encouraged to participate and care was taken to assure that every mark drawn by each participant was agreed on by the whole group. Generally speaking, it was noticed that respondents were listening to each other's opinions, and they tried to respect contradictory perceptions.

3.5. Qualitative data processing and analysis

The interviews were held in Arabic, and the narratives of the recordings were transcribed and then translated into English. Narratives can convey and highlight the importance of the acquired spatial knowledge (Caquard, 2014). They can also connect the mapped sites with their detailed descriptions (Young and Gilmore, 2017). In addition, narratives can help in understanding some unclear mapped features (Young and Gilmore, 2017; Caquard, 2014). For example, when a respondent says "*there is solid waste along Aqaba Marine Park*"; this piece of information that was not drawn on the map could be linked to the GIS. Reading of the transcripts was carried out in parallel with reviewing the maps drawn by respondents. Thematic analysis of transcripts was conducted using the same procedures described by Braun and Clarke (2006) as explained in Chapter Two. The steps followed were 1) familiarization with the acquired data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, and 6) producing the content for each theme (Braun and Clarke, 2006). To assure the anonymity of the respondents, codes (PR1, PR2, PR, etc., PR indicating Participatory Respondent) were used to refer to the respondents in the analysis.

3.6. Spatial Data Processing and Analysis

3.6.1. Preparing the Digitized Georeferenced Maps

The participants' hard copy maps were transformed into digitized georeferenced maps relying on both the hand-drawn hard copy maps and the recordings (Ramirez-Gomez *et al*., 2017). The digital recording of the PGIS meetings which included a discussion of mapped features helped in digitizing these feature more efficiently following the same sequence of the discussion (Young and Gilmore, 2017; Cinderby, 2010). Figure 3.7 illustrates the process of transforming each hard copy map into a GIS map, which involved the following steps:

1- Taking a digital photograph for the hand-drawn maps (Figure 3.6),
2- Uploading the photograph as JPEG raster image (300 dpi) into the GIS system (ArcMap 10.2.1),
3- Georeferencing the uploaded photograph into GCS_WGS_1984. Note that at the end of each meeting, reference features (e.g. buildings and streets) from the underlying aerial photograph (the base map) were marked by the researcher on the respondents' maps (the transparent paper) to correctly position the map and

facilitate the georeferencing process later in order to increase the accuracy of the respondent's marked features.

4- Digitizing the mapped themes drawn by respondents as points, lines, and polygons into matching feature types in GIS (Point feature, line feature, and polygon feature).

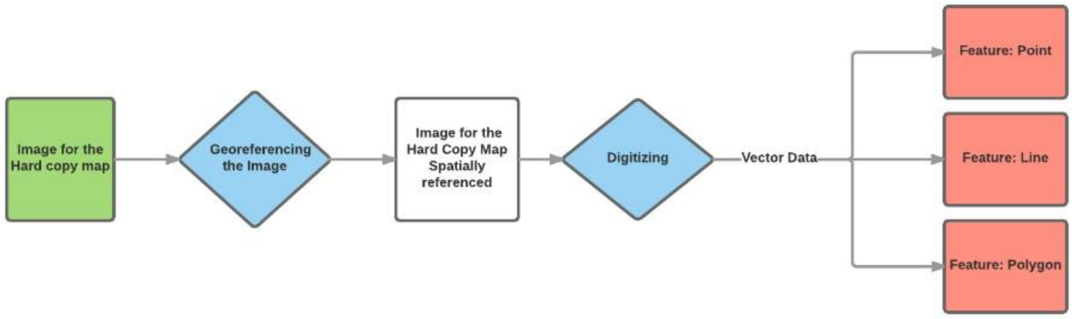
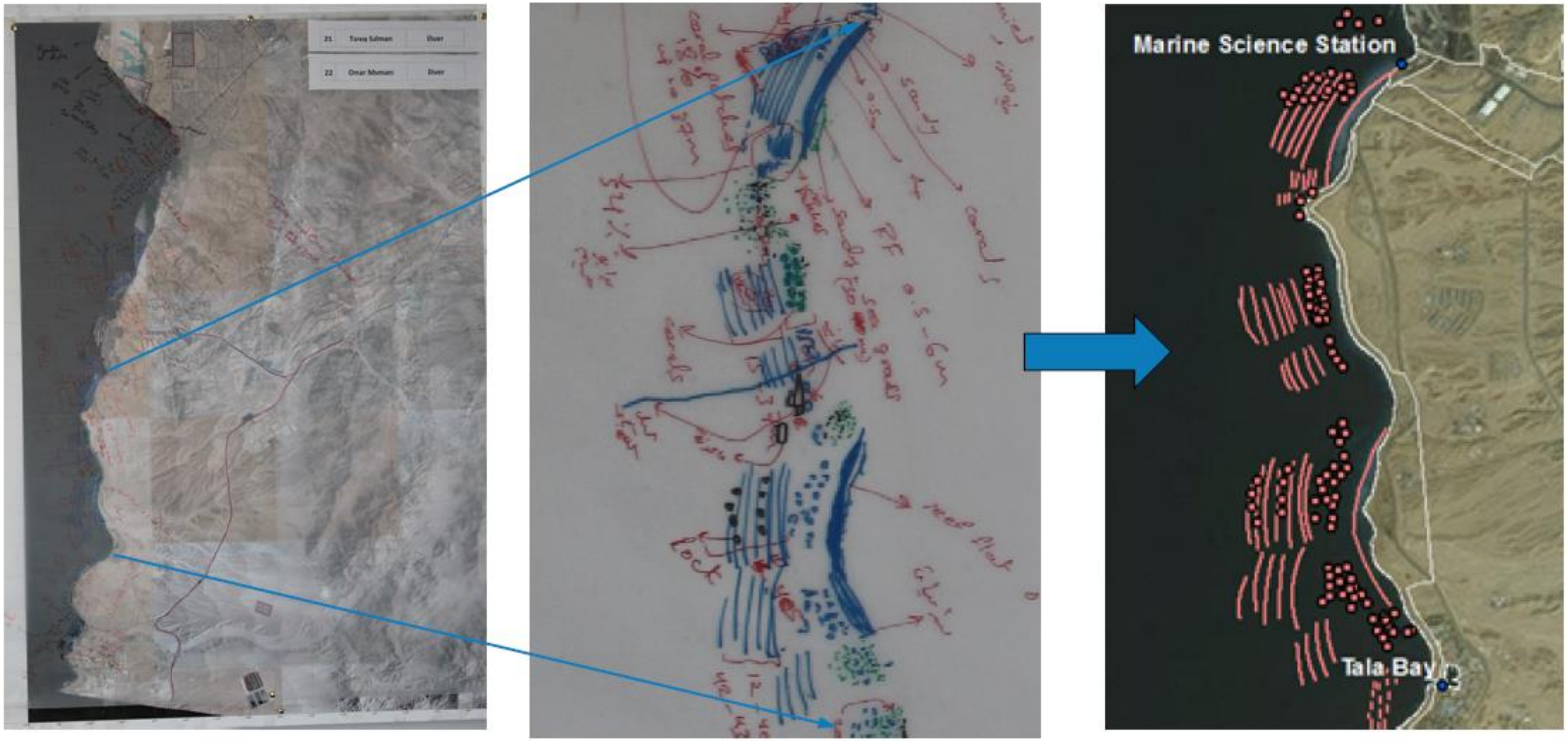


Figure 3.7: The process of converting the drawings of respondents on the hard copy maps obtained in PGIS meetings to vector data ready for further spatial analysis.

The digitizing process resulted in a vector GIS map showing all the mapped features for each respondent. Maps were given a unique name, reflecting the respondent, the coastal user group, age, gender and level of education which in turn, helped in further analysis and comparison of GIS maps according to the respondent's demographic information (as in Cinderby, 2010). In addition, while digitizing, small descriptions for the digitized features were added as "attributes" after listening to their description from the recordings.

An example of a digital image taken from a hard copy map marked by two divers will be used to illustrate this process. Figure 3.8 shows the image that includes all the marked features and the reference features marked by the researcher for the entire coastline. This figure presents two examples for reference points; "1" as a polygon reflecting a building and "2" as lines reflecting main roads including intersection. Example for the mapped coral locations by the above two divers with focus on the AMP zone is shown in Figure 3.9.

Figure 3.8: Illustration of a digital image for a hard copy map marked by two divers, including reference features identified by researcher.



(a) **(b)** **(c)**

Figure 3.9: Digitizing process: (a) A digital image of a hard copy map with input from two divers, with the base map behind; (b) An enlarged section of the transparent paper in figure (a) (without the base map) showing the mapped coastal resources along the AMP, abundance of corals as patches and continuous are represented by small blue points and lines respectively; and (c) The digitized coral patches and continuous corals included in figure (b) represented by points and lines.

3.6.2. Spatial analysis for the digitized georeferenced maps

Spatial analysis steps for vector data included buffering and merging, while spatial analysis steps for raster data included conversion and raster calculator (Figure 3.10). Details of the spatial analysis are explained using the same example of corals mapped by divers along AMP zone.

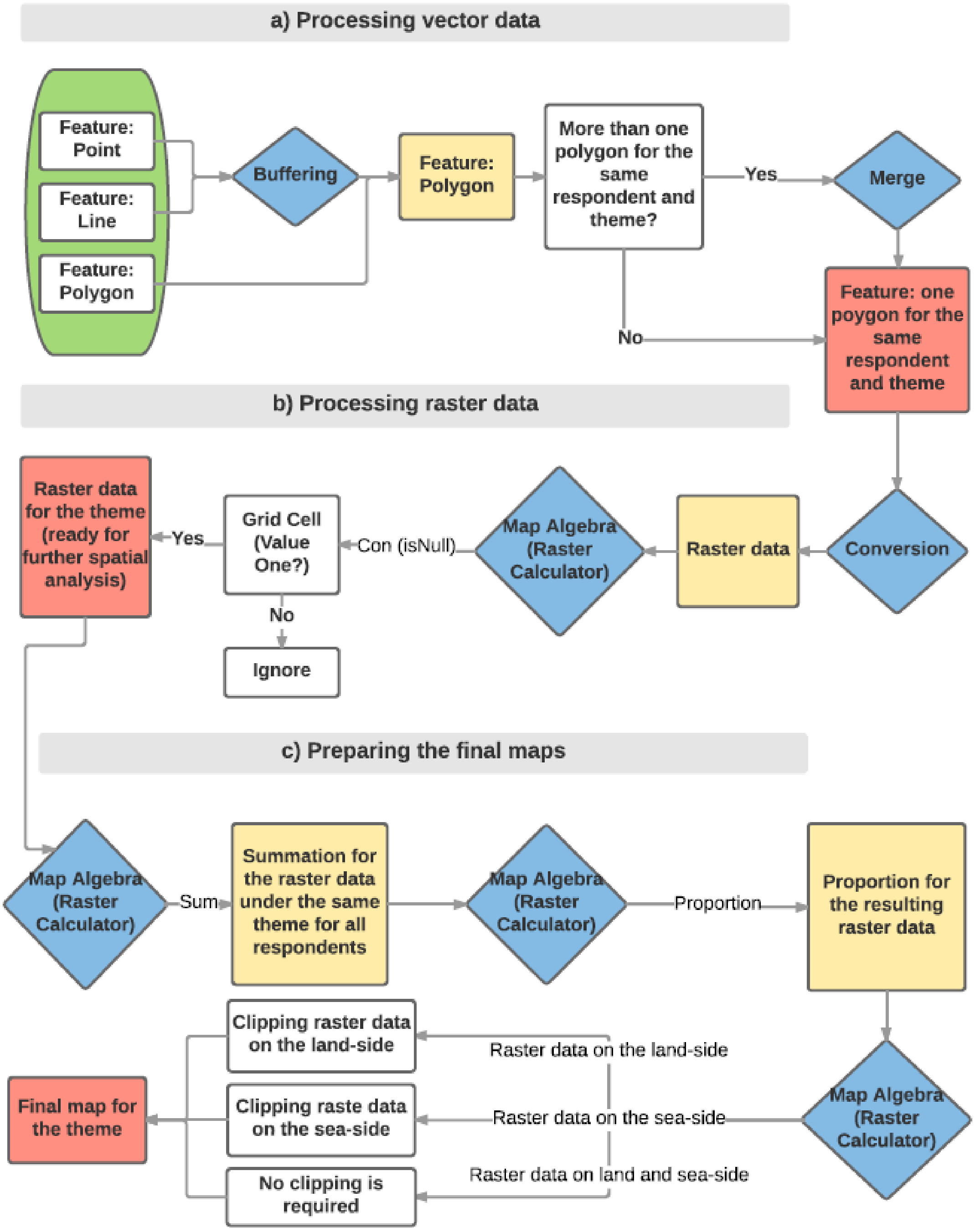


Figure 3.10: Flow chart of spatial analysis for each theme from the respondents' maps, a) processing vector data stage, including buffering and merging, b) processing raster data stage, including conversion and raster calculator, and c) preparing the final maps stage using the raster calculator.

3.6.2.1. Processing Vector Data

Points, lines, and polygons represent the vector data ready for further spatial analysis (Figures 3.11a and 3.11b). The decision to buffer all the line and point features into polygons was taken because the number of polygons mapped by respondents is high compared to the number of lines while buffering points into polygons also decreased the importance of positional imprecision of point map features (Close and Hall, 2006). Point and line data were converted using the buffer tool into polygons (Figures 3.10 and 3.11c).

Buffering enabled the capture of information in the neighbourhood of points and lines (such in Brown *et al*., 2015), reducing false precision that could be associated with treating participants hand drawings as spatially accurate (such in Brown, 2012b; Close, 2003). After buffering features, all information has the same polygon feature type for further spatial analysis.

As stated by Hall and Close (2007), there is no precise scientific basis for selecting the appropriate buffer width; however, a uniform distance of 200 m was used in this study. When the participant used a marker with 0.5 mm thickness, it meant that the drawn line on the map with the scale of (1:20,000) is equal to 10 m in reality. The buffer zone, therefore, allows a participant's point to be within 20 pen widths of where they actually drew it. Brown (2012) used 1000 m for buffering native vegetation points, while Bernard *et al.* (2011) used 2000 m to buffer hunting and fishing sites. An intermediate buffer distance of 200 m was selected by Baldwin (2012) to buffer space use patterns (such as fish landing sites, recreational areas, historic sites and ship building sites) and threats (such as illegal dumping sites, land-based sources of pollution). The intermediate 200 m buffer distance has been used here for a similar mapping exercise. The 200 m also captures moving features, such as fishing and boating activities. In such cases, the adopted buffer radius may reflect just a fraction of the working area, but gives a better estimation than individual points or lines (Bernard *et al*., 2011). The distance was also useful for capturing the impact either on the landside or the seaside.

The chosen distance was still small enough to avoid potential overlap with the nearby features (Dalton *et al.*, 2015). For successful ICZM implementation, the priority areas generated from overlaying buffer zones cannot be too large, so that special attention can be focused on small areas important to ICZM success. If the buffer distance is too large, the final priority areas may also be too large.

The choice is also consistent with the total study area, where the total length of the coastline is 27 km, making a large buffer width inappropriate (such as the 1 km used by Brown, 2012b). However, 200 m is large enough to give more conservative scenarios (Bernard *et al*., 2011).

In addition, the 200 m distance was selected to avoid covering larger areas compared with its real areas. This was done by checking the areas for specific features which can be viewed on the aerial images (such as some land-based coastal activities, e.g. ports and touristic activities)

Where respondents mapped more than one type of feature for the same theme, the buffered points, lines, and polygons were merged (Figure 3.10) to get one set of polygons for the theme (Figure 3.11d).

3.6.2.2. Processing Raster Data

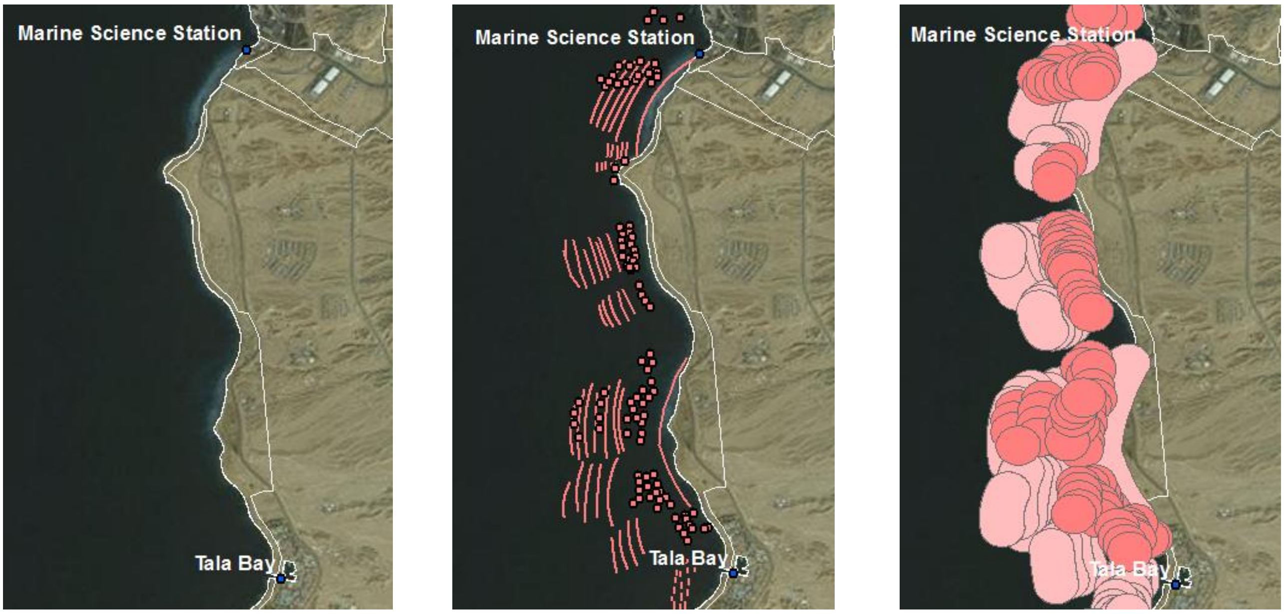
The resulting vector data set in the form of polygons was converted into a raster dataset to carry out raster calculations (Figure 3.11e). The Raster calculator was used in order to identify the cells with non-zero values, i.e. areas in features identified by respondents (Figure 3.11f)

3.6.2.3. Preparing the Final Maps for Each Theme

Final maps for each theme were prepared by overlaying the individual respondents' raster maps in order to get the sum of respondents for each theme (Figure 3.12a). These raster maps give the level of consensus varying between respondents. In order to get a percentage for the level of consensus among respondents who mapped the theme, another raster calculation divided the number of respondents who agreed on the location of the theme for each grid cells by the total number of respondents who mapped the theme (Figure 3.12b).

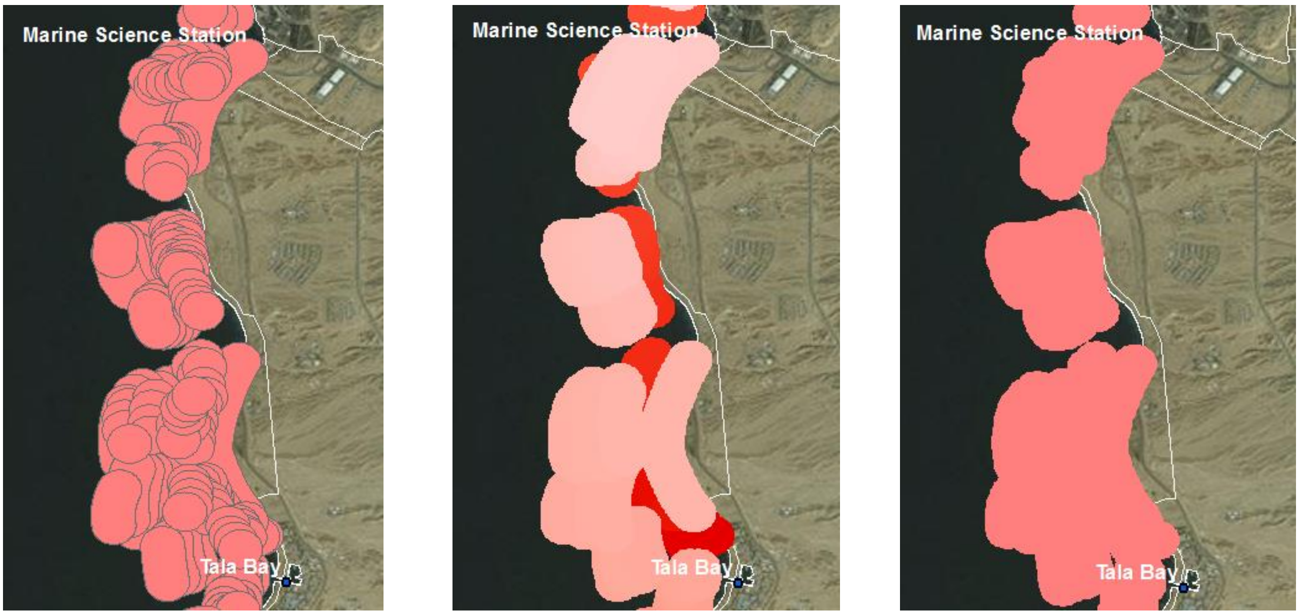
Finally, proportional maps were clipped in order to exclude mapped areas which are not compatible with the theme under investigation. Non-compatible themes appear as a result of applying the buffer on point or line features for either offshore or onshore features, and so, the buffer zones spilled onto land or sea, respectively. An example for clipping seaside only for the proportional map of corals abundance along AMP is presented in Figure 3.12c.

Processing vector data



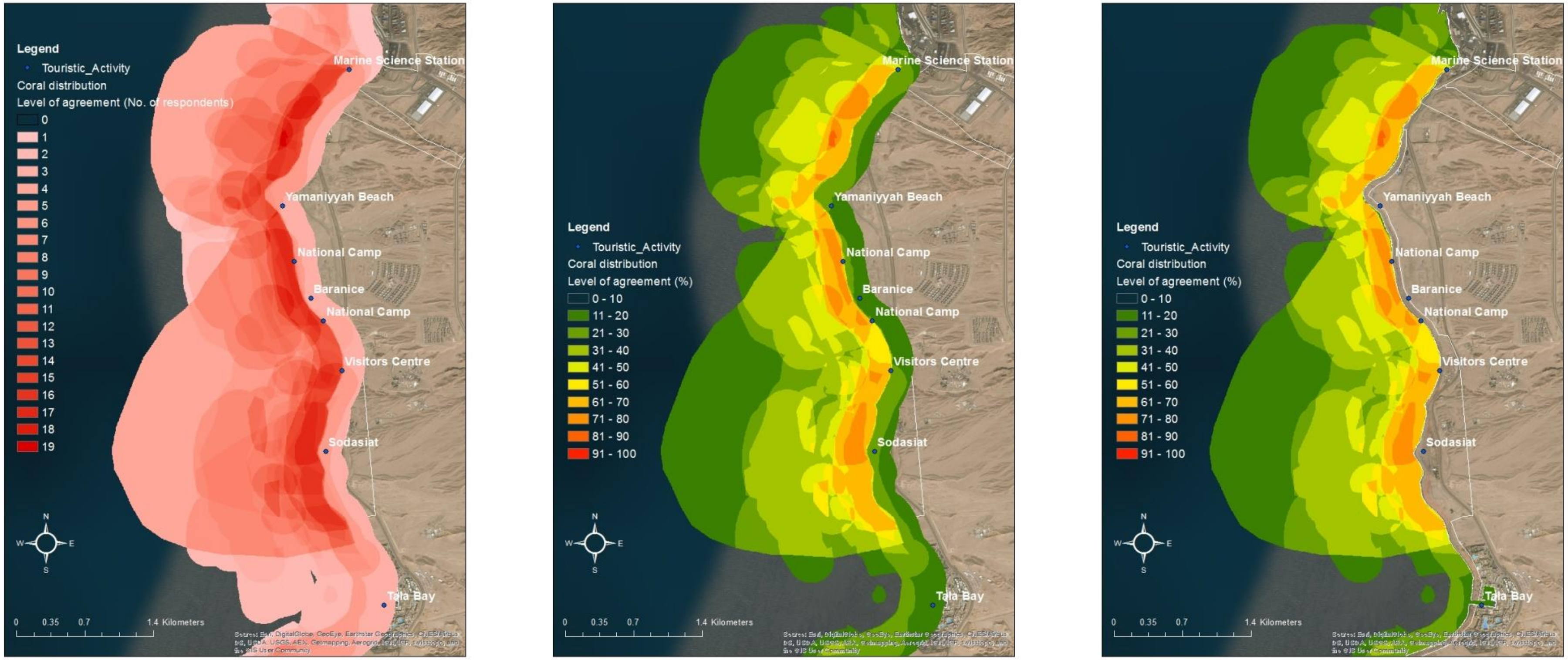
(a) **(b)** **(c)**

Processing raster data



(d) **(e)** **(f)**

Figure 3.11: An example of the spatial analysis steps for corals along AMP as mapped by a diver: (a) the base map, (b) vector data as points and lines, (c) buffering points (dark pink) and lines (light pink) to polygons, (d) merging points and lines polygons, (e) conversion vector data into raster data, and (f) applying raster calculation to get 0/1 values.



(a) **(b)** **(c)**

Figure 3.12: The final PGIS maps for the example presented in Figure 3.11, (a) sum map, (b) proportional map, and (c) the clipped map. Sum maps are prepared (using the raster calculator) by overlaying the corals mapped by respondents along AMP, the level of consensus varies between 1 and 19, reflecting the lowest and the highest number of respondents who agree on the presence of corals in specific locations, respectively. Proportional maps were prepared (using the raster calculator) by dividing 19 (the highest number of respondents who agree on the coral locations) by 23 (the total number of respondents who mapped the corals) and multiplied by 100 to give percentages, Raster data are shown in the form of percentage intervals (1 – 10, 11 – 20, 21 – 30 … 91 – 100) for better representation and comparison of the results.

3.7. Overview for the results

3.7.1. Analysis for the PGIS respondents

Forty-one respondents were recruited for this study representing various coastal user groups and/or ICZM actors (Figure 3.13). The local stakeholder group included 24 respondents representing fishermen, divers, boaters, and members of an NGO and a current project on coastal conservation. Seven researchers from the University of Jordan and MSS and ten officials working in different directorates within ASEZA constitute the research and official stakeholder groups, respectively.

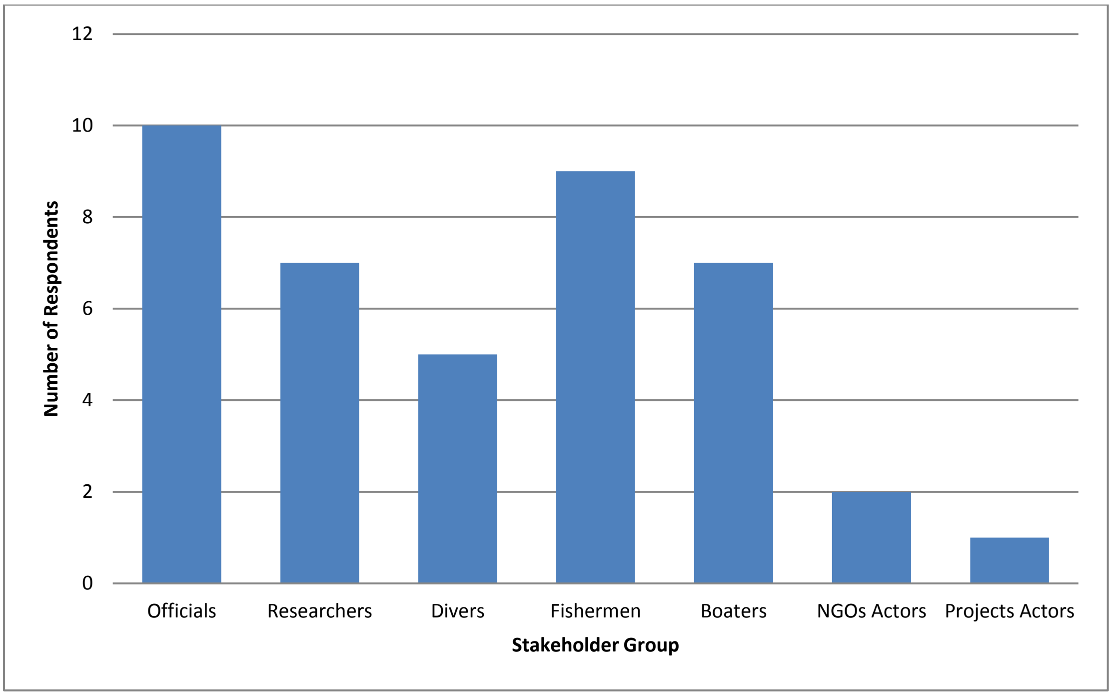


Figure 3.13: Respondents of the PGIS categorized according to coastal users groups.

Figures 3.14 shows a summary of the basic demographic information collected from the participant.

Age showed that the youngest participants are from the locals group, with almost third of them in their twenties and less than half (42%) in their thirties, yet, none of them were children or teenagers. Officials' age varies between thirties and fifties, while the researchers' group reflects the eldest group in this study with almost 70% in their forties while the rest are in their fifties.

Years of experience had a range which was wide in the locals group, ranging between less than 5 years up to 35 years. The officials' experience was also wide but to a lesser extent (between 6 and 30), while it was in a narrow range for the researchers (11 – 25).

Level of education showed that all of the officials in this study hold a university degree, while most of the researchers hold a Ph.D. degree. However, the level of education for the participating locals was low; almost 70% of them are either illiterate or just completed their secondary school, and the only local participant who is holding the Ph.D. degree reflecting the one who is working on a project. The high illiteracy rate among the locals is surprising. According to Al-Shibly and Alrefai' (2016), the illiteracy rate in Jordan is among the lowest compared to Arab countries. Similarly, the reported illiteracy rate by UNICEF for Jordanian youth (between 15 and 24 years) for the years 2009 – 2014 do not exceed 1%.

Gender revealed that 40% of the participating officials were females, reflecting the only females participating in this study. Although the sampling type was purposive, the researcher tried to make a gender balance, but no females were found either in the researchers or the locals' community. As stated in the literature (Al-Shibly and Alrefai', 2016), there are many social and economic challenges facing Jordanian women due to traditional, cultural, and religious values about the roles of both men and women in the society. For example, it is not culturally accepted in Aqaba for females to work as fisher, diver, or boater. While female researcher is common in Jordan, however, it seems not the case in Aqaba.

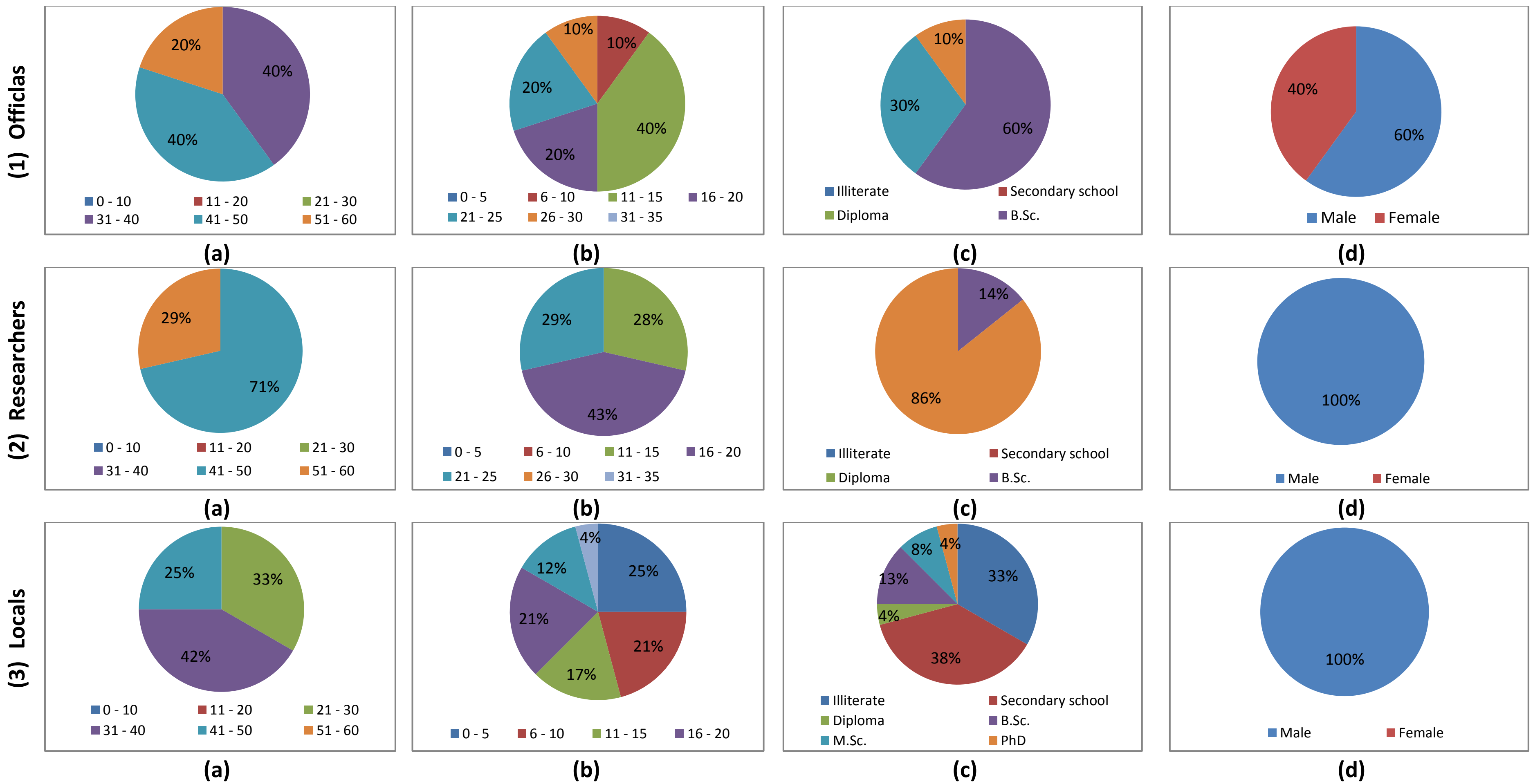


Figure 3.14: Summary of demographic information for PGIS participants in the stakeholder's groups. Vertically, the pies show specific demographic information for the three groups: (1) officials, (2) researchers, and (3) locals. Horizontally, the pies show the all the demographic information for the same group including: (a) age, (b) years of experience, (c) level of education, and (d) gender. The pie slice represents the percentage from the total group. Total number: Officials, n= 10; Researchers n=7; locals n=24.

3.7.2. Emerged themes from content analysis

Figure 3.15 shows the resulting themes from the thematic analysis, which reflects the structure of the following Chapters in the thesis (Chapters 4-7). Note that spatial data are classified based on the same thematic analysis themes described in the Figure below (3.15).

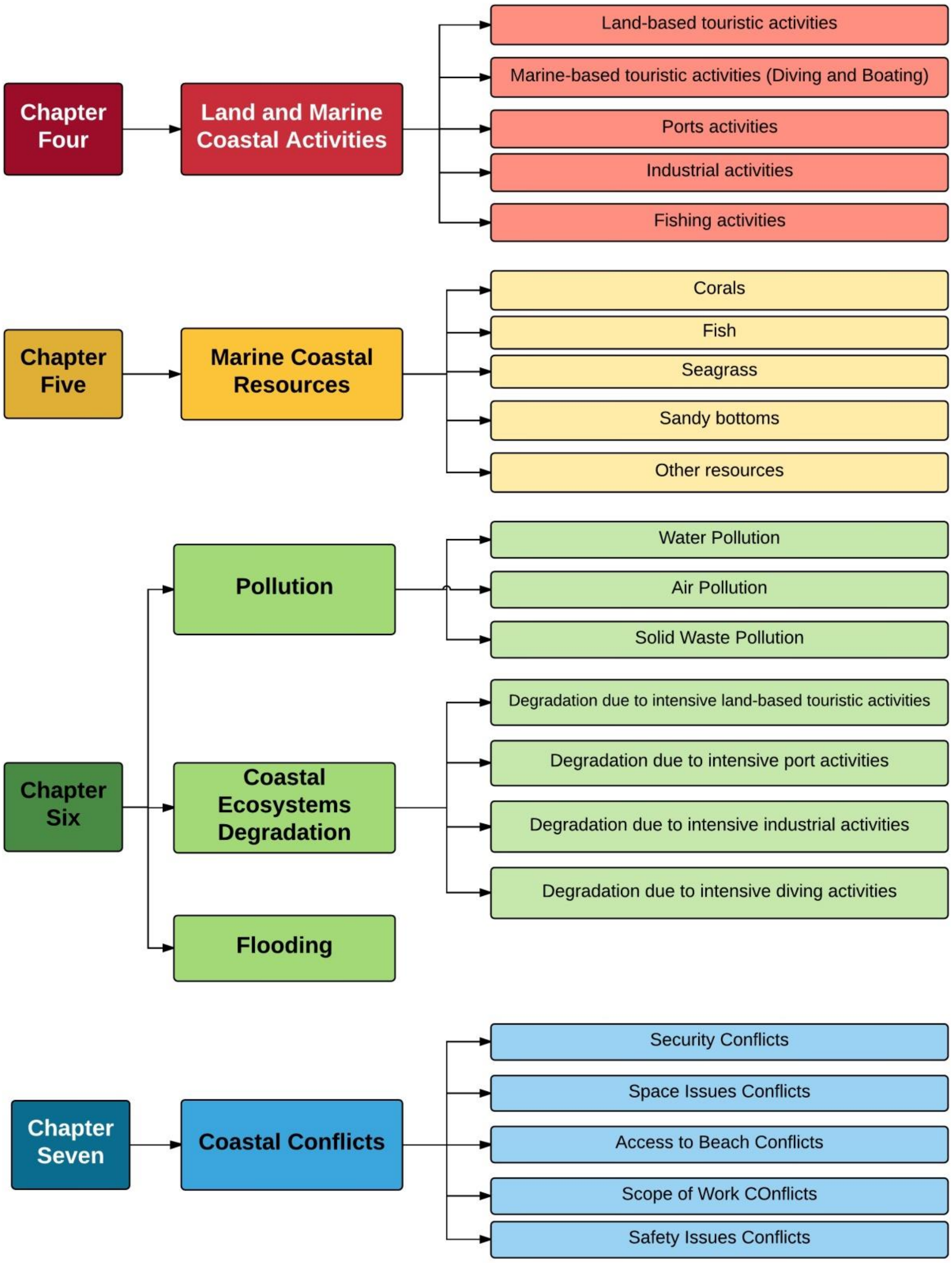


Figure 3.15: Themes resulting from the content analysis based on the transcripts and maps of the PGIS meetings.

3.7.3. PGIS maps and Identification of Priority Areas

The PGIS process resulted in three sets of maps. The first set (22 final maps) reflects the spatial distribution of the coastal activities, resources, impacts, and conflicts among coastal users (Table 3.2). The second set of maps summarise this information for each group (officials, researchers, and locals) separately.

Table 3.2: List of themes of the final GIS maps based on stakeholders consensus.

Chapter Four: Coastal Activities
Land-based touristic activities
Diving activities
Boating landing sites
Boating trips
Port activities
Industrial activities
Permitted fishing sites
Restricted fishing sites
Prohibited fishing sites

Chapter Five: Coastal Resources
Corals
Fish
Seagrass
Sandy bottoms

Chapter Six: Coastal Impacts and Pressures
Water pollution
Air pollution
Solid waste pollution
Coastal ecosystem degradation from land-based touristic activities
Coastal ecosystem degradation from port activities
Coastal ecosystem degradation from industrial activities
Coastal ecosystem degradation from diving activities
Flooding

Chapter Seven: Coastal Conflicts
Coastal-use conflicts

Priority issues identified by stakeholders may be because stakeholders perceive the issue as important such as the case of coastal resources, or because they have concerns for example in relation to coastal impact and pressures or existing conflicts. Priority issues were thus identified based on the highest response rate for mentioning and mapping a theme under investigation (Figure 3.16). Priority areas were identified by overlaying all the components of the theme under study, for example, priority areas for coastal resources were achieved by overlaying all the final coastal resources maps (corals, fish, seagrass, and sandy bottoms), and those areas with the highest consensus on presence of the coastal resources reflect the priority areas (Figure 3.16).

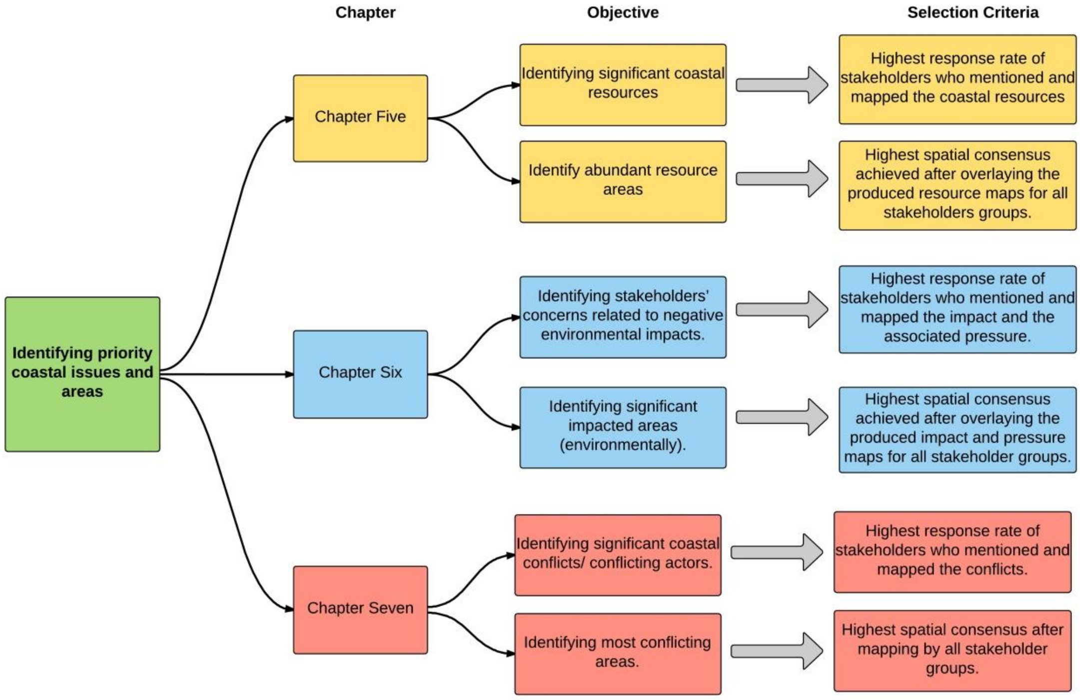


Figure 3.16: Selection criteria for identifying priority coastal issues and areas for the following Chapters.

3.8. Conclusion

This Chapter has presented the methodology for acquiring spatial LK from the coastal resource users and ICZM actors in Aqaba. Based on the findings of Chapter Two, where the lack of adequate spatial knowledge and weak role of the local community were found to be the major issues hindering successful implementation of ICZM, PGIS methods were used. The resulting GIS maps, together with the narratives have been used in the remaining Chapters of the thesis to represent the coastal profile, identifying coastal pressures, and to highlight areas of conflicting interest in management decision-making.

Forty-one coastal resource actors participated in the PGIS interviews, which include 10 officials, 7 researchers, and 24 locals. The acquired LK from the PGIS interviews is of two types; qualitative data and spatial data, which reflects knowledge on land-based and marine-based coastal activities, marine coastal resources, coastal pressures and impacts, and coastal conflicts between coastal resource users, which were mapped and/or mentioned by PGIS respondents.

4. Chapter Four: Land-Based and Marine-Based Coastal Activities

4.1. Introduction

The successful implementation of ICZM for any coastal zone requires the development of a coastal profile as a basic requirement in their first ICZM phase “Issue identification and assessment” before any “Planning” is conducted (GESAMP, 1996). Chapters 4 and 5 present the coastal profile derived from local knowledge obtained in the PGIS meetings. Chapter 4 focus on coastal activities and Chapter 5 address coastal natural resources. In particular, the specific aims of this Chapter are to 1) identify land-based and marine-based coastal activities of Aqaba coastal profile, as being applied by other authors (González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; Christie *et al*., 2006; ATKINS, 2004; EC, 2002; GEF/UNDP/IMO, 1996), with special focus on their spatial distribution (e.g. EC, 2007; Anuchiracheeva *et al*., 2003); 2) evaluate the perceptions of ICZM stakeholders through comparing their spatial perceptions, in a way to verify consensus and disagreements and to identify if the LK is a trustworthy source in filling the current knowledge gap as recognized previously in Chapter two; and 3) evaluate the efficacy of PGIS in developing the coastal profile for coastal activities as a way in enhancing the level of non-officials participation the ICZM decision-making process. Note that activities will be described from the north to the south following the classification of the National Monitoring Program (NMP) of Aqaba Special Economic Zone Authority (ASEZA) (Chapter Two). The “special zone”, although not mentioned in the NMP, was highlighted by respondents as a distinctive area for its touristic and military activities, and will be included in the analysis.

4.2. Land-Based Touristic Activities

Aqaba is a main touristic attraction for local tourists and for tourists coming from abroad, especially after the current unstable political situation in the surrounding countries (PR13, PR23, and PR24). Seventy-six percent of respondents (8 officials, 6 researchers, and 17 locals) mapped land-based touristic activities along the coast of Aqaba (Figure 4.1 and Table 4.1). A further 20% of respondents (n=8) described land-based touristic activities without mapping them. Respondents reported touristic activities including hotels, touristic projects, private and public beaches, cultural and archaeological sites. Officials, researchers, and locals reported land-based touristic activities that occurred in the touristic zone and the marine park zone, researchers also mapped features in the industrial zone (Figures 4.1 and 4.2).

The key locations for tourist activity highlighted by all respondents (Table 4.1) are Tala Bay (mentioned by over 87% of respondents), hotels' area (80%), and Ghandoor Beach (76%). A number of respondents (PR5, PR6, PR7, PR8, PR13, and PR18) explained that Tala Bay is located in the Aqaba Marine Park (AMP) and consists of three five stars hotels and an artificial lagoon with a waterfront of 2 km. The waterfront along the hotels' area is around 1 km where marine sports such as swimming and boating are concentrated (PR16, PR18). About 44% of the respondents stated that these hotels have the best location along the north coastline (e.g. PR2, PR16, and PR17), privately managing beaches, which used to be visited primarily by the locals. There are now only few remaining public beaches along the Aqaba coastline. Ghandoor beach is one of these public beaches, which accommodates a high number of local visitors because it is free of charge and located near the city centre (e.g. PR2, PR16, and PR17).

The next most important set of touristic activity locations (Table 4.1) includes Yamaniyyah and national campsite (as public beaches) and Berenice (66% of respondents). Berenice is a former public beach, now it is a private beach and tourist accommodation. Those three locations are within the AMP, which attract many visitors (PR7, PR9, PR14, and PR15). The border of AMP is the Marine Science Station (MSS) in the north and Tala Bay in the south and has a total length of about 7 km (PR1, PR5, and PR6). The AMP is a multi-use area which consists of both closed and open reserved areas (PR7, PR18). The closed reserved areas are marine protected areas (MPA) where land and marine-based touristic activities are prohibited like in the MSS (PR14, PR15, PR16, and PR19). At the open reserved area, -land-based touristic activities are carried out along the public beaches (Yamaniyyah and the national campsite) and Berenice.

Table 4.1 shows that all groups agree on Tala Bay, hotels' area, and Ghandoor beach as the predominant land-based touristic activities. Officials and researchers highlighted the mega touristic projects, Ayla (60% of officials, 86% of researchers) and Saraya (70% of officials, 86% of researchers), both still under their construction phase. Ayla will be the biggest touristic project in Aqaba coast, including five-star hotels, touristic beaches, and three artificial lagoons. Ayla has already added 17 km artificial coastline to the total length of the Jordanian coastline (PR4, PR6, and PR12). Saraya will include five-star hotels and apartments, and an artificial lagoon (See Appendix 1). Note, however, officials emphasise mega touristic projects as important drivers of economic development (e.g. PR8, PR19), while researchers focus on their role as drivers of an increasing pressure on coastal natural resources (e.g. PR1, PR2, and PR3). Officials are also interested in Marsa Zayed, which is also a future touristic project, and Berenice (both mentioned by 60% of officials) for the same reason mentioned above. Moreover, MSS was indicated by 70% of officials as a location for touristic activities, although in reality, it is a research centre and marine protected area, this suggests that officials are not aware of its role. Locals emphasise public beaches (Table 4.1) like Ghandoor, Yamaniyyah, and the national campsite as touristic-related areas that are involved within their scope of work (fishing, diving, and boating).

The highest spatial consensus among stakeholders is 61% for the Royal Yacht club (Figure 4.1 and Table 4.1). The next highest consensus is for the visitors' centre. Both officials and researchers highest spatial consensus were similar for Tala Bay (100% and 88%, respectively) and Saraya project (88% and 67%, respectively). However, locals show a lower level of spatial consensus (maximum value of 53%) on other touristic areas, such as Royal Yacht Club, and the public beaches (Ghandoor and national campsite).

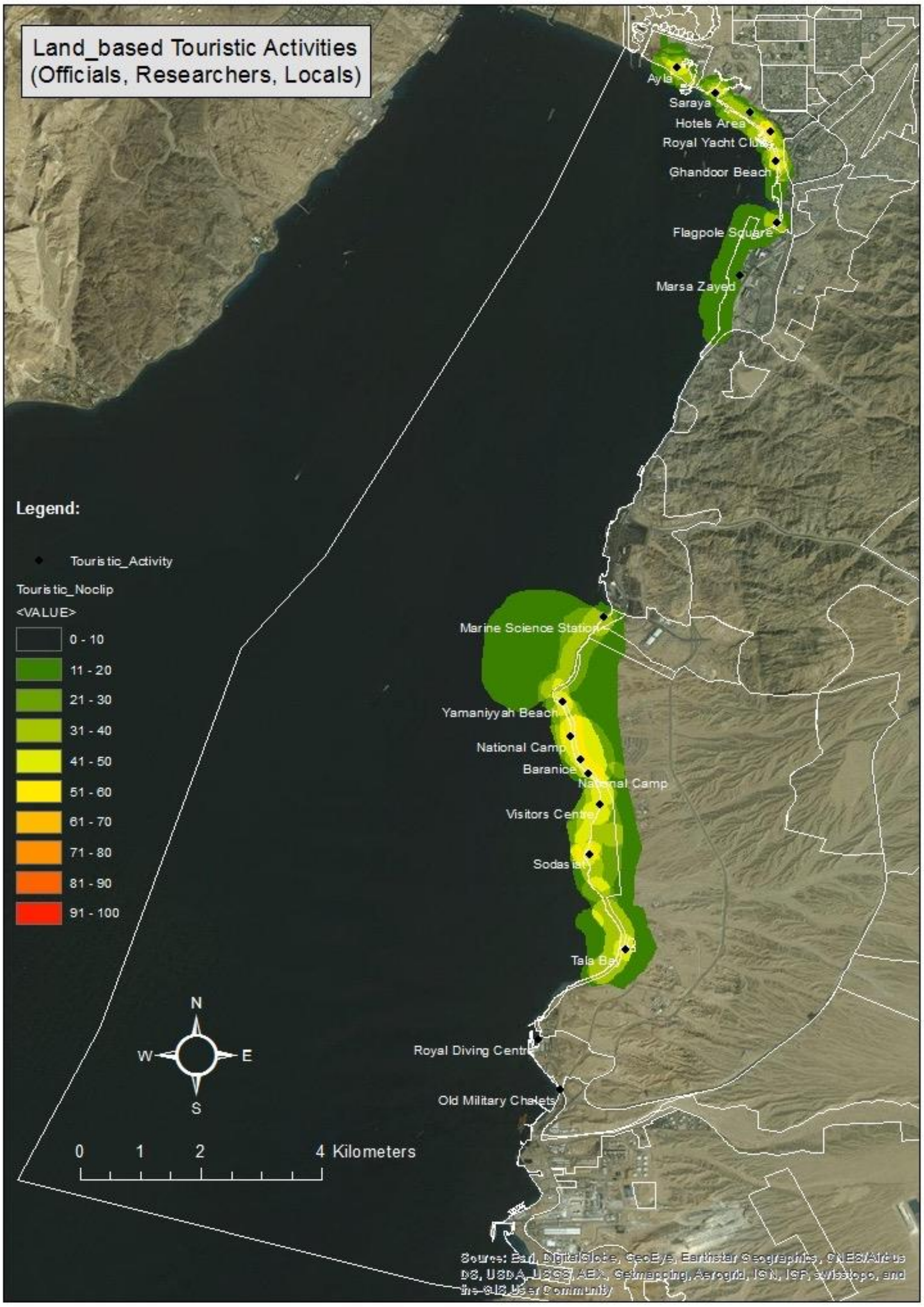


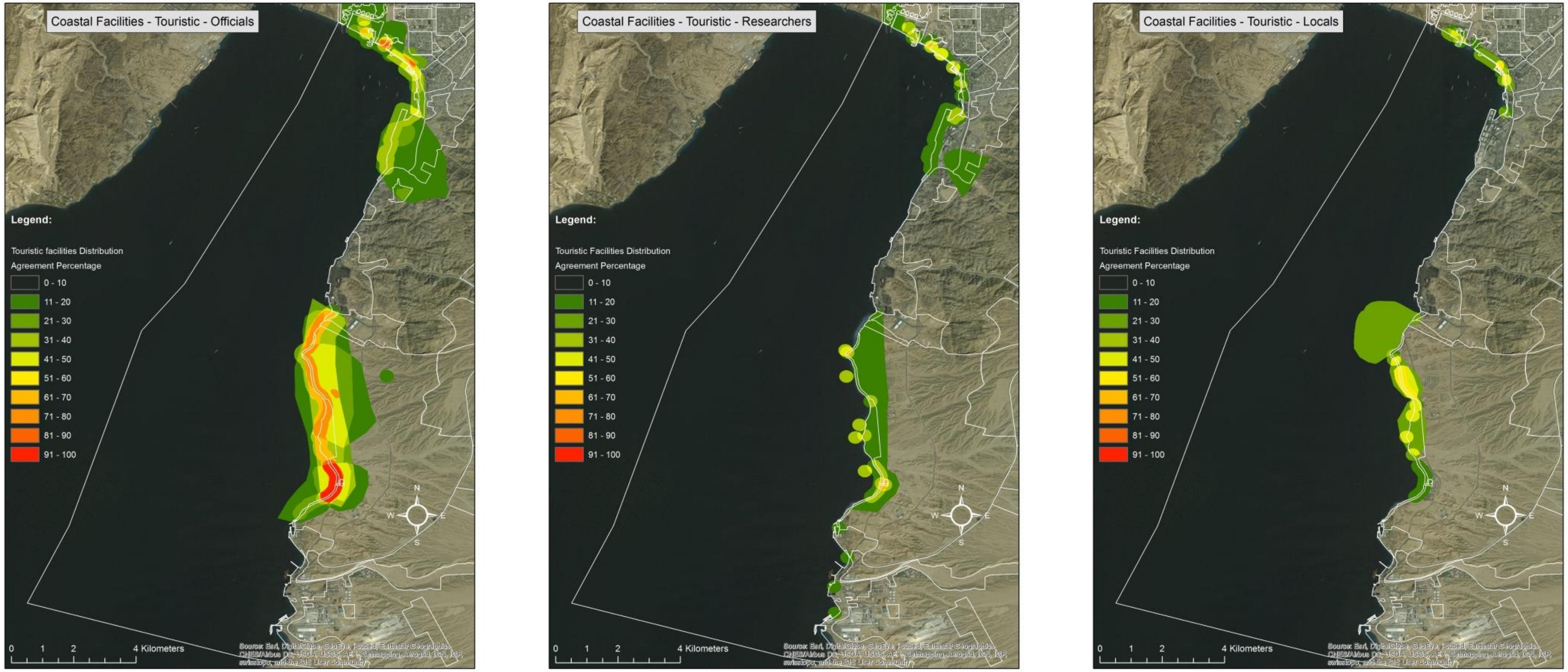
Figure 4.1: Land-based touristic activities locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 4.1: Level of awareness on the locations of land-based touristic activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Zone	Location of Land-based Touristic Activity	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic zone	Ayla Project	6	6	8	20	6	3	8	17	52%
	Royal Palace	0	0	6	6	0	0	0	0	NA
	Saraya Project	7	6	8	21	6	4	2	12	42%
	Hotels' area	8	6	19	33	6	4	8	18	35%
	Royal Yacht Club	4	4	13	21	1	4	6	11	61%
	Ghandoor beach	9	6	16	31	3	2	4	9	45%
Port Zone	Marsa Zayed Project	6	3	8	17	3	2	2	7	16%
Aqaba Marine Park Zone	Marine Science Station	7	0	6	13	1	0	0	1	NA
	Berenice	6	2	19	27	3	0	6	9	52%
	Yamaniyyah	4	5	18	27	0	1	4	5	52%
	National Campsite	4	5	18	27	0	3	7	10	52%
	Visitors' Centre	0	3	19	22	0	2	3	5	55%
	Assodasiat	2	3	9	14	0	3	3	6	52%
	Tala Bay resorts	7	7	22	36	6	6	2	14	45%
Special Zone	Royal Diving Centre	0	2	4	6	0	1	2	3	3%
	new chalets for the General Intelligence	4	3	1	8	0	0	0	0	NA
	Public Security chalets	4	3	1	8	0	0	0	0	NA
	Jordan Armed Forces chalets	4	3	1	8	0	0	0	0	NA
	Old general intelligence chalets	0	2	0	2	0	2	0	2	3%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) **(b)** **(c)**

Figure 4.2: Spatial knowledge on the locations of the land-based touristic activities according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

4.3. Marine-Based Touristic Activities

4.3.1. Diving Activities

Diving is a main attraction for tourists, mainly for those coming from abroad, especially Europe, therefore the number of local divers is very low (PR13, PR23, PR24). AMP regulates the diving activities of the 21 diving centres in Aqaba (PR1, PR5, and PR25). There are two types of diving in Aqaba, recreational and commercials (PR7). Recreational diving relies on diving centres which take people to practice diving. Commercial diving is mainly carried out to conduct corals surveys. This is a prerequisite to get an environmental impact assessment (EIA) for those proposed projects that affect corals abundant areas, such as in the case of the new main port project (PR3, PR7). Most diving along the coastal zones of the Red Sea is “boat’s diving”, while the diving experience that Aqaba offers is unique because divers can choose to either do boat diving or shore diving (PR8, PR17, and PR24). Boat diving activities usually start from the Royal Diving Centre (Figure 4.1), while shore diving starts from any identified diving sites that is supported with cross over jetties (PR8, PR17, and PR24).

Diving sites are recorded by the park and well known to the dive centres (PR7, PR16) as part of public knowledge. However, only three respondents (1 researcher, and 2 local divers) were able to identify the location of the dive sites, even though 29% of the sample mentioned diving activities during the meetings (Figure 4.3 and Table 4.2). Respondents reported 24 dive sites along the whole coastline (Figure 4.3 and Table 4.2); most of them located in the AMP zone (19 dive sites), but also including sites at the port zone (2), special zone (2), and industrial zone (1). Stakeholders highlighted that they cannot dive at some of those sites; for example, the site opposite to Tala Bay is only open for Tala Bay’s residents, while sites at the special zone are prohibited for divers (Table 4.2).

Diving routes were found to be an exclusive part of the local knowledge as there are no official records about these routes. Some respondents emphasise that only locals as diving trainers and guides have this information, which they used to explain the features of the routes to their clients before starting a diving trip (PR8, PR14, PR15, PR16, PR17, and PR25).

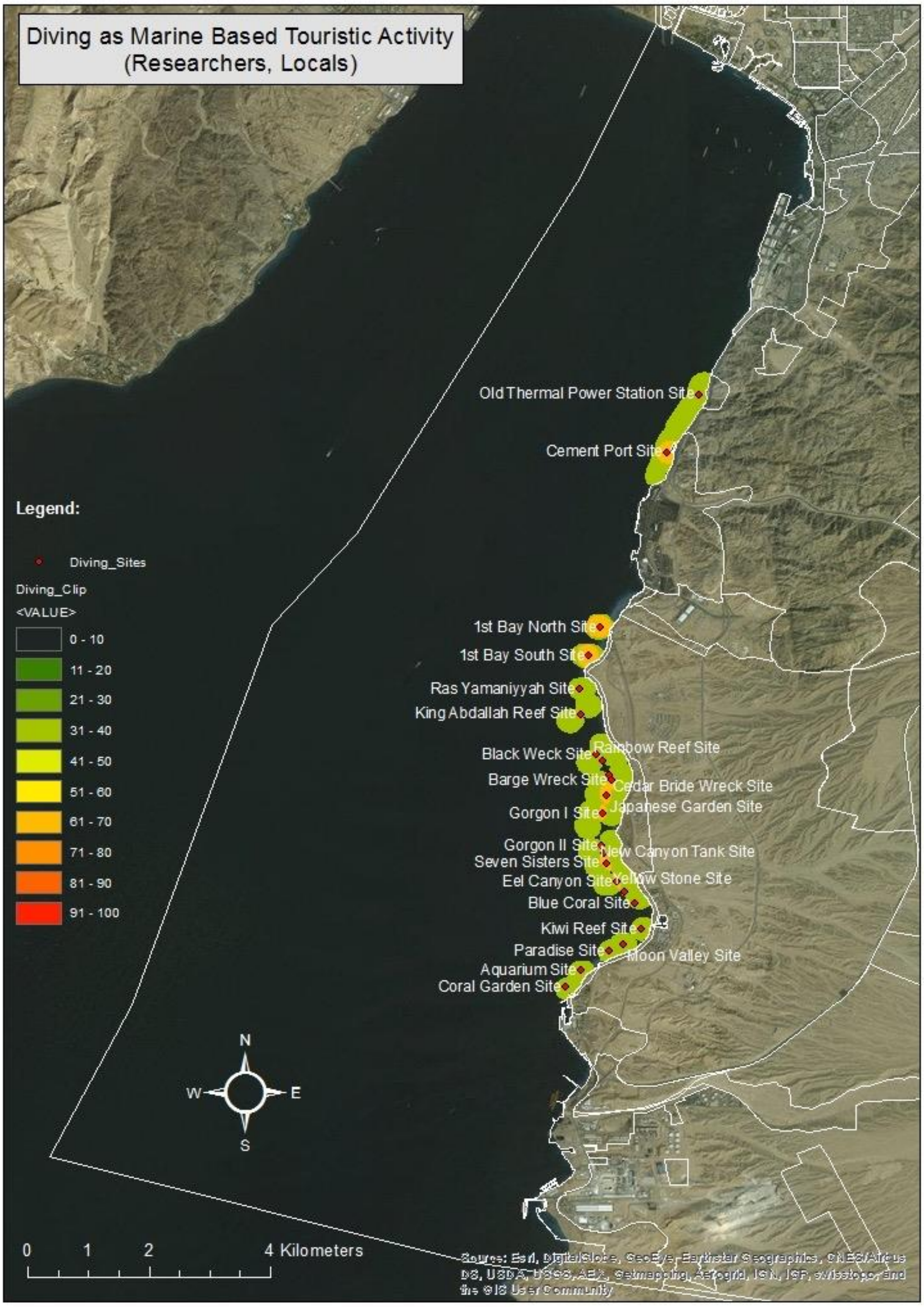


Figure 4.3: Diving sites as marine-based touristic activity locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 4.2: Level of awareness on the locations of diving sites along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Diving Site		Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Official (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic zone	**Opposite Ghandoor Public Beach**	0	0	2	2	0	0	0	0	N/A
Port Zone	**Old Thermal Power Station Site**	2	1	8	11	0	1	1	2	33%
	Cement Port Site	0	1	4	5	0	1	0	1	N/A
Aqaba Marine Park Zone	**1st Bay North and south Site:** Open, supported with buoys (PR23) but lacking other facilities (e.g. toilets (PR25).	0	0	6	6	0	0	2	2	67%
	Ras Yamaniyyah Site: Open, but not supported with the required facilities for divers (PR25)	0	0	2	2	0	0	1	1	N/A
	King Abdallah Reef Site: it was divided into two sites	0	0	10	10	0	0	2	2	67%
	Black Wreck Site: Open	0	0	4	4	0	0	2	2	67%
	Rainbow Reef Site: Open	0	0	6	6	0	0	2	2	67%
	Cedar Bride Wreck Site: Open	0	0	3	3	0	0	2	2	67%
	Barge Wreck Site: first artificial site in Aqaba (1986)	0	0	6	6	0	0	1	1	N/A
	Japanese Garden Site: hosts some of the translocated corals from the Saudi border wall site (PR13)	0	0	7	7	0	0	2	2	67%
	Gorgon I and II Sites: Used to be one dive site (PR18, PR23)	0	0	4	4	0	0	2	2	67%
	Seven Sisters Site: Supported with services (PR23)	0	0	3	3	0	0	2	2	67%
	New Canyon Tank Site: drowned by King Abdallah 13 years ago but now closed	0	0	3	3	0	0	1	1	N/A
	Shoruq Site: Closed	0	0	1	1	0	0	0	0	0%
	Eel Canyon Site: Closed	0	0	3	3	0	0	1	1	N/A
	Yellow Stone Site: Open	0	0	2	2	0	0	2	2	67%
	Blue Coral Site: Closed from the beach for non-residents of Tala Bay	0	0	2	2	0	0	1	1	N/A
	Kiwi Reef Site: Closed from the beach for non-residents of Tala Bay	0	0	3	3	0	0	1	1	N/A
	Moon Valley Site: Closed from the beach for non-residents of Tala Bay	0	0	4	4	0	0	1	1	N/A
	Paradise Site: closed from the beach for non-residents	0	0	5	5	0	0	1	1	N/A
Special Zone	**Aquarium Site:** Closed	0	0	7	7	0	0	1	1	N/A
	Coral Garden Site: Closed	0	0	5	5	0	0	1	1	N/A
Industrial Zone	**Saudi Border Wall Site:** Damaged and closed	0	0	5	5	0	0	1	1	0%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

4.3.2. Glass Bottom Boats Activities

Boaters are one of the main stakeholders along the Aqaba coastline, representing a vital touristic sector while reflecting the historical and cultural heritage of the city. Boating activities are an important source of income (PR4, PR5, PR8, PR17, PR30, PR31, PR32, and PR33, PR39, PR40, PR41). About 40% of respondents described boating activities during the interviews (4 officials, 3 researchers, and 9 locals including 7 boat operators) (Table 4.3). However, the spatial locations of these boating activities (landing sites and the routes for the boating trips) were purely acquired from local users' knowledge, i.e., the boat operators (17% of respondents, n=7) (Figure 4.4, Figure 4.5, and Table 4.3).

Eleven respondents stated that the number of boaters has increased and their activities have become more organized since the establishment of ASEZA. A researcher mentioned, "*Boating is more organized now, where jetties and buoys are positioned along the landing sites to facilitate boating landing and trips*" (PR4). ASEZA placed jetties for launching and landing, and buoys for avoiding random anchorage in the sea that may negatively impact the corals along AMP (PR4, PR7, and PR16). Respondents reported that boating activities occur within the touristic zone and AMP zone (Figure 4.4 and 4.5). The hotels' Area and Ghandoor public beach were the locations most frequently mentioned (about 32% of respondents). Yamaniyyah beach (22%) and the fishermen's port were also seen as key locations (20%) (Table 4.3).

Boaters can land and load tourists along three sites within the park (Figure 4.4) which are 1) the area between Yamaniyyah beach and the national campsite, 2) the visitors' centre, and 3) Assodasiat. There is a high spatial consensus on the landing sites along the AMP (100%), while consensus was at a medium level along the public beaches of the touristic zone (Table 4.3). It is noticeable that this activity is associated with the public beaches that accommodate high numbers of local visitors coming from throughout the kingdom, in addition to the local residents of the hotels who wish to go for boating trips.

Boating routes are part of the local knowledge with no official records. The manager of the park stated: *"There are no officially established routes for the boaters, they memorize them, it is their daily work"* (PR17), and an ASEZA planner mentioned:

> "*Glass boats are working randomly in terms of routes for their trips, but usually focusing their work along the north coastline within the touristic zone, they do their trips opposite to hotels' area and Ghandoor beach*" (PR8).

Figure 4.5 shows that short trips are carried out either in the touristic zone or AMP zone, while the long trips are heading from the touristic zone to AMP zone. Boaters stated that there are 89 boats, with about 10 boats only offering the long trips due to the high associated costs (PR30, PR31, PR32, PR33, PR39, PR40, and PR41). Boaters travel parallel to the coastline, keeping a distance of 500 m from the shore (PR39 – PR41), and when they go to deeper sea areas, they keep at least 200 m from the territorial water (PR30, PR31, PR32, and PR33). They usually visit areas where corals exist, and they use their inherited local knowledge to show and explain types and locations of corals to the tourists (PR8, PR16, PR18, PR31, PR32, PR33, PR39, PR40, and PR41).

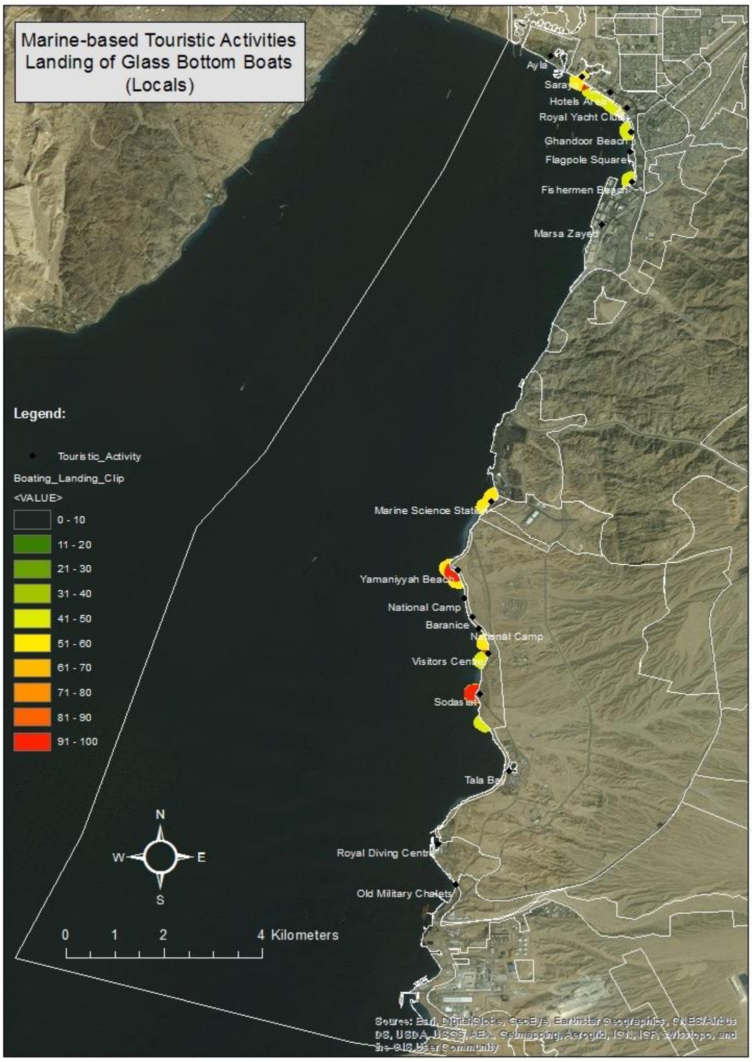


Figure 4.4: Boating landing sites as marine-based touristic activity locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

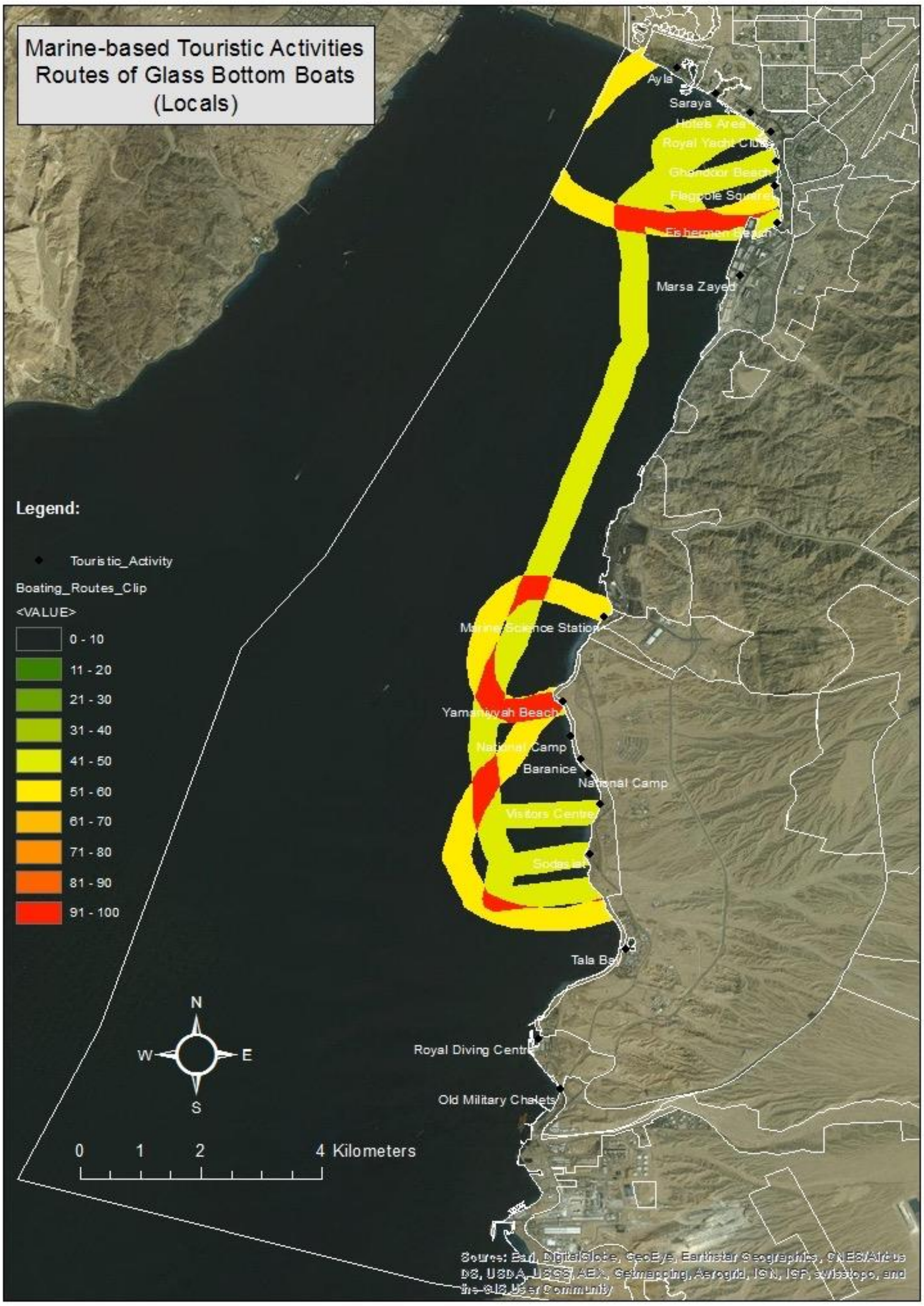


Figure 4.5: Boating trips as marine-based touristic activity locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 4.3: Level of awareness on the locations of landing sites for boating activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Landing site for boating activity		Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic zone	Saraya Project	0	0	4	4	0	0	4	4	57%
Touristic zone	Hotels' area	3	2	8	13	0	0	3	3	43%
Touristic zone	Ghandoor Beach	3	2	8	13	0	0	3	3	43%
Touristic zone	Fishermen's port	0	1	7	8	0	1	7	8	43%
Aqaba Marine Park Zone	Yamaniyyah beach	1	0	8	9	0	0	0	0	100%
Aqaba Marine Park Zone	National Campsite	0	0	7	7	0	0	7	7	100%
Aqaba Marine Park Zone	Visitors' centre	0	0	7	7	0	0	7	7	100%
Aqaba Marine Park Zone	Assodasiat	0	0	7	7	0	0	7	7	100%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

4.4. Port Activities

Results show that there is a high level of awareness about port activities with twenty-six respondents (8 officials, 4 researchers, and 14 locals) mapping them along the port zone and the industrial zone (Figure 4.6, Table 4.4). A further 12 respondents mentioned port activities without mapping them. The high response rate for highlighting the port activities is unsurprising because they are the only ports for the Kingdom (e.g. PR10, PR11, and PR18). The Jordanian borders were until the 60s at the end of the port zone. However, the Kingdom of Saudi Arabia collaborated with Jordan, by providing an extra 12 km, and so, the current length of the Jordanian coastline is 27 km (PR5, PR19). This historical reference explains why the current locations for most of the ports are between the touristic zone and the AMP. Nowadays, ASEZA's current vision encompasses relocating most of the ports to be within the industrial zone, and accordingly, the main port and the phosphate port are already in the process of being relocated (PR19). A researcher mentioned that there is a plan to relocate the passengers' port (PR3). However, the reallocation of the container's port is thought to be difficult according to an official, due to the shortage of coastline in the industrial zone (PR19).

The main port (mentioned by over 85% of respondents) was established in the 50s and went through several development stages over time (PR18). Aqaba Container's Terminal, ACT (71%), the old phosphate port (68%), and the passengers' port (59%) were also found to be key features of port activities (Table 4.4). ACT is acknowledged by the locals to contribute significantly to the economy of the country (PR10, PR11) and was extended recently (PR8, PR12). The phosphate port was developed in the 60s for exporting raw phosphate, and used to handle both phosphate and petroleum, but exporting petroleum was moved later to the industrial zone (PR18). This port will be dismantled to be replaced by Marsa Zayed touristic Project (e.g. PR8, PR12, PR26, PR27, PR28, and PR29)

Most officials focused on the passengers' port and the main port due to their role as sources of national income, while most locals mentioned the main port due to their impact in their daily work. Researchers showed a high level of awareness of the old phosphate port, due to its impact on coastal pollution (Table 4.4).

The highest spatial consensus is around the fishermen's port (63%), followed by ACT and the passengers' port (62%) (Figure 4.6 and Table 4.4). There is a high level of consensus in all three stakeholders' groups in the spatial distribution of the port activities (Figure 4.7).

Note that spatial knowledge of the local group is mainly limited to the main port (old) with less ability to map activities in the industrial zone.

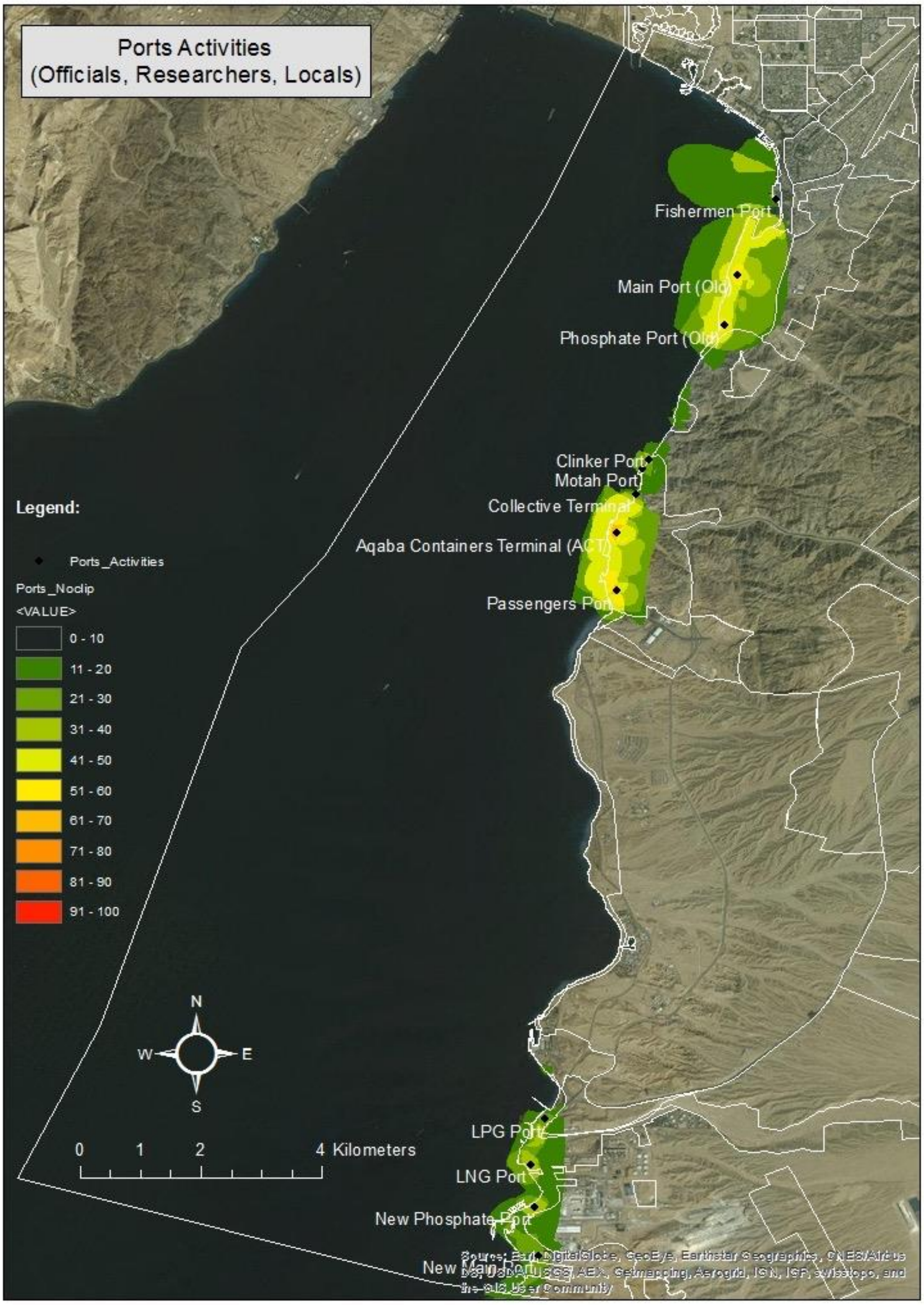


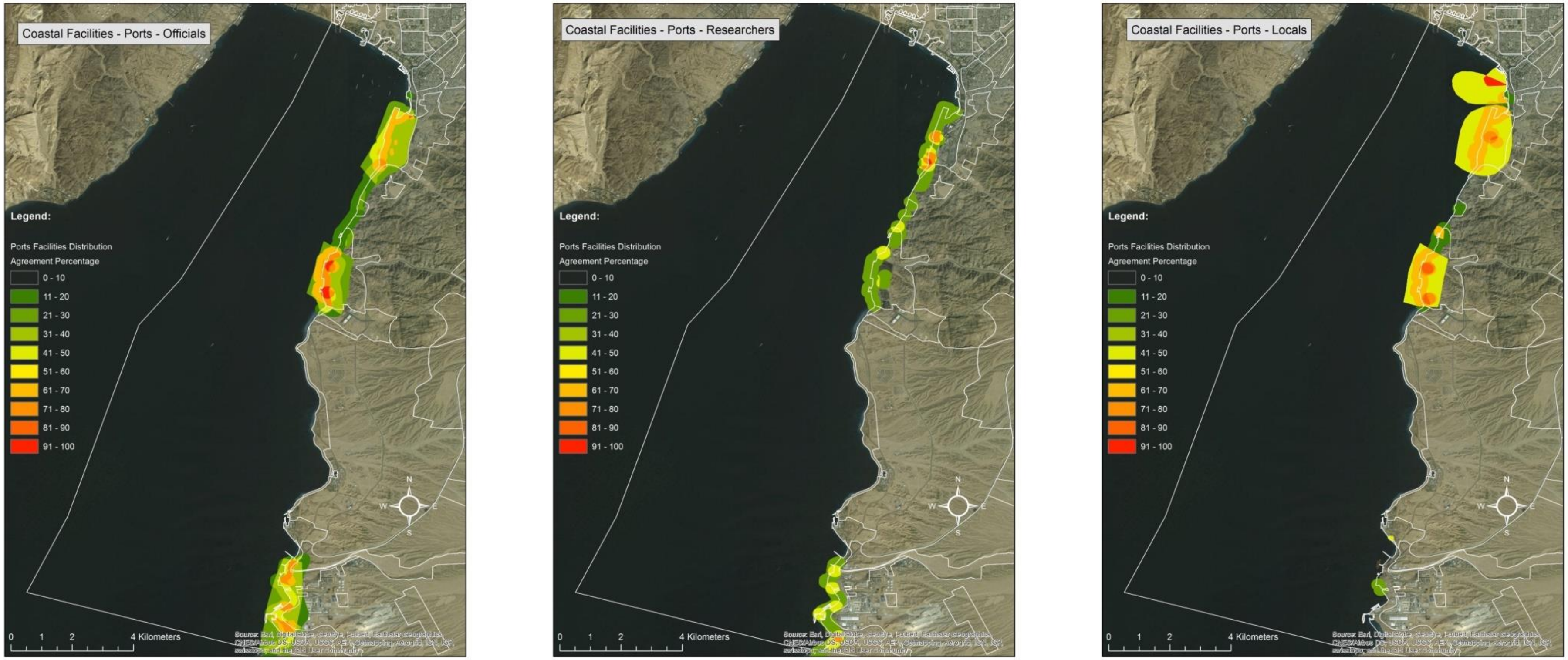
Figure 4.6: Port activities locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 4.4: Level of awareness on the locations of port activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Location of port activities		Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	**Ships anchorage**	6	1	2	9	0	0	0	0	NA
Touristic Zone	**Fishermen's Port**	4	2	10	16	1	1	9	11	63%
Port Zone	**Main port**: Most of the exports to the country are handled in this port, but it will be dismantled	9	4	22	35	5	2	7	13	54%
Port Zone	**Old Phosphate Port:** Used for exporting phosphate, but it will be dismantled	7	7	14	28	4	3	2	9	54%
Port Zone	**Clinker Port** – Used for unloading livestock, rice and grains	0	4	3	7	0	2	1	3	31%
Port Zone	**Mu'tah Port** – Used for unloading livestock, rice and grains	4	0	6	10	3	0	0	3	27%
Port Zone	**Collective Terminal Port:** Used for loading cement, and unloading other goods	4	0	5	9	3	0	0	3	23%
Port Zone	**Aqaba Containers Terminal**	8	6	15	29	8	3	7	18	62%
Port Zone	**Passengers port:** Used for travelling passengers, mainly between Jordan and Egypt	9	4	11	24	8	3	7	18	62%
Special Zone	**Navy Port**	0	1	8	9	0	0	0	0	NA
Industrial zone	**LNG Port:** Gas port	5	4	0	9	4	0	0	4	27%
Industrial zone	**LPG Port:** Gas Port	5	4	0	9	4	0	0	4	31%
Industrial zone	**New Phosphate Port:** The new port for handling phosphate instead of the old phosphate port	5	3	0	8	4	0	0	4	31%
Industrial zone	**New Main Port:** The new port instead of the main port within the port zone	7	3	3	13	5	3	0	8	31%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) **(b)** **(c)**

Figure 4.7: Spatial knowledge on the locations of the port activities according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

4.5. Industrial Activities

Around 40% of respondents (8 officials, 4 researchers, and 5 locals) mapped industrial activities (Figure 4.8 and Table 4.5), even though 86% of respondents mentioned these activities during the meetings. Officials and researchers seem to highlight the industrial activities because many industries are operating from Aqaba due to its high demand for water (PR8, PR19). Respondents mapped the industrial complex, the central power station, the old thermal power plant and the Egyptian electricity cable. Officials, researchers, and locals reported that industrial activities occurred in the industrial zone and the port zone; locals only mapped one feature (the electricity cable between Egypt and Aqaba) in the AMP zone.

The key locations for industrial activities highlighted by respondents (Table 4.5) are the old thermal power plant (49% of respondents) and the industrial complex (46%). Note, however, that the old thermal power plant was stated as a predominant industrial activity (even by locals, 67%), although it is not operational. It has yet to be dismantled. It is mapped specifically by the divers as there is a dive site in this area. One researcher (PR13) clarified that the new plant (currently called the Central Power Station) is located within the industrial zone (PR13). Activities within the industrial complex are mainly heavy industry such as fertilizers and storage of chemicals (PR5, PR9, PR12, and PR19). In addition, there are three sources for the phosphate industry in the industrial complex; Jordanian phosphate mining company, fertilizers industry and Kemapco (PR6). Participants stated that there are two artificial lagoons for water-cooling, one in the central power station and the other within the industrial complex (PR5, PR14, PR15, and PR16).

The highest agreement is for the industrial complex and central power station (60%) (Figure 4.8 and Table 4.5). Officials and researchers show consensus on the spatial locations of the industrial activities, while locals, mainly divers, mapped only the electricity cable within AMP. Figure 4.9 shows that there is a high consensus for the mapping within the stakeholder's groups of officials, researchers, and locals, 88%, 75%, and 60% respectively.

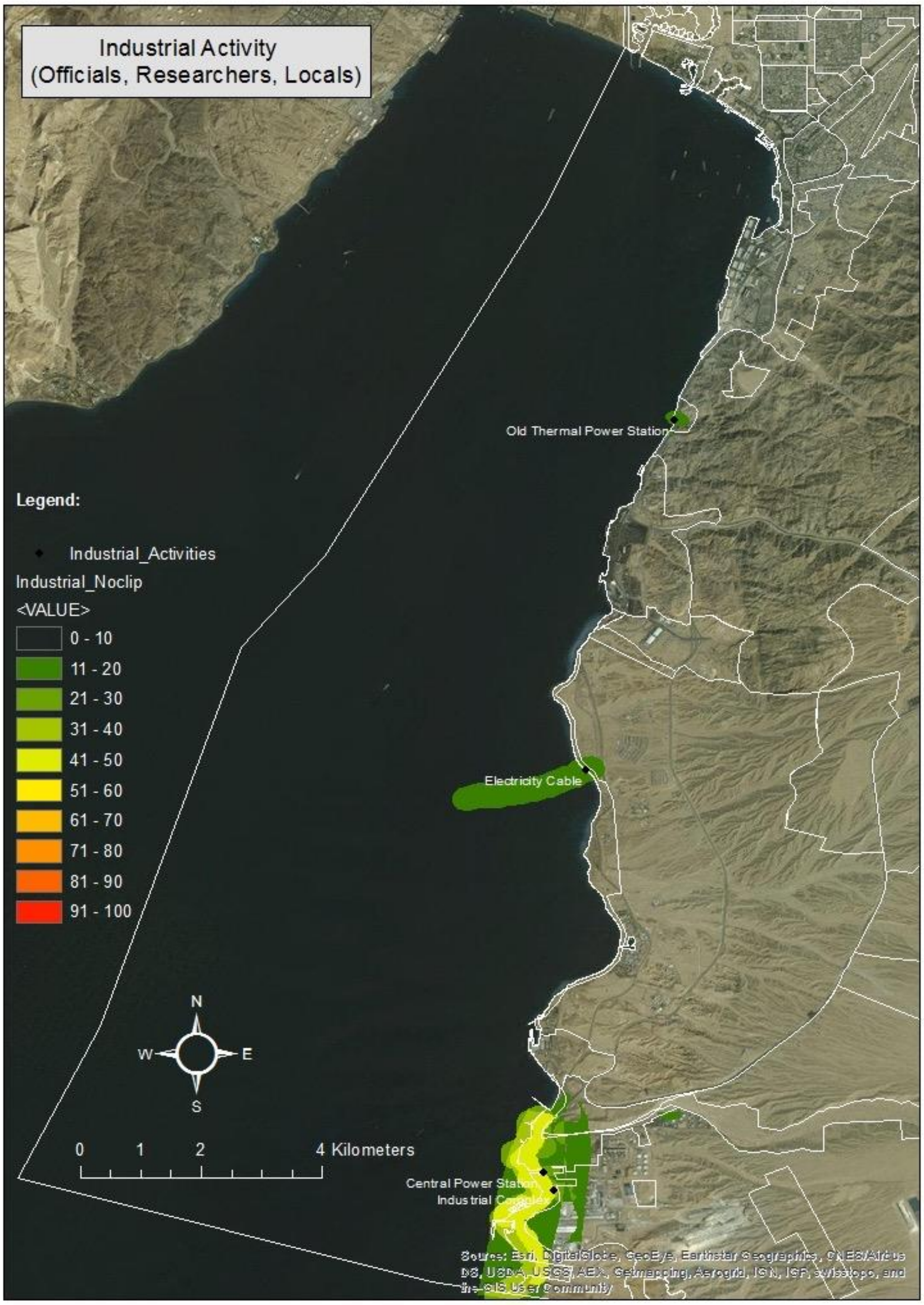


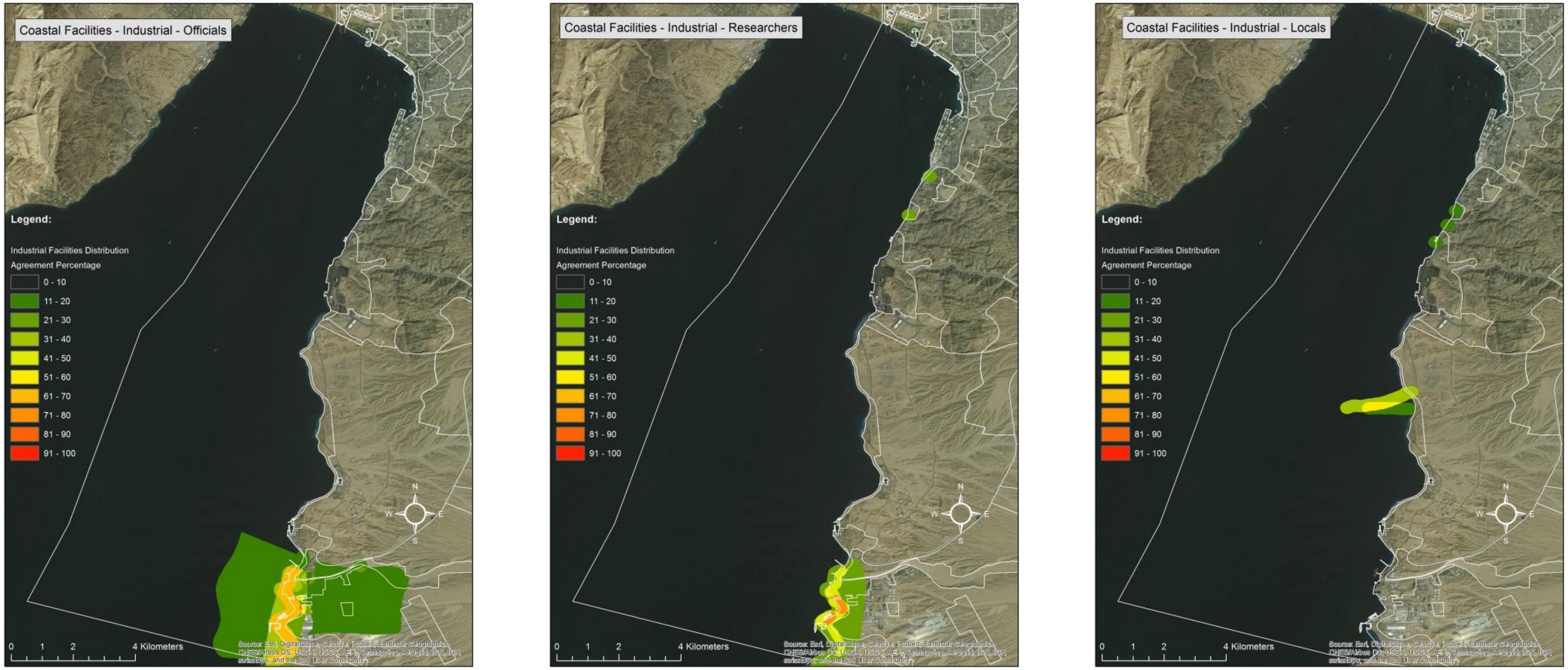
Figure 4.8: Industrial activities locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 4.5: Level of awareness on the locations of industrial activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Landing site for boating activity		Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
1	Old Sewage Treatment Plant	0	1	0	1	0	0	0	0	NA
2	Old thermal power station	1	3	16	20	0	2	3	5	12%
3	Electricity Cable	0	0	3	3	0	0	3	3	12%
4	Industrial complex	6	5	8	19	6	4	0	10	60%
5	Central Power Station	5	3	0	8	3	2	0	5	60%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) (b) (c)

Figure 4.9: Spatial knowledge on the locations of the industrial activities according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

4.6. Fishing Activities

More than 30% of respondents reflecting 1 official, 2 researchers, and 11 locals (mainly fishermen) mapped fishing activities in Aqaba, with a further 17% of respondents (n = 7) describing them without mapping. Respondents marked three categories for the locations of fishing: permitted fishing sites; restricted fishing sites; and prohibited fishing sites. Permitted fishing sites are along the touristic zone and the port zone (Figure 4.10 and 4.11, Table 4.6). Key locations are the Royal Yacht Club (mentioned by 15% of respondents), hotels' area and the Ghandoor beach (both mentioned by 12%). The restricted fishing sites are located along AMP (except Tala Bay) (Figure 4.12 and Table 4.7). Prohibited fishing sites are within the special zone and the industrial zone and to a lesser extent in the touristic, port, and AMP zones (Figure 4.13, Table 4.8). Prohibited sites for fishing are Tala Bay, the new and the old military chalets. Although fishing status (permitted, restricted, and prohibited) was mapped mainly by the fishermen, one researcher also mapped fishing sites along the deep sea within the touristic zone (Figure 4.11), and two researchers and one official participated in mapping prohibited fishing sites (Figure 4.14).

The PGIS sessions show that there are around 120 fishers (all are men), 70 of them rely on fishing as their main source of income, while the rest have additional sources of income (working in ASEZA, the ports or other activities) (PR4, PR16). There are no records for recreational fishermen (PR4, PR5), perceived by an official as unimportant with only a few people engaged in recreational fishing (PR7). Fishing is being governed by the AMP and two fishermen associations (1 official, 3 researchers, and 9 fishermen). The responsibility of monitoring fishing activities lies in different organisations depending on the fishing sites. For example, AMP has the responsibility in the park; the Navy forces take responsibility along the touristic zone, while the Aqaba Ports Corporation monitors fishing activities in the ports (PR26, PR27, PR28, and PR29). Appendix 5 shows some photos that reflect different aspects for the fishing activities in Aqaba as taken during the field work.

There are no official sites or routes for fishing; the only perceived rule mentioned by three researchers and an official (PR3, PR4, PR5, and PR17) is that fishermen should keep a distance of 300 m from the corals in any zone. One of the researchers explained that fishermen prefer to do fishing in the seagrass environment, thus avoiding damage to the nets that the corals can cause (PR5). An official highlighted that fishermen simply memorize their routes as part of their daily work (PR17). Fishermens' local knowledge revealed that they can go into the deep sea by distances ranging between 1 and 3 km, as it is not permitted to go beyond since this is near the borders of the territorial water (PR26, PR27, PR28, and PR29). The fishermen described the width of the Gulf of Aqaba as varying from the north to the south, and they perceive this as key for their daily work, because it enables them to keep a distance from the territorial water when they go for deep fishing, otherwise they can get arrested (PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38). Fishermen catch large fish using the small fish species, but highlight that catching the small fish species is a challenge because these are near the shore, and as described previously, most of the shore is categorized as either restricted or prohibited (PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38).

The only area where fishermen can go freely is the fishermen's port (See Appendix 1), but this area is poor for both small and large fish species (PR26, PR27, PR28, and PR29) (spatial distribution of fish species is discussed in Chapter Five). Fishermen emphasize that the fishing practices in the past were less regulated. For example, fishing was described as very common and intense along the special zone and specifically along Sharif Naser port (the old fishermen's port, currently the navy port), but it is not permitted anymore (PR21, PR22, PR26, PR27, PR28, and PR29, PR34, PR35, PR36, PR37 and PR38). Sharif Naser port was the main port for the 30 fishermen at that time, used for the last 40 years, and located between the old general intelligence chalets and the navy (PR26, PR27, PR28, and PR29). A local respondent explained that fishermen were permitted to go beyond the territorial water, and even that they were able to reach Saudi Arabia and Yemen. This is no longer possible for security reasons and the unstable political situation in the region (PR18).

Old fishing practices were also emphasized by a researcher (PR5). PR5 stated that fishermen used to make what is called "Hawakeer" along Tala Bay. Hawakeer is a very large net placed over night with fish collected the following day. It leads to overfishing. Hawakeer was also highlighted in the 1st fieldwork as now prohibited by ASEZA and controlled through the park rangers (PR5).

Fishermen have to start their trips from the fishermen's port in the touristic zone and register in the navy office there. They also have to register there when they come back (PR26, PR27, PR28, and PR29). Fishermen are only permitted to start their trips at 6 am and have to come back before the sunset (PR34 – PR38). They prefer to start their work earlier, and in the past, they were permitted to start fishing from 4 – 5 am. The fishermen's port is also used by other locals, particularly glass bottom boats and speed boats (PR26, PR27, PR28, and PR29). However, security agents differentiate between the fishermen's boats and other boats based on the colour; red boats are for fishing while white boats are for tourism (Appendix 11).

Results show that there is a high level of spatial disagreements in the identification of permitted, restricted, and prohibited fishing sites. Various locations were mapped both as permitted and restricted, for example, the Saraya project, hotels' area, Royal Yacht Club, Ghandoor beach, the fishermen's port and some sites in the port zone (Figure 4.10, Figure 4.12, Table 4.6). Disagreement is also evident in the status of either restricted or prohibited areas along the AMP (Figure 4.12, Figure 4.13). Meetings revealed that the distance that fishermen must remain from the shore (specifically the berths) is not clearly understood, but one researcher (PR4) identified it as at least 300 m.

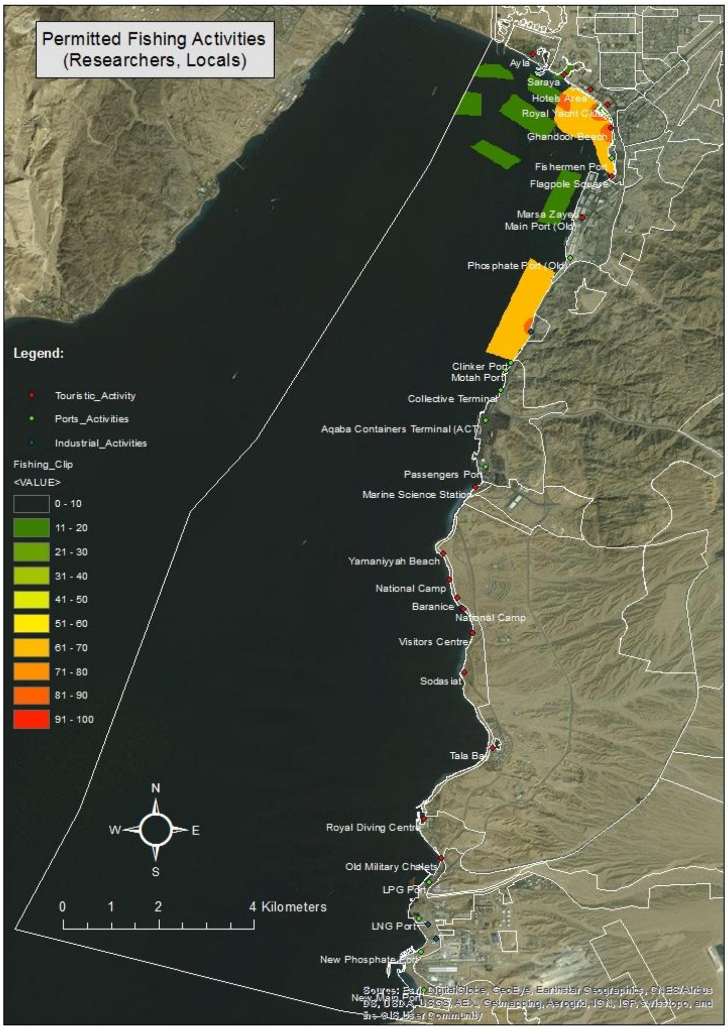


Figure 4.10: Permitted fishing sites generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

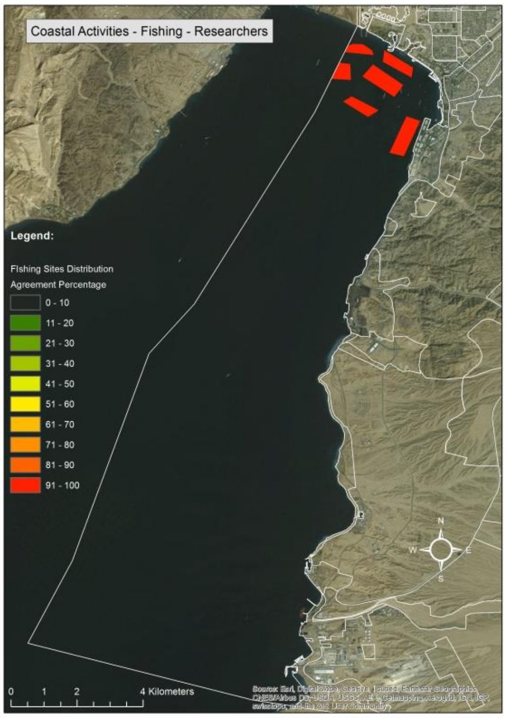
Table 4.6: Level of awareness on the locations of permitted fishing sites along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Permitted Fishing Site	Number/ Percentages* of Respondents who Mentioned/ mapped				Consensus in Spatial Location
	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Saraya Project[2]	0	1	1	2	18%
Hotels' area[2]	0	1	4	5	83%
Royal Yacht Club[2]	0	1	5	6	83%
Ghandoor Beach[2]	0	0	5	5	83%
Fishermen's Port[2]	0	0	4	4	67%
Main Port[3]	0	1	0	1	17%
Area between main port and containers port[3]	0	0	4	4	67%

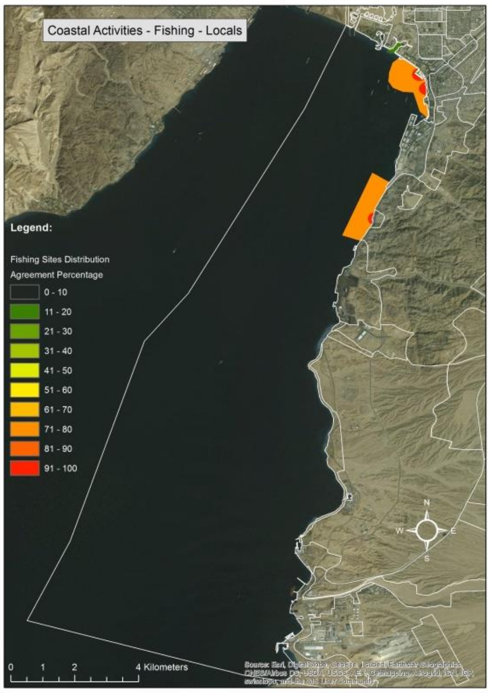
Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

1: mapped as permitted fishing site only, **2**: mapped as permitted fishing site by the above respondents, but other respondents mapped it as restricted fishing site, **3**: mapped as permitted fishing site by the above respondents, but other respondents mapped it as restricted and prohibited fishing site.

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a)



(b)

Figure 4.11: Spatial knowledge on the locations of the fishing sites according to different stakeholders' views: a) researchers and b) locals. Shading shows percentage of consensus among respondents mapping the area.

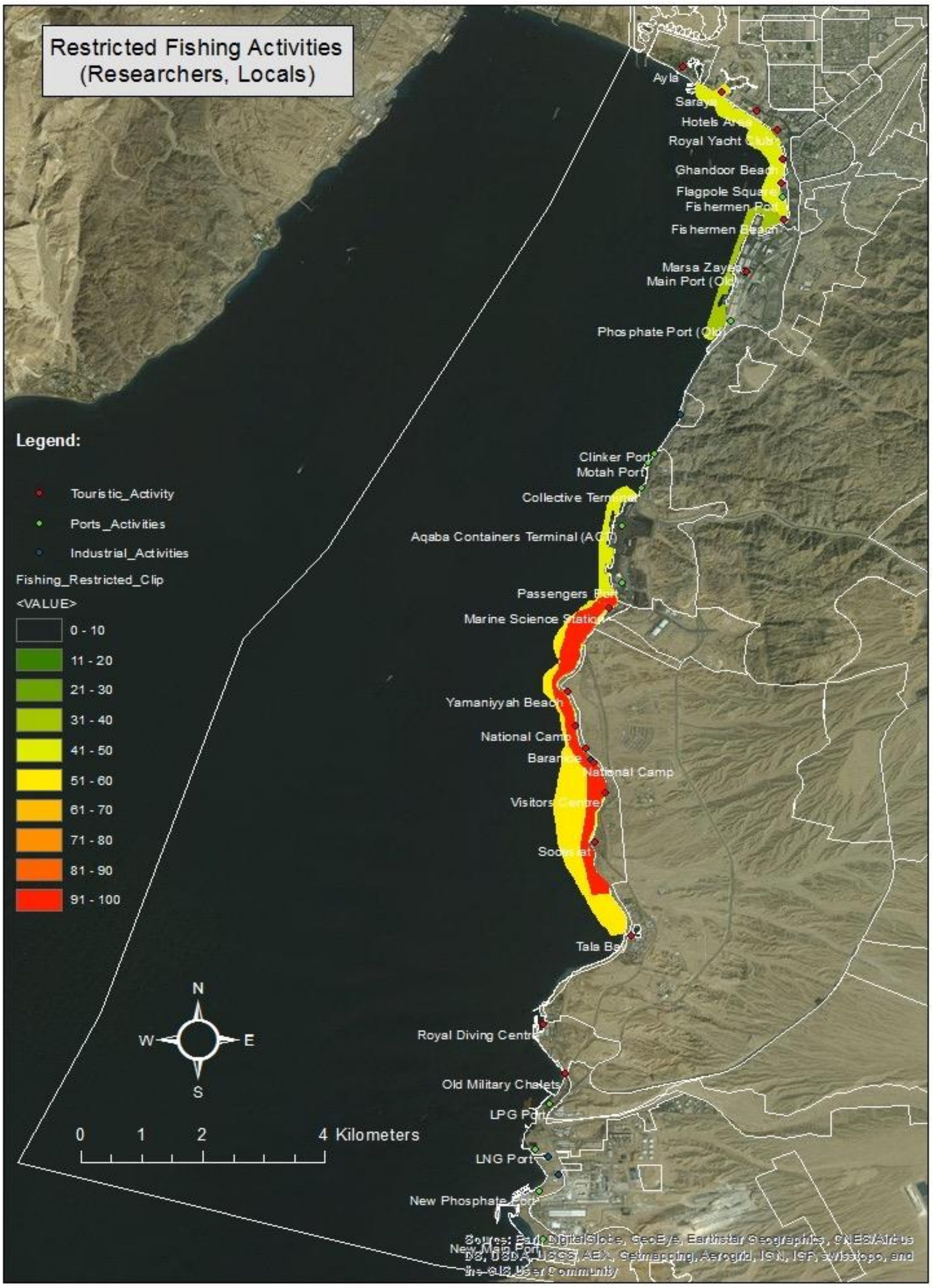


Figure 4.12: Restricted fishing sites generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

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Table 4.7: Level of awareness on the locations of restricted fishing sites along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

	Location	Description	Number/ Percentages* of Respondents who Mentioned/ mapped				Consensus in Spatial Location
			Officials (10)	**Researchers** (7)	**Locals** (24)	**All** (41)	
Restricted Fishing Sites	Saraya Project[2]	The presence of navy while fishermen are fishing; moreover, fishermen should keep a distance of 200 – 300m from the shore	0	0	5	5	50%
	Hotels' area[2]	Fishing is permitted just during summer specifically to catch small fish	0	0	5	5	50%
	Royal Yacht Club[2]	Fishing is permitted just during summer specifically to catch small fish	0	0	5	5	50%
	Ghandoor Beach[2]	The presence of navy while fishermen are fishing; moreover, fishermen should keep a distance of 200 – 300m from the shore, but they can go along the beach just to collect the small fish. Fishing is permitted just during summer specifically to catch small fish	0	0	5	5	50%
	Fishermen's Port[2]	The presence of navy while fishermen are fishing.	0	0	5	5	50%
	Main Port[4]	Fishermen should keep it from the shore (specifically the berths), but this distance is not clear among respondents. Fishermen can collect small fish between 6 am and 9 am and just during summer.	0	0	5	5	50%
	Containers port[4]		0	0	5	5	50%
	Passengers port[3]		0	0	5	5	50%
	Marine Science Station	Fishing is permitted after specific distance from the shore and depending on both the fishing gear and the season	0	0	10	10	100%
	Yamaniyyah beach	Fishing is permitted after specific distance from the shore and depending on both the fishing gear and the season. Along these areas, it is permitted to collect small fish only	0	0	10	10	100%
	National Campsite		0	0	10	10	100%
	Berenice	Fishing is permitted after specific distance from the shore and depending on both the fishing gear and the season	0	0	10	10	100%
	Visitors' centre	Fishing is permitted after specific distance from the shore and depending on both the fishing gear and the season	0	0	10	10	100%
	Assodasiat		0	0	10	10	100%
	Tala Bay		0	0	6	6	50%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

1: mapped as restricted fishing sites only; 2: mapped as restricted fishing site by the above respondents but other respondents mapped it as permitted fishing site; 3: mapped as restricted fishing site by the above respondents but other respondents mapped it as prohibited fishing site; and 4: mapped as restricted fishing site by the above respondents but other respondents mapped it as permitted and prohibited fishing site.

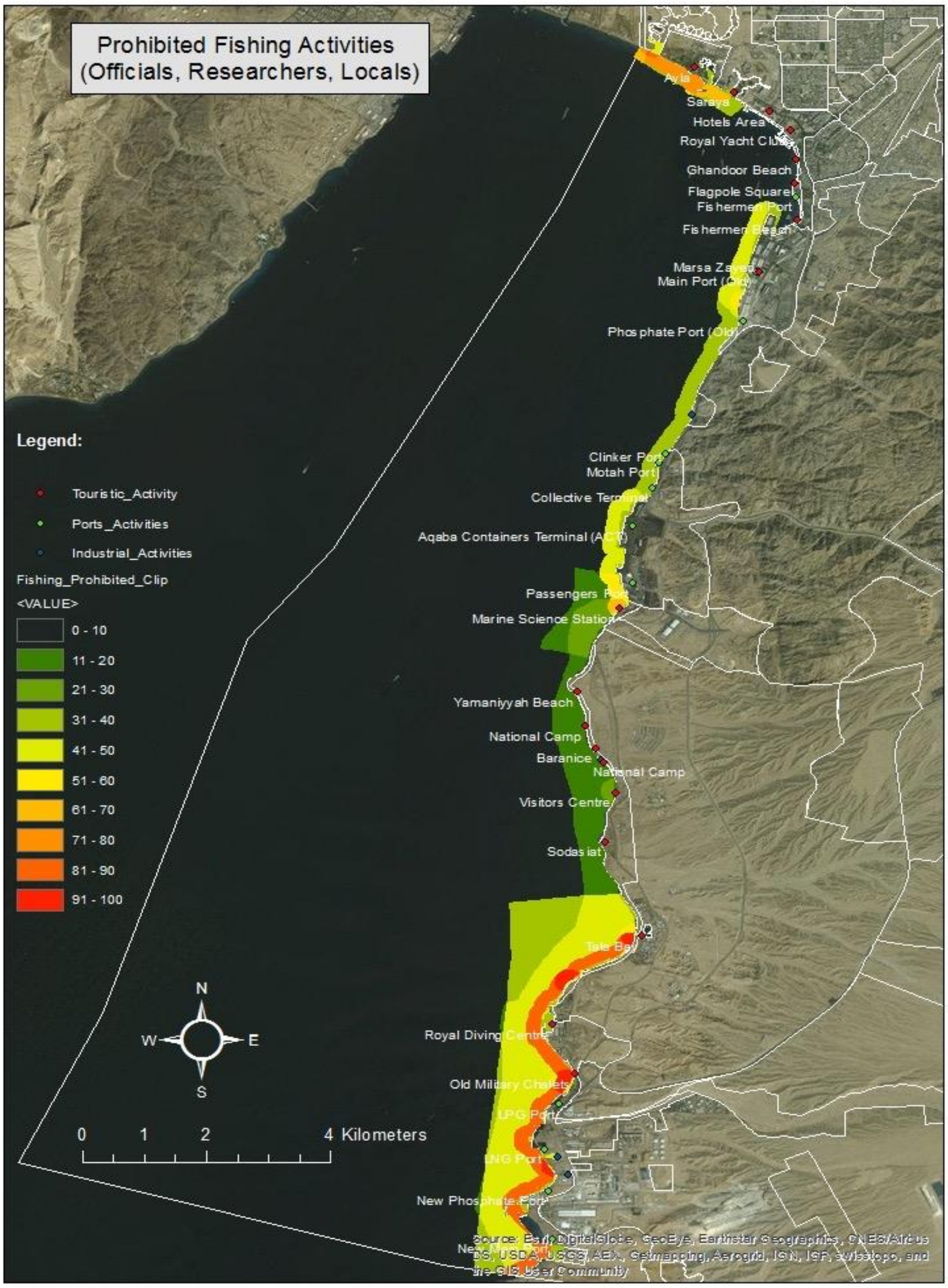


Figure 4.13: Prohibited fishing sites generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

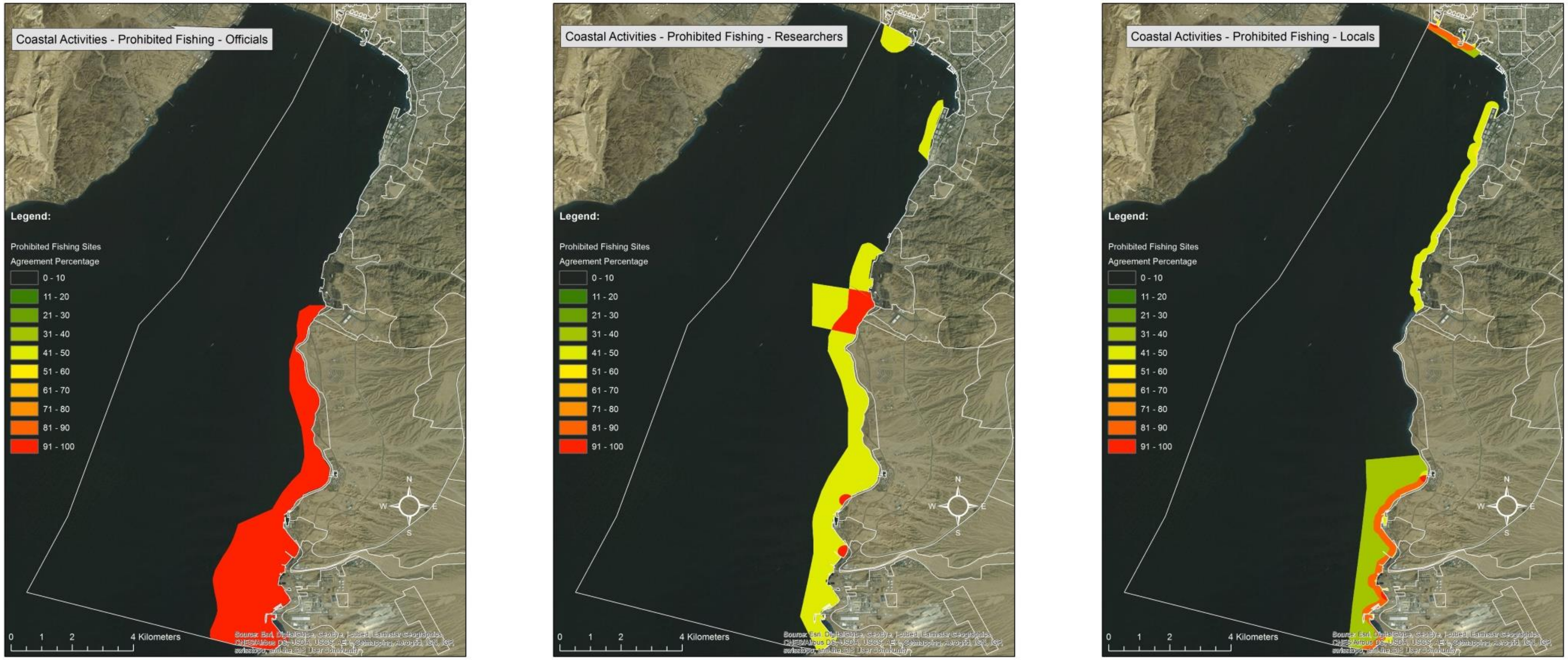
Table 4.8: Level of awareness on the locations of prohibited fishing sites along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Prohibited Fishing Site	Number/ Percentages* of Respondents who Mentioned/ mapped				Consensus in Spatial Location
	Officials (10)	Researchers(7)	Locals (24)	All (41)	
Ayla Project[1]	0	0	9	9	85%
Royal Palace[1]	0	1	10	11	77%
Main Port[4]	0	1	6	7	46%
Phosphate port[2]	0	0	6	6	54%
Containers port[4]	0	1	6	7	46%
Passengers port[3]	0	1	6	7	46%
Marine Science Station[3]	1	2	6	9	23%
Yamaniyyah beach[3]	1	1	0	2	15%
National Campsite[3]	1	1	0	2	15%
Berenice[3]	1	1	0	2	15%
Visitors' centre[3]	1	1	1	3	23%
Assodasiat[3]	1	1	0	2	15%
Tala Bay[3]	1	1	10	12	92%
New military chalets[1]	1	2	9	12	92%
RDC[1]	1	1	9	11	85%
Military chalets[1]	1	1	9	11	85%
Old military chalets (old fishermen's port) [1]	1	2	9	12	92%
Industrial Zone[1]	1	1	9	11	85%
Total Responses	12	19	114	145	

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

1: mapped as prohibited fishing site only; 2: mapped as prohibited fishing site by the above respondents but other respondents mapped it as permitted fishing site; 3: mapped as prohibited fishing site by the above respondents but other respondents mapped it as restricted fishing site; and 4: mapped as prohibited fishing site by the above respondents but other respondents mapped it as permitted and restricted fishing site.



(a) **(b)** **(c)**

Figure 4.14: Spatial knowledge on the locations of the prohibited fishing sites according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

4.7. Land-Based and Marine-based activities within the Coastal Profile

Figure (4.15) shows the estimated coverage areas in Km^2 for each of the identified land and marine-based coastal activities based on stakeholders' spatial knowledge.

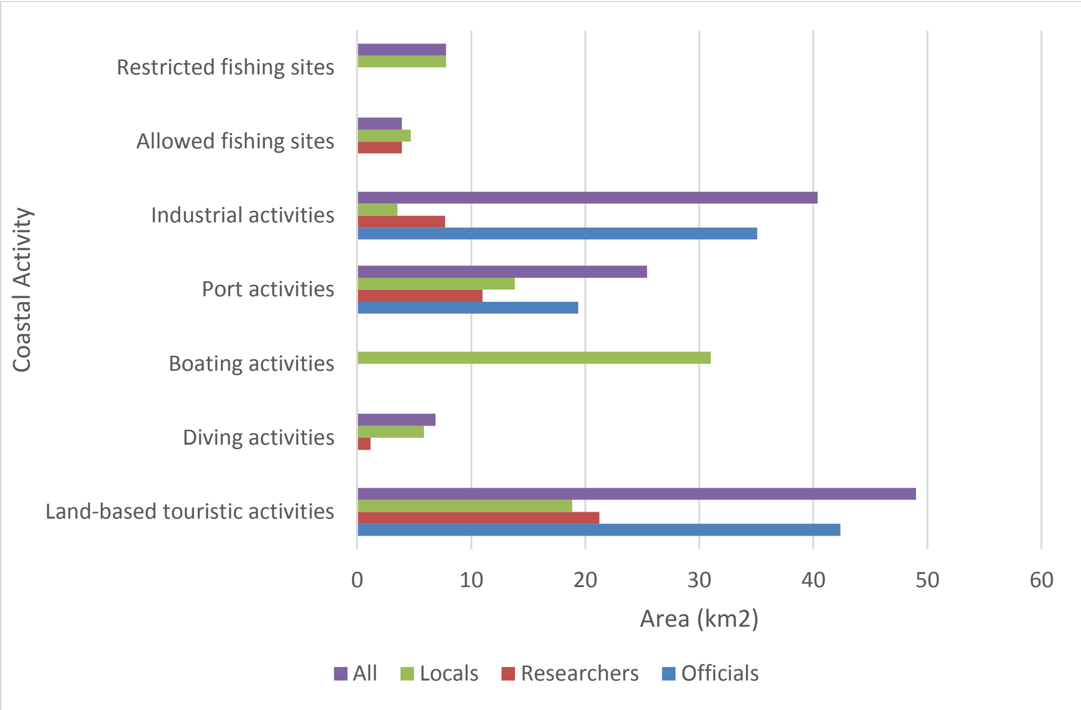


Figure 4.15: Total area in (km^2) under each of the identified coastal activities based on the perception of officials, researchers and locals who mapped in the PGIS interviews.

Respondents agreed that land-based touristic activities cover the largest area along the coast (49 km^2). This is followed by the industrial activities (40 km^2), boating activities (31 km^2, including the routes along the sea). Diving activities represent a small area (7 km^2), and fishing reflects the smallest space along the coastline (4 km^2). According to officials, the coverage area of land-based touristic activities is higher (42 km^2) than that perceived by researchers (21 km^2) and locals (19 km^2). Port activities were mapped relatively similar by the three groups with a coverage area of 19 km^2, 11 km^2, and 14 km^2 for the officials, researchers, and locals respectively. However, the area under industrial activities shows clear differences depending on the type of stakeholder. According to the reported information from officials, these activities (industrial) represent 35 km^2.

4.8. Discussion

This Chapter developed a coastal profile for the land and marine-based coastal activities following the IZCM literature (e.g. González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; Christie *et al*., 2006; ATKINS, 2004; EC, 2002; GEF/UNDP/IMO, 1996), and spatially identify them using the PGIS (e.g. EC, 2007; Anuchiracheeva *et al*., 2003).

The abundant biodiversity and resources along coastal zones attract people to live along the coast (Papageorgiou *et al*., 2017; Miller, 1993), who develop various economic activities, including fishing, aquaculture, agriculture, touristic, port and maritime, industrial, utilization of specific natural resources, infrastructure, energy related activities, and oil and gas exploitation (e.g. Andre's *et al*., 2017; Papageorgiou *et al*., 2017; Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010; EC, 2009; Halpern *et al*., 2008; World Bank, 1996; Miller, 1993). The results show that land and marine-touristic, port, industrial and fishing activities are common in Aqaba, with land-based touristic activities mentioned by 95% of total respondents, port activities 93%, and industrial activities 86%. Marine based activities on which local livelihood depend on, i.e., boating, fishing and diving, were less frequently mentioned in the PGIS interviews, with values of 39%, 51% and 29%, respectively.

A common challenge when mapping the same area by different groups is that each group will focus on specific issues that reflect their diverse 1) interest (Brown *et al*., 2016; Brown, 2012b), 2) identity (Brown *et al.*, 2016), 3) importance (Brown *et al*., 2016; Corbett and Rambaldi, 2009; Alcorn, 2000), and 4) agenda of the community (Corbett and Rambaldi, 2009). The results of this Chapter however show that all stakeholders groups, officials, researchers, and locals agreed that land-based touristic activities are the predominant activities in Aqaba. This suggests that the acquired knowledge from the locals (LK) is an alternative source in filling the current spatial knowledge gab. Thus, the spatial profiling for the coastal activities resulted in fairly high consensus even when integrating the knowledge from the three groups (61%, 63% and 59%) for the touristic, ports and industrial activities. This provides an indication that the acquired knowledge from the locals is comparable with the ones acquired, for example, from the researchers.

However, this Chapter also shows that port and industrial activities took the second place in terms of awareness by the officials and researchers, of whom few mentioned and mapped marine-based activities. These findings reflect the officials' perception of the high economic potential of land-based activities, and researchers' view on the significance of these land-use activities as drivers for the pressures on the coastal resources. Moreover, consistently with Alcorn (2000), who found that mapping a particular activity may occur for different reasons, this Chapter shows that researchers mentioned boating as an activity posing pressure on the coastal resources; and officials described diving and fishing mainly when dealing with the need to integrate management of all players along the coast addressing coastal conflicts. More specifically, a common perception among officials is that fishing is not economically feasible. An official in ASEZA stated "*Fishing is a weak industry in Aqaba, ASEZA is trying to empower it, but still, it is not feasible due to low fish stock and limited fishing sites*". Fishing is considered for both officials and research as a key part of the Aqaba culture, but with low impact in the local economy (PR17, PR5). This low level of awareness of fishing activities among researchers and officials may also indicate that there is a low interaction between these stakeholders and fishermen, illustrating the ICZM challenges of weak communications found in Chapter 2. It also confirms the lack of research on the status of fisheries in Aqaba. In fact, during the PGIS meetings, there were lots of disagreements while discussing and mapping the legal status of fishing activities (e.g. whether permitted, restricted and prohibited). This also supports the initial findings shown in Chapter 2, where the lack of spatial knowledge about fishing activities was one of the agreed Aqaba ICZM challenges.

This Chapter is useful to evaluate the efficacy of PGIS in the process of developing the coastal profile for the above activities which in turn, can enhance the role of non-official stakeholders from the first phase of the ICZM process. Thus, PGIS meetings were shown to be a successful approach to capture the local views and values in the coastal profile. The results illustrate that each local group, divers, boaters, and fishermen, has its interests and priorities when mapping coastal activities. Divers provided unique local knowledge on the diving sites, boaters focused on the landing sites for boating and the boating routes, and fishermen focused on permitted, restricted and prohibited fishing sites. The findings contribute to the literature by adding spatial records on separate maps for each one of those marine activities in Aqaba, overcoming thus one of the key challenges for the community mapping, which is ensure that the agendas of the locals are presented in the final maps (Corbett and Rambaldi, 2009).

All of the above differences in identifying and mapping provide an evidence for the importance of integrating the perception of all the players within the ICZM process in the early planning stage which can be accomplished in this thesis through enhancing the role of participation.

One of the challenges in applying PGIS is reaching consensus amongst the local community (Alcorn, 2000). Aqaba locals' agreement reached 100% when mapping boating and fishing activities, an important issue that can give legitimacy to the produced maps in this Chapter if they were to be used in political debates (Alcorn, 2000). However, overall highest spatial consensus is lower than the consensus achieved for stakeholder group individually. This result can be explained because Individual groups mapped in relation to their knowledge of specific activities and features of the coast related to their scope of work (e.g. officials and researchers) or their daily livelihood. This is a common argument in the literature associated to the complexity of the mapping process and reaching consensus when involving different stakeholder groups (e.g. Brown *et al*., 2016; Brown and Kytta 2014; Corbett and Rambaldi, 2009; Alcorn, 2000).

PGIS usage also shows differences between the response rates for mapping and mentioning. Even though this may be explained by the specific knowledge of those working on specific activities (an argument mentioned above), a further explanation could be that PGIS respondents were not familiar with the mapping process, and so, it was easier for them to explain the activities rather than mapping them. Yet, this means that those coastal users do not have enough knowledge about other marine activities. For example, a small number of divers mapped fishing sites. The results here show that there is a difference between acknowledging and being able to map; in other words, being aware of specific activities does not necessarily mean having the spatial knowledge about it. However, note that the low response rate for spatially identifying some activities (e.g. diving) may highlight the question of accuracy and validity (Brown *et al*., 2012). Nevertheless, such spatial knowledge, even from a limited number of respondents, is a unique knowledge and therefore an important element in the coastal profile.

Thus, the Chapter shows that using the PGIS provided unique and rich information, in which many can be considered culturally sensitive information (Rambaldi *et al*., 2006), especially that acquired from the divers, boaters, and fishermen during the group meetings. Consistently with Young and Gilmore (2017) which illustrated that the PGIS can capture traditional knowledge nuances that Cartesian grid and the traditional cartographic systems might not capture, this Chapter showed that the fishermen in this study identified permitted, restricted, and prohibited fishing sites, a classification that was not identified or documented before, and give an indication of their long historical connection with the area. Similarly, boaters' local knowledge was shown to be fundamental in terms of identification of landing sites and routes along the public beaches. Coastal users were able to shed light on and spatially identify knowledge that neither officials nor researchers managed to do.

Interestingly, the fact that fishermen actually mapped the actual areas where they do fishing regardless if it is legally permitted or not, means that fishermen felt relaxed and honest in admitting their illegal practices. This could be because the PGIS meetings were carried out in their work zone (fishermen's port and public beaches), and so they felt less stressful and more confident in providing and mapping their sensitive LK (Cinderby, 2010). However, collecting such knowledge can be dangerous and one of the limitations for the PGIS specifically and the community mapping generally as stated in the literature (Fox *et al*., 2006; Abbot *et al*., 1998). Young and Gilmore (2017) stated that if the produced maps include sensitive knowledge, even though they reflect heritage local knowledge, it will be difficult to control how such knowledge is being transmitted and used; and the risk can accelerate if such maps are being published online (Young and Gilmore, 2017). In order to overcome this challenge, Corbett and Rambaldi (2009) recommended that the maps' producer should use them with considerable consideration and highlighted that if the maps are presenting unique information for certain individuals, such information should not be shared with other community members. In this study, the maps are being used for research purposes only.

4.9. Conclusion

This Chapter identify land-based and marine-based coastal activities for the coastal profile of Aqaba. The results in this Chapter reflect the gathered local knowledge from coastal resource users that have been used to develop the coastal profile, a basic requirement for ICZM implementation.

Existing land-based coastal activities as being identified in this coastal profile are touristic, ports, and industrial activities, and marine-based coastal activities are diving, boating, and fishing. Both officials and researchers were shown to have a high level of awareness when it comes to the land-based coastal activities. However, both groups have a low level of awareness in relation to marine-based coastal activities, in other words, the daily life of the local divers, boaters, and fishermen. The results also show that local participants, who are the coastal users, reflect a significant source of knowledge, in particular in relation to marine-based coastal activities. It was found that that the level of consensus when mapping coastal activities (both land-based and marine-based) for each group alone is higher than the overall consensus for the three groups, which illustrates the complexity of integrating the perception of different ICZM stakeholders. Moreover, the response rate for mapping coastal activities was always lower compared to the response rate for just identifying (without mapping). Awareness regarding the spatial coastal knowledge seems, therefore, to be lower than the non-spatial knowledge. The applied PGIS showed to be efficient in engaging all the players along Aqaba coast, leading to rich and unique information, mostly not documented before to the author's knowledge, especially in relation to spatial local knowledge.

5. Chapter Five: Marine Coastal resources in Aqaba

5.1. Introduction

ICZM was developed to reduce the adverse impacts of human activities along coastal ecosystems (Breen and Hynes, 2014). In order to do so, the first phase of the ICZM cycle suggests identifying and assessing coastal resources that need to be conserved and used in a sustainable way (GESAMP, 1996; UNSD, 1992 as seen in Chapters 1 and 2). This can be done through highlighting areas characterized by abundant coastal resources, helping to prepare special management programs for such priority areas (GESAMP, 1996; UNSD, 1992). Consequently, the first phase can pave the road for the second phase in the ICZM, program preparation that defines the required mechanisms for resources allocation and the required changes in resource usage.

The aim of this Chapter is to develop a coastal profile for Aqaba coastal resources (coral, fish, seagrass and sandy bottoms) in order to be able to identify priority areas based on these coastal resources. We therefore address the specific research objectives of (i) identifying the location of areas that require special management attention, (i) gathering information on qualitative assessment on the type, depth, coverage percentage and current status of coastal resources along the coast, and (iii) contrasting the perceptions between the ICZM stakeholder groups on the spatial distribution of these resources.

Similarly to Chapter Four, the location of marine coastal resources along the coastline will be analysed focusing on the level of consensus amongst the PGIS participants. The resources will be described from the north to the south following the same zonal classification: touristic zone, port zone, AMP zone, special zone and industrial zone.

5.2. Corals

Nearly three-quarters of the stakeholders (73%) that participated stated that corals are a main coastal resource in Aqaba (5 officials, 7 researchers, and 18 locals). The presence of corals is considered crucial because corals attract fish (PR4, PR5). Moreover, many coastal resource users depend on corals, including divers, fishermen, and boaters (PR4, PR8).

More than half of respondents (56%) participated in the mapping process of corals: 3 officials; 6 researchers; and 14 locals. Moreover, 17% of respondents (n = 7) discussed corals status during the meetings without mapping them. Figure 5.1 and Table 5.1 show the spatial distribution of corals along the coast, as well as stakeholder consensus. Key locations for corals are the areas between Yamaniyyah beach and Assodasiat (mentioned by 51% of respondents), the area between MSS and Yamaniyyah beach (46%), and MSS (44%). All of these areas are located in the AMP and coral is mapped less frequently further away from the AMP. As expected, this is consistent with the spatial distribution of the diving activities (see Chapter Four). The next most important locations for corals are located in the industrial zone; this includes the area opposite the LNG (34%), LPG and the new phosphate port (32%).

The highest spatial consensus was found along the Yamaniyyah public beach (83%) and in the areas between the national campsite and Assodasiat (74%). A diver described the corals along the Yamaniyyah beach as:

> *"The area starts with very nice pinnacles of corals (soft corals) and fringing reef that looks like a zigzag. This area is very rich in pinnacles of corals in small size in addition to a large amount of hard and soft corals that are very healthy and beautiful" (PR24).*

Corals along the AMP zone include both original and transplanted corals. Corals which were thought to be negatively impacted by infrastructure developments were transplanted to the AMP along the visitors' centre coastline (PR12, PR21, and PR22). Corals were transplanted from the new main port area (PR12, PR16), the extension of the containers port (ACT), the LNG, the LPG, and the oil terminal (PR12).

In the touristic zone, corals distribution is perceived to be low (Table 5.1, Figure 5.1). Information on corals in this zone relies on the local knowledge of two expert divers, who argued that there are some patches of corals near the Ghandoor public beach. This was confirmed by an expert researcher in corals (PR3). Divers recognize the uniqueness of their knowledge:

> "*Corals along Ghandoor public beach as well as the fishermen's port start from 12 m depth and increase after 18 m depth and can reach up to 35 m depth*. *Most people do not dive there because they do not know about the presence of corals in this area"* (PR21, PR22).

Figure 5.2 shows that both officials and locals focused on mapping corals along the AMP, with almost similar consensus (100%, and 86% respectively). However, locals complement official knowledge by mapping corals in further areas, even though the level of consensus was lower for these cases (only up to 36%). On the other hand, researchers believe that corals exist along the entire coastline, with high consensus level of 83% in different areas within the port, AMP, the special and the industrial zones.

Figure 5.3 provides a detailed qualitative descriptive analysis of corals along the coast, characterizing, information such as the type, depth, coverage percentage and current status of corals based on the PGIS interviews. For illustrative purpose, this figure describes coral status opposite to the land-based coastal activities presented in Chapter Four. Corals can be found in the form of patches, fringing reef, reef flat, reef wall, in addition to the transplanted corals and the artificial reef found opposite to intensive land-based coastal activities (e.g. main port, the old phosphate port, ACT, Berenice, and the military chalets). Reef flat is found in areas where land-based coastal activities are less intense (e.g. between the old phosphate port and the old thermal power plant, the old thermal power plant, and between ACT and the passengers port). Transplanted corals are mainly located opposite to the visitors' centre. Artificial reefs to encourage coral establishment are located opposite to Ghandoor beach.

Coral relative abundance is higher in the south because biological and physical conditions change from north to south (PR16), but generally, corals are found near the shore, and so they are classified as shallow reefs. As a consequence, they are easily accessible by diving, but also they can be impacted easily by anthropogenic land-based activities (PR16). The PGIS interviews reveal that the depth of the corals varies between 1 m to 45 m, except for the reef wall opposite the old thermal power plant and the military chalets, which can reach 100 m in depth (Figure 5.3). Moreover, the highest coral coverage (CC) is in the area between the old thermal power plant and the clinker port (CC = more than 70%) at 8 m depth, the area between the ACT and the passengers' port (CC = 52%), and Yamaniyyah beach (CC = 53%).

The status (quality and abundance) of corals is decreasing. Six respondents (1 official, 3 researchers, and 2 locals) stated that there were corals present in the touristic zone, but that nowadays this zone is characterized mainly by a sandy environment. Another researcher stated that opposite to RYC, coral patches used to exist especially to the south border of the RYC, but they have deteriorated and the area has also become a sandy environment (PR5). The port zone used to have a high abundance of corals (PR23) but not anymore. Furthermore, badly impacted corals were identified opposite the main port, ACT, Berenice, and the new main port (Figure 5.3).

The presence of high coral coverage was identified as a key factor that determined the cultural, economic and environmental attraction of local tourism in the south coast, along the special zone and the industrial zone, during the last 40 years (PR16). However, nowadays this is not the case because the industrial zone is no longer accessible. The corals in the industrial zone accounted for 35% of the total corals in Aqaba (PR13). Corals that used to exist in this area were described as unique (PR13). Divers stated that it was possible to dive 200 – 300 m distance and still on 12 m depth only before reaching the drop-off of 40 – 45m depth (PR21, PR22). Divers were able to enjoy the presence of large areas of corals without going deep in the sea. Corals were in the form of large colonies, and their size used to increase with depth. Particularly, in front of the old intelligent services chalets, currently the location of the LPG port (Figure 5.1), there were coral reefs on the shore, with percentage coverage of about 38% (PR21, PR22). Corals were found in the form of cabbage (called 'cabbage corals') with each cabbage coral covering an area of around 20 – 30 m^2. Moreover, this area was also described as a habitat with high fish stock (PR21, PR22).

Some contradictions were found among stakeholders. For example, two divers (PR21, PR22) described the corals along the collective terminal (Figure 5.3) while another two officials (PR14, PR15) mentioned that there are no corals in that area. Similarly, there are some corals along the passengers' port (e.g. PR21, PR22); and again this contradicts the official version because one official stated that no corals can be found along the passenger's terminal (PR9). Furthermore, some respondents stated the presence of corals opposite the ACT (PR8, PR12, PR14, PR15, PR21, and PR22), while an official (PR9) stated there are no corals. Two divers (PR21, PR22) stated that this contradiction can be due to the fact that along the terminal area, corals are almost dead up to 45 m depth, but patches of corals can be rarely noticed (Figure 5.3).

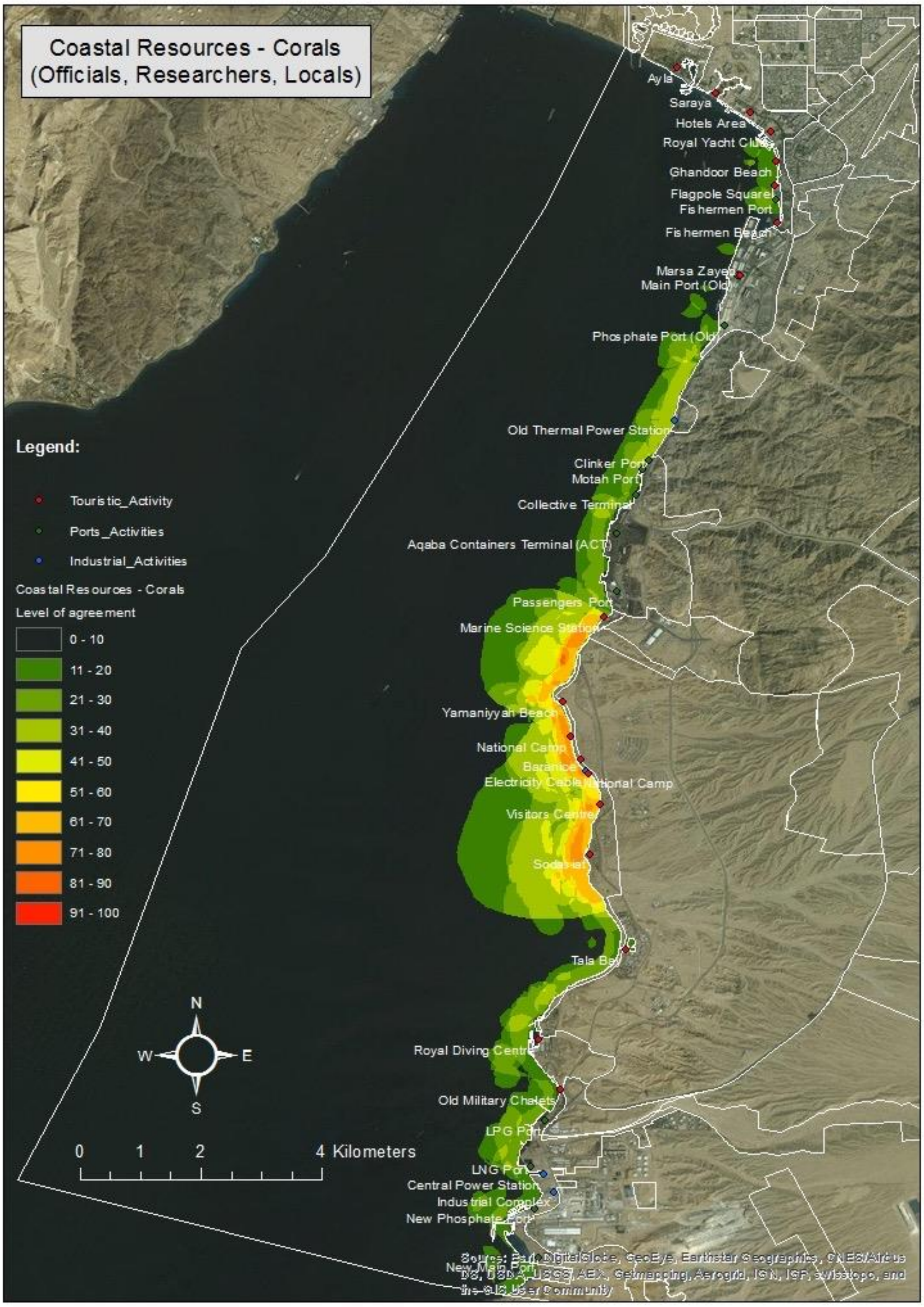


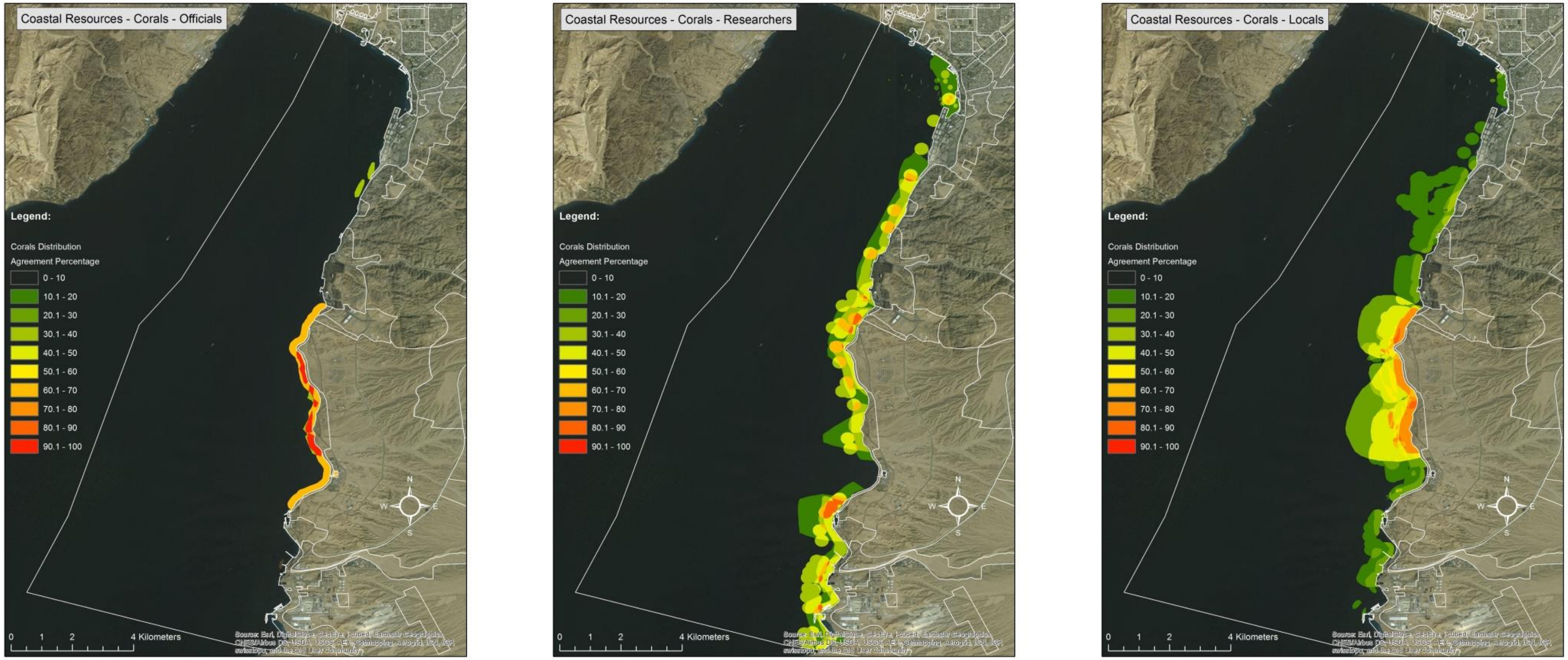
Figure 5.1: Corals locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 5.1: Level of awareness on the locations of corals along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Zone	Location of corals	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic zone	Hotels' area	0	1	0	1	0	1	0	1	NA
	Royal Yacht Club	0	2	5	7	0	1	1	2	22%
	Ghandoor Beach	0	2	7	9	0	1	2	3	22%
	Fishermen's Port	0	0	3	3	0	0	0	0	NA
Port Zone	Main Port	0	2	2	4	0	2	2	4	17%
	Old Phosphate Port	1	4	5	10	1	4	4	9	22%
	Area between phosphate port and clinker port	0	6	6	12	0	5	6	11	44%
	Clinker port	0	4	5	9	0	4	5	9	44%
	Collective terminal	0	5	4	9	0	5	3	8	30%
	Aqaba Containers Terminal	4	2	3	9	0	2	3	5	30%
	Passengers port	0	5	3	8	0	5	3	8	30%
Aqaba Marine Park Zone	Marine Science Station	2	5	11	18	2	5	10	17	65%
	Area between MSS and Yamaniyyah Beach	2	5	12	19	2	5	12	19	65%
	Yamaniyyah Beach	3	5	13	21	3	5	13	21	83%
	National Campsite	3	5	13	21	3	5	13	21	74%
	Berenice	3	5	13	21	3	5	13	21	74%
	Visitors' Centre	3	4	14	21	3	4	14	21	74%
	Assodasiat	3	5	13	21	3	5	13	21	74%
	Tala Bay	2	0	5	7	2	0	4	6	22%
Special Zone	New Military chalets	1	4	6	11	0	4	3	7	44%
	Royal Diving Centre	1	5	5	11	0	5	3	8	35%
	Military Chalets	1	4	5	10	0	4	4	8	35%
Industrial zone	LPG	1	6	6	13	0	5	3	8	35%
	LNG	1	6	7	14	0	5	4	9	NA
	New Phosphate Port	1	6	6	13	0	5	3	8	30%
	New Main Port	1	6	4	11	0	5	1	6	26%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) **(b)** **(c)**

Figure 5.2: Spatial knowledge on the location of the corals according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

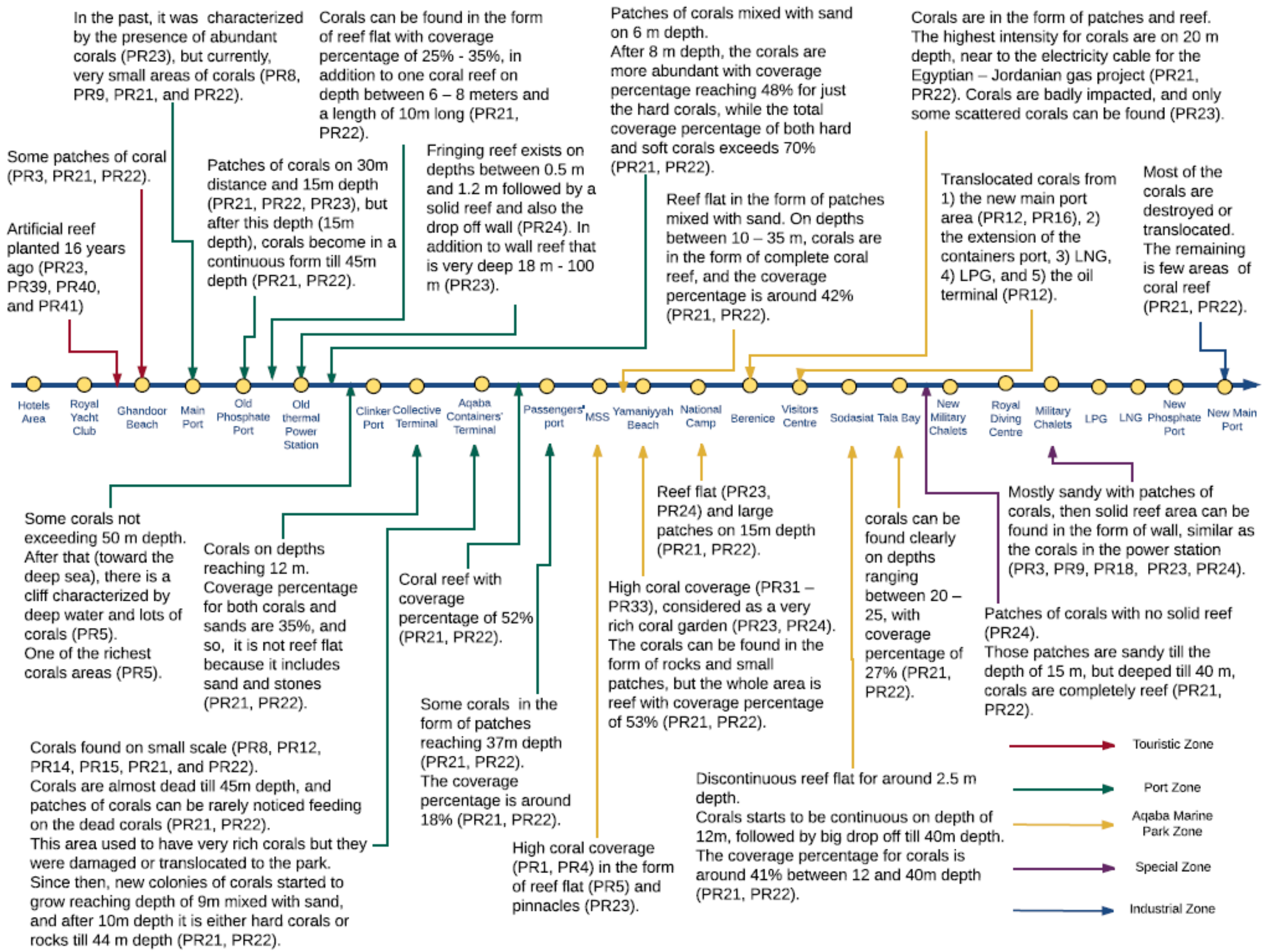


Figure 5.3: Key descriptive local knowledge about corals along Aqaba coastline, including information, if mentioned in the PGIS interviews, on the type of corals, its type, depth, coverage percentage and current status.

5.3. Fish

Generally, fish species in Aqaba are small, colourful and usually coexists with the corals (PR3, PR4, PR21, PR22, and PR23). Fishing is not considered as an economically feasible activity (e.g. PR5, PR23), which was also highlighted by respondents of the semi-structured interviews. Some specific anthropogenic threats which limit this industry in Aqaba are also identified in Chapter Two (section 2.3.2.4). However, note that respondent PR17 highlighted that ornamental fish trade in the Amman market at the capital city of Jordan could be potentially profitable.

Figure 5.4 shows that the level of consensus varies between 82%, and 46%, which is a fairly high agreement compared with mapping of other coastal resources in this Chapter. Table 5.2 shows that the presence of fish as a coastal resource was only mentioned by locals and researchers (14 and 3, respectively). Thus, nearly 60% of the locals, including all the fishermen interviewed, as expected, included fish as a resource. Consequently, the spatial distribution of fish stock was heavily reliant on the local knowledge of fishermen.

Table 5.2 also illustrates that fish abundance occurs within the AMP, specifically opposite the public beaches like Yamaniyyah beach and Assodasiat, and the visitors' centre (all mentioned by 34% of respondents), in addition to the hotels' area (32%) and Ghandoor beach (29%).

Stakeholders classified fish according to their size (Figure 5.5). Small fish species can be found in large quantities near the shore, particularly in shallow waters of depths up to 150 m (PR26, PR27, PR28, and PR29). This fact is attributed by the stakeholders to the abundance of seagrass near the coast in the north area because this type of habitat acts as a nursery for small fish species (PR4, PR6). Small fish species also hide from the large fish under the berths at the ports (PR26, PR27, PR28, and PR29). This knowledge of the location and relative abundance of small fish species was stated to be key for fishermen as they use them to catch larger fish (PR4, PR26, PR27, PR28, and PR29). Large fish are found deep at sea (PR4, PR16) but fishermen often lack advanced fishing gear to catch them (PR4). At deeper depths ranging between 500 m and 700 m, species such as seahorse and tuna can be found in particular seasons (PR26, PR27, PR28, and PR29).

Figure 5.5 shows that respondents agreed that the area between the clinker port and Tala Bay hosts small and large fish species during summer and winter (2 researchers, 1 diver, and 9 fishermen). In addition, 2 divers and 5 fishermen stated that the small fish species are available along the coastline between Ayla and Saraya, but just during summer as stated by 2 divers and 5 fishermen. Moreover, four fishermen described the area along the special zone and the industrial zone as areas hosting large fish. At Ayla specifically, fish stock is abundant in the lagoons because the water quality is high and fishing is prohibited, but it was recognised that this may change once Ayla begins to operate (PR6).

Figure 5.5 shows that locals mentioned a decrease in fish stock, which was also confirmed by researchers (e.g. PR1, PR4), for example in the area between ACT and the new main port (PR16, PR21, PR22, PR23, PR26, PR27, PR28, and PR29) including the AMP, specifically along Tala Bay, (in an area identified by the locals as "Almamlah" (PR21, PR22). The latter was a very popular area for fishermen, characterized by the highest fish stock because of the presence of abundant seagrass that could reach 60 cm height (PR21, PR22). Similarly industrial zone used to be characterized by high fish stocks in the past , particularly at the area opposite to Prince Rashed Port (which used to be the old fishermen's port at the north of the industrial zone, and used to be high coverage of corals in this area) and along the Dirrah bay area (Saudi wall). PR21 and PR22 stated that these areas used to be characterized by the high coral cover and large fish species were easily found, while they were looking for food.

An official (PR7) clarified that an assessment of fish stock was conducted through the Department of Statistics (DOS) in the past, but without the use of scientific methods (the approach used by DOS was not clarify). At the time this research was conducted, a UNDP project was being carried out with the main objective of assessing the types and quantities of fish stock in the deep water in order to evaluate the economic feasibility of fisheries activities (PR7, PR13), and to provide recommendations on fishing techniques (PR8). A researcher interviewed, who is working on this project, mentioned:

> "*In reality, deep sea in Aqaba is not that deep; it considered as mesopelagic which means that large fish exist on depths between 1 – 1000 m. Since there is a small difference in temperature between the sea surface and the mesopelagic depth (just below the sea surface and extends up to 1000 m), it is possible to find the same fish (on the surface and the mesopelagic), therefore there is high potential to find high amount of fish in the deep sea in contrast to other seas worldwide where there is huge difference in the temperature between the sea surface and the deep sea*" (PR4).

However, not all researchers agreed on the need for this project. Thus, PR5 stated, *"In the case of finding fish in the deep sea, it is not economically feasible; the main reason is the low productivity of the sea". He added: "There are different habitats as seagrass and coral reefs, and corals are known to attract many different species but due to the low primary productivity, the abundance of fish stock is low".* Note that the primary productivity was discussed in Chapter Two.

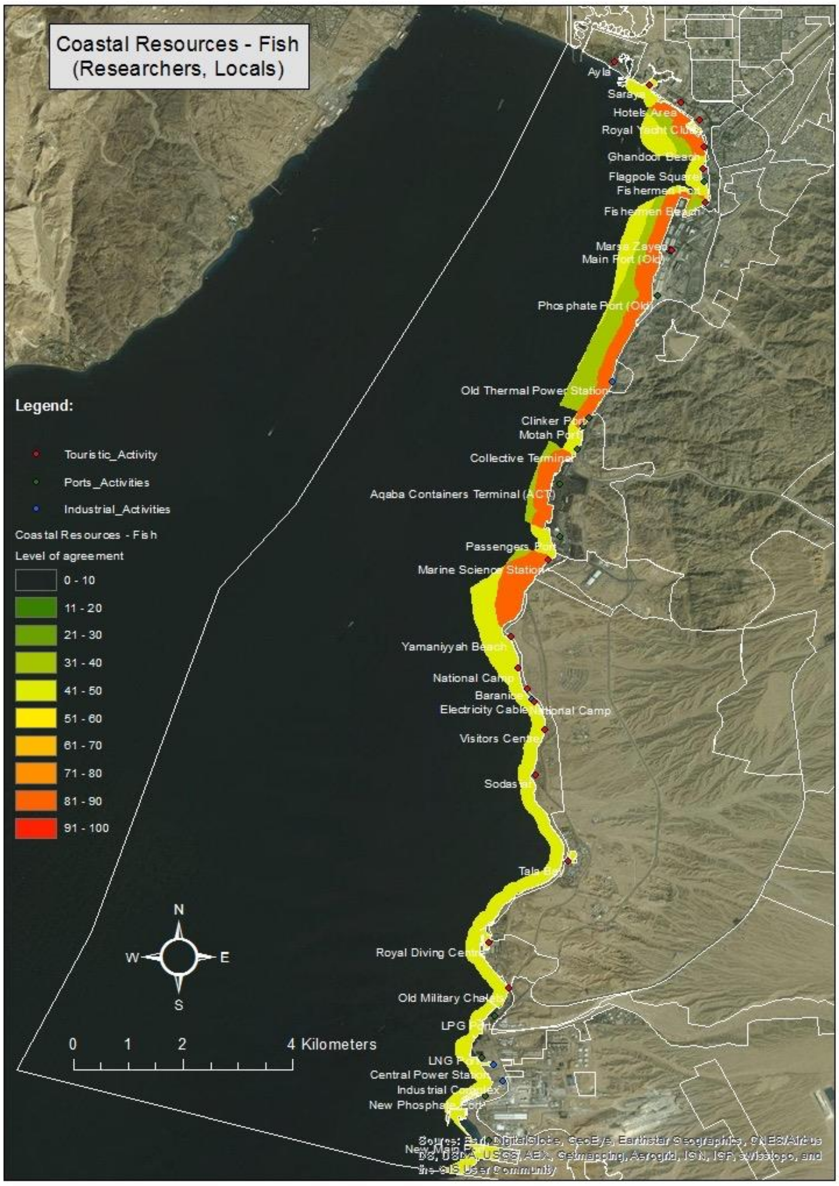


Figure 5.4: Fish locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 5.2: Level of awareness on the locations of fish along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Zone	Location of fish	Number/ Percentages* of Respondents Mentioned				Number/ Percentages* of Respondents Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Ayla	0	2	7	9	0	0	0	0	NA
	Royal palace	0	2	7	9	0	0	0	0	NA
	Saraya Project	0	2	7	9	0	0	5	5	46%
	Hotels' area	0	2	11	13	0	1	9	10	82%
	Royal Yacht Club	0	2	9	11	0	1	9	10	82%
	Ghandoor Beach	0	1	11	12	0	1	9	10	82%
	Fishermen's Port	0	1	5	6	0	1	0	1	NA
Port Zone	Main Ports	0	1	9	10	0	1	9	10	82%
	Old Phosphate Port	0	1	9	10	0	1	9	10	82%
	Area between phosphate port and clinker port	0	1	9	10	0	1	9	10	82%
	Clinker port	0	1	9	10	0	1	9	10	82%
	Collective terminal	0	1	9	10	0	1	9	10	46%
	Aqaba Containers Terminal	0	1	9	10	0	1	9	10	82%
	Passengers port	0	0	9	9	0	0	5	5	46%
Aqaba Marine Park Zone	Marine Science Station	0	2	11	13	0	0	9	9	82%
	Area between MSS and Yamaniyyah	0	2	12	14	0	0	9	9	82%
	Yamaniyyah Beach	0	2	12	14	0	0	5	5	46%
	National Campsite	0	2	11	12	0	0	5	5	46%
	Berenice	0	2	11	12	0	0	5	5	46%
	Visitors' Centre	0	2	12	14	0	0	7	7	46%
	Assodasiat	0	2	12	14	0	0	5	5	46%
	Between Assodasiat and Tala Bay	0	2	12	14	0	0	5	5	46%
	Tala Bay	0	2	11	13	0	0	5	5	46%
Special Zone	New Military chalets	0	1	9	10	0	0	5	5	46%
	Royal Diving Centre	0	1	9	10	0	0	5	5	46%
	Military Chalets	0	1	9	10	0	0	5	5	46%
Industrial Zone	LPG and LNG	0	1	9	10	0	0	5	5	46%
	Industrial Complex	0	1	13	14	0	0	0	0	NA
	New Phosphate Port	0	1	9	10	0	0	5	5	46%
	New Main Port	0	1	8	9	0	0	6	6	46%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

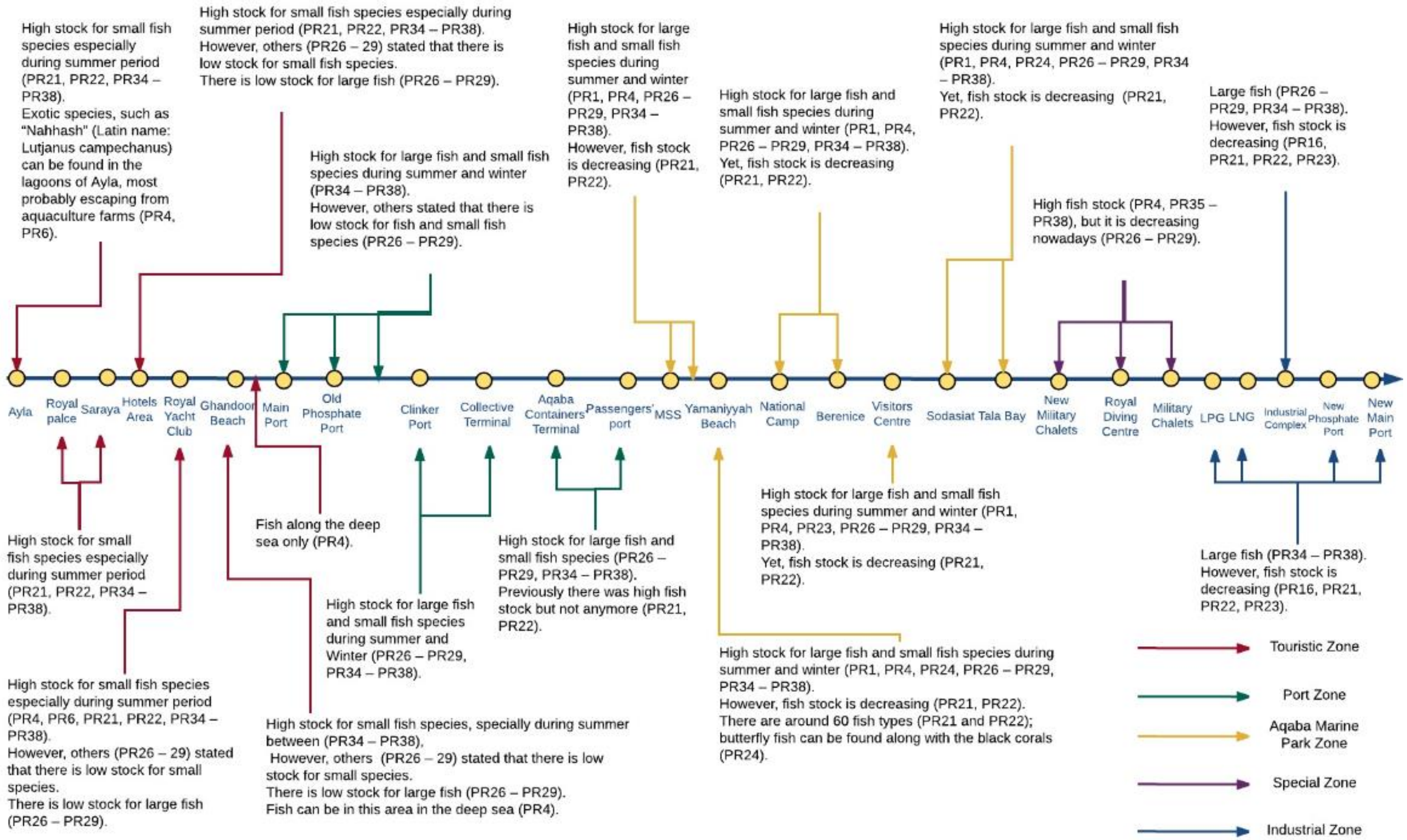


Figure 5.5: Key descriptive local knowledge about the fish along Aqaba coastline, including information, if mentioned in the PGIS interviews, on the status of fish stock, and fishing season.

5.4. Seagrass

Only 20% of respondents participated in the mapping process of seagrass: 5 researchers, and 3 local divers, with just an additional one local who mentioned this coastal resource without mapping it. According to the researcher (PR4), seagrass is a key coastal resource in Aqaba, because it acts as a nursery for the fish stock, and therefore its availability impacts in the coastal economy.

Figure 5.6 shows that seagrass is abundant along the touristic zone and AMP zone, with less scattered areas along the port zone. Generally, seagrass can be found in a continuous form on depths up to 35 m, and in the form of spots after this depth along specific areas. Key locations for seagrass highlighted by respondents are between Ayla and RYC in the touristic zone, and opposite Tala Bay in the AMP zone (Table 5.3). The highest spatial consensus for the seagrass is opposite Tala Bay (89%), and the hotels' area and the RYC (67%) (Figure 5.6 and Table 5.3). Both researchers and divers mapped seagrass almost similarly (Figure 5.7).

However, respondents indicated that the status of seagrass is changing over time similar to other coastal resources (Figure 5.8). For example; there is no longer seagrass opposite the inlets of Ayla lagoons, this can be explained by the high pressure from the influent and effluent water, preventing seagrass from surviving (PR21, PR22). Opposite Saraya project, seagrass has been negatively impacted by the construction activities; and quality of this habitat has also decreased opposite the RYC, and the entire special zone (PR21, PR22).

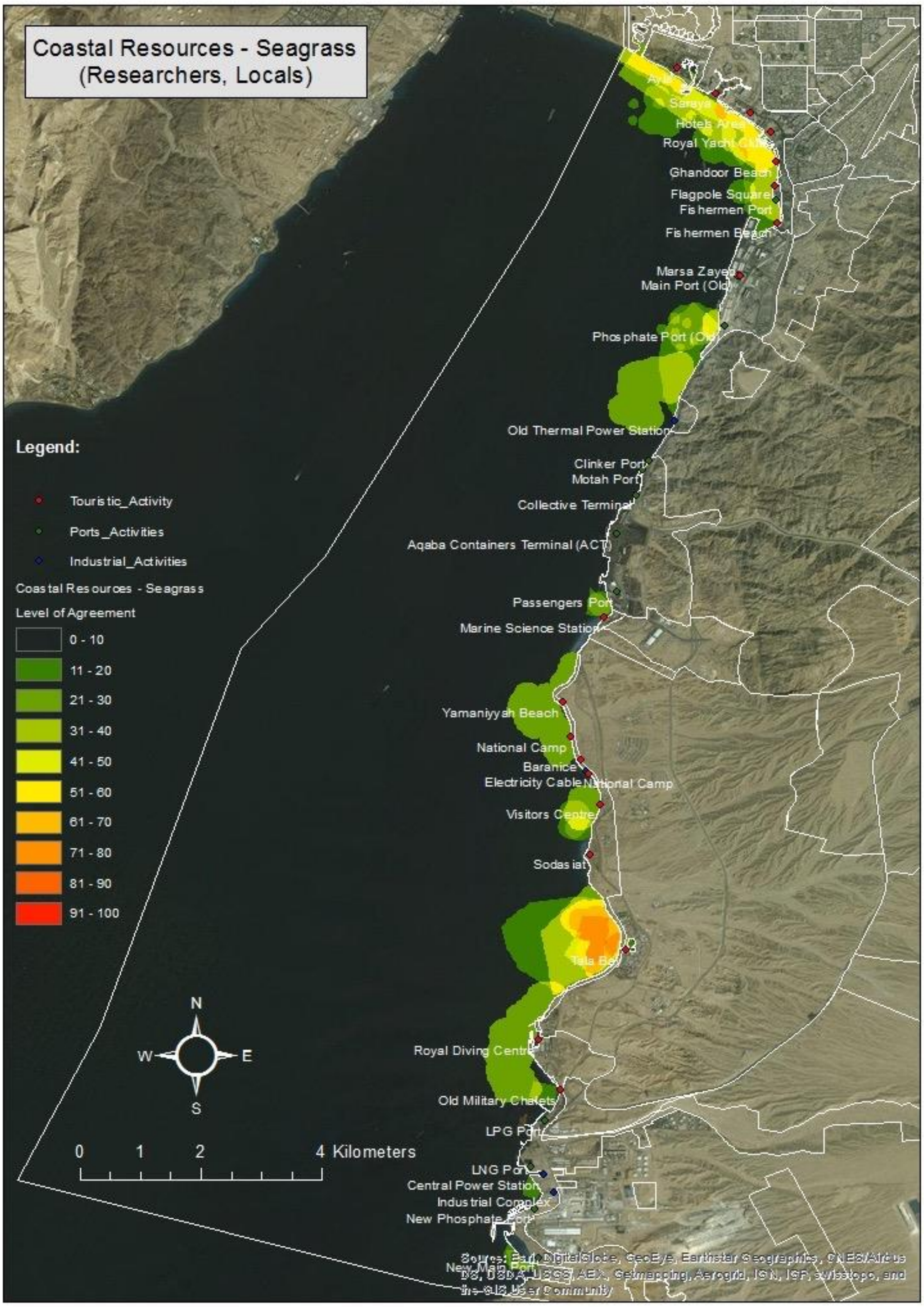


Figure 5.6: Seagrass locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 5.3: Level of awareness on the locations of seagrass along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Zone	Location of Seagrass	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic zone	Ayla Project	**0**	**5**	**2**	**7**	**0**	**5**	**2**	7	**44%**
	Royal Palace	**0**	**5**	**2**	**7**	**0**	**0**	**0**	0	**NA**
	Saraya Project	0	5	2	**7**	0	5	0	5	44%
	Hotels' area	0	5	2	**7**	0	5	2	7	67%
	Royal Yacht Club	0	5	2	**7**	0	5	2	7	67%
	Ghandoor Beach	0	4	2	**6**	0	4	2	6	56%
	Fishermen's Port	0	2	0	**2**	0	2	2	4	33%
Port Zone	Main Port	0	0	2	**2**	0	0	0	0	NA
	Old Phosphate Port	0	3	2	**5**	0	3	2	5	56%
	Area between phosphate port and clinker port	0	1	0	**1**	0	0	2	2	33%
	Clinker port	0	0	2	**2**	0	0	0	0	NA
	Collective terminal	0	0	0	**0**	0	0	0	0	NA
	Passengers port	0	2	0	**2**	0	2	0	2	22%
Aqaba Marine Park Zone	Marine Science Station	0	2	2	**4**	0	0	0	0	22%
	area between MSS and Yamaniyyah	0	0	2	**2**	0	0	2	2	NA
	Yamaniyyah Beach	0	0	3	**3**	0	0	2	2	22%
	National Campsite	0	0	3	**3**	0	0	2	2	22%
	Berenice	0	0	2	**2**	0	0	2	2	22%
	Visitors' Centre	0	1	2	**3**	0	1	3	4	44%
	Assodasiat	0	0	2	**2**	0	0	0	0	NA
	Area between Assodasiat and Tala Bay	0	0	2	**2**	0	0	0	0	NA
	Tala Bay	0	5	3	**8**	0	5	3	8	89%
Special Zone	New Military chalets	0	0	2	**2**	0	0	2	2	22%
	Royal Diving Centre	0	0	2	**2**	0	0	2	2	22%
	Military Chalets	0	1	2	**3**	0	1	2	3	22%
Industrial Zone	New Main Port	0	1	0	**1**	0	0	0	0	22%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
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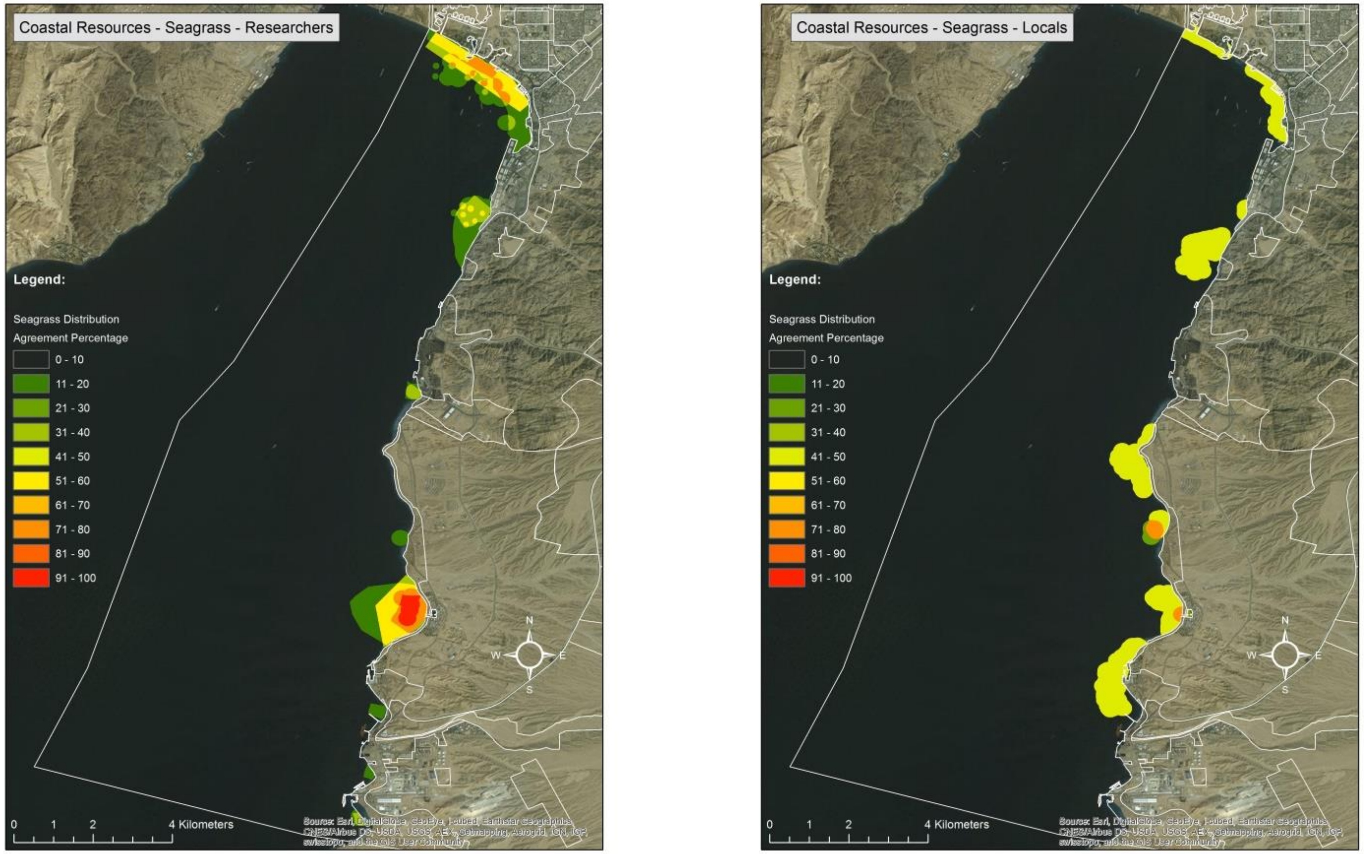
81 - 90%
91 - 100%



(a) (b)

Figure 5.7: Spatial knowledge on the location seagrass according to different stakeholders' views: a) researchers, and b) locals. Shading shows percentage of consensus among respondents mapping the area.

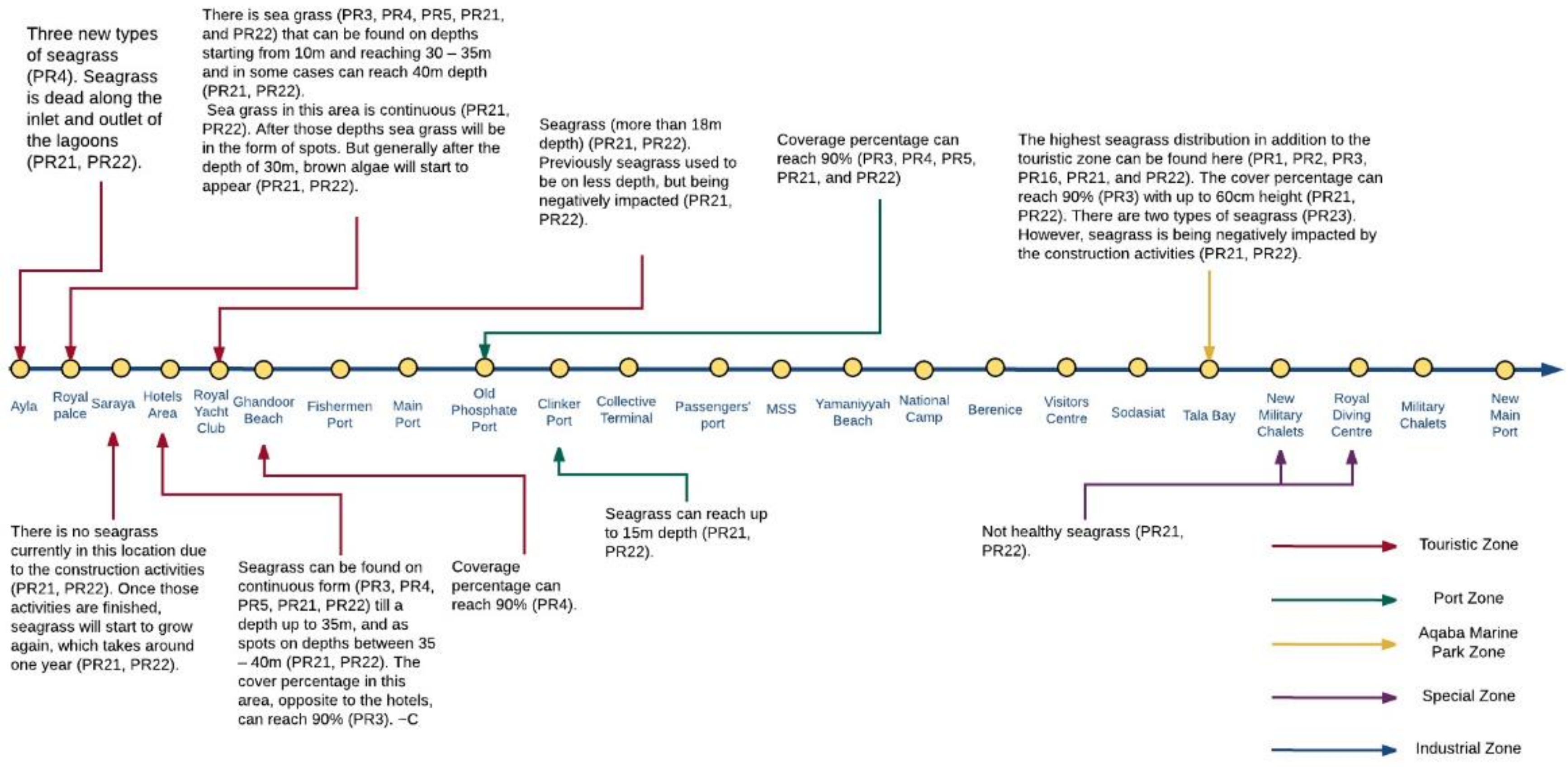


Figure 5.8: key descriptive local knowledge about the seagrass along Aqaba coastline, including information, if mentioned in the PGIS interviews, on the type of seagrass, its type, depth, coverage percentage and current status.

5.5. Sandy bottoms

Aqaba coastline is characterized by the presence of a high number of submarine valleys, with sandy environments along their floors. Corals or seagrass are often found at the valley's sides (PR4, PR21, and PR22). Generally, such sandy environments are important for the nourishment of the sandy beaches, a key for recreation and tourism. This is the reason behind classifying it as a coastal resource.

Only locals and researchers identified sandy bottoms as a resource. Two researchers and four locals mentioned and mapped it. Figure 5.9 shows the spatial distribution of sandy bottoms, which are mainly located in the touristic zone (with the exception of the fishermen's port) and the visitors' centre within AMP zone. The spatial level of consensus among all stakeholders varies between 83% and 17%; with the highest consensus occurring along Saraya, RYC, and Ghandoor public beach (Figure 5.9 and Table 5.4).

Figure 5.10 provides some description of local knowledge about the sandy bottoms along the coastline, highlighting the changes in the environment from coral abundant areas into a sandy environment. For example, a diver stated that the touristic zone was rich with corals, but the change from the corals to a sandy environment is obvious particularly opposite the inlet and outlet of Ayla lagoons, and opposite Saraya project due to the construction activities (Figure 5.10). Figure 5.11 shows that locations identified by researchers and locals were almost identical along the coastline, with only small differences in the AMP zone and the industrial zone. Locals covered larger areas of the sandy environment within AMP zone, and researchers mapped some areas of seagrass within the industrial zone.

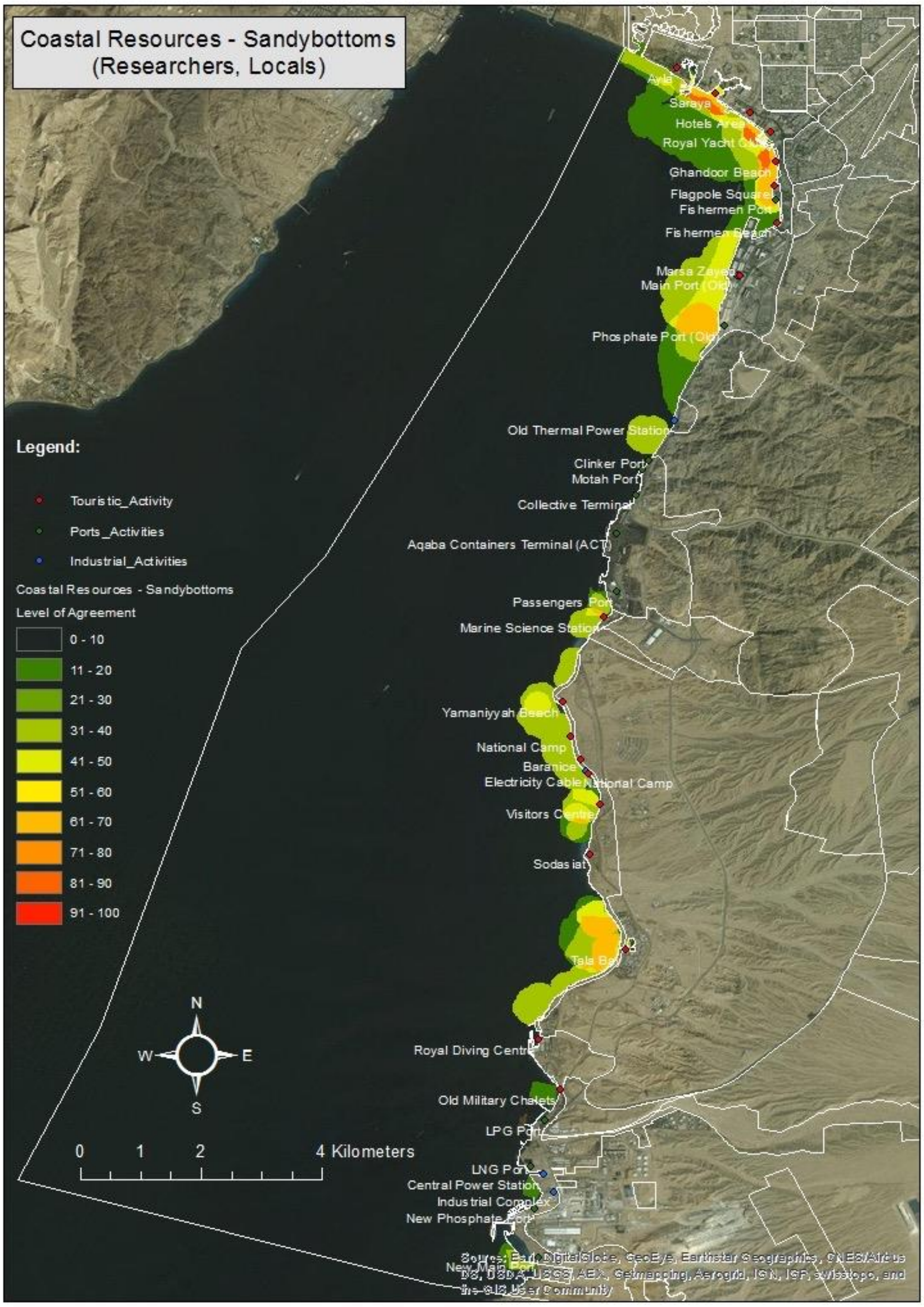


Figure 5.9: Sandy bottoms locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 5.4: Level of awareness on the locations of sandy bottoms along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped these activities during the PGIS interviews.

Zone	Location of Sandy Bottoms	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Ayla Project	0	2	3	5	0	2	1	3	50%
	Royal Palace	0	2	3	5	0	0	0	0	0%
	Saraya Project	0	2	3	5	0	2	3	5	83%
	Hotels' area	0	3	2	5	0	2	1	3	50%
	Royal Yacht Club	0	3	3	6	0	2	3	5	83%
	Ghandoor Beach	0	2	4	6	0	2	3	5	83%
	Fishermen's Port	0	1	3	4	0	1	3	4	67%
Port Zone	Main Port	0	1	2	3	0	1	2	3	50%
	Old Phosphate Port	0	2	2	4	0	2	2	4	67%
	Area between phosphate port and clinker port	0	1	2	3	0	0	2	2	33%
	Clinker port	0	0	2	2	0	0	0	0	0%
	Aqaba Containers Terminal	0	0	2	2	0	0	2	2	0%
	Passengers port	0	2	2	4	0	2	2	4	33%
Aqaba Marine Park	Marine Science Station	0	0	2	2	0	0	2	2	67%
	Area between MSS and Yamaniyyah Beach	0	0	2	2	0	0	2	2	33%
	Yamaniyyah Beach	0	0	4	4	0	0	3	3	50%
	National Campsite	0	0	2	2	0	0	2	2	33%
	Berenice	0	1	2	3	0	0	2	2	33%
	Visitors' Centre	0	2	3	5	0	2	3	5	50%
	Tala Bay	0	2	2	4	0	2	2	4	67%
Special Zone	New Military chalets	0	0	2	2	0	0	2	2	0%
	Royal Diving Centre	0	0	3	3	0	0	0	0	0%
	Military Chalets	0	1	2	3	0	1	0	1	0%
	Industrial complex	0	1	0	1	0	1	0	1	17%
	New Main Port	0	2	0	2	0	2	0	2	33%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

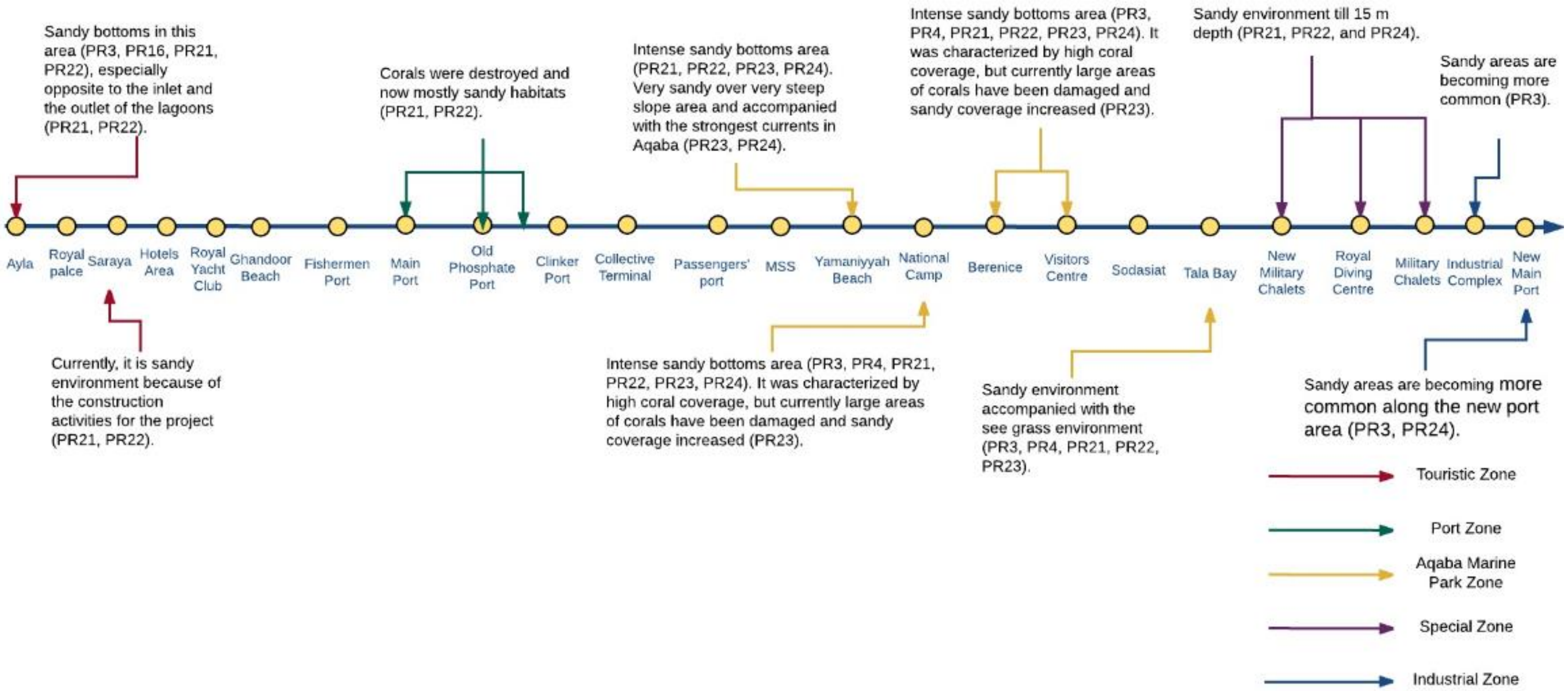
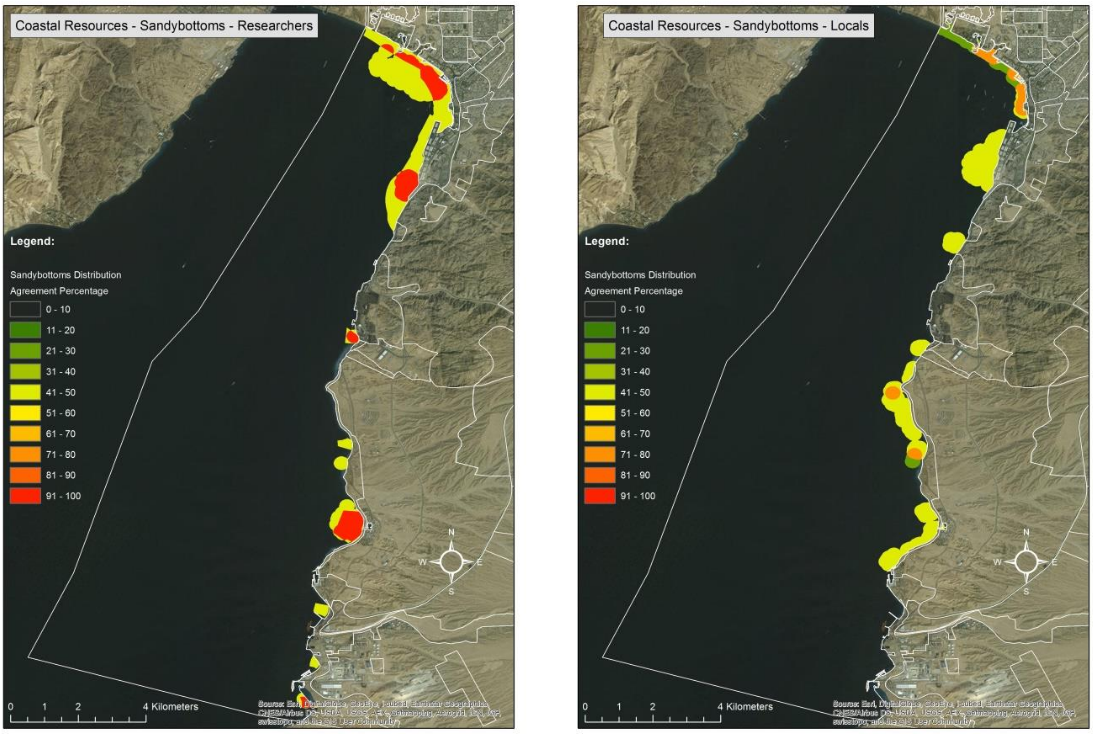


Figure 5.10: key descriptive local knowledge about the sandy bottoms along Aqaba coastline, including information, if mentioned in the PGIS interviews, on the type of sandy bottoms, its type, depth, coverage percentage and current status.



(a) **(b)**

Figure 5.11: Spatial knowledge on the locations of the sandy bottoms according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

5.6. Other Coastal Resources

Other coastal resources that were mentioned by respondents in Aqaba are sponges (PR4, PR5, PR21, PR22, and PR23), eels (PR4, PR5, and PR23) and algae (PR4, PR5, PR21, and PR22). Sponges are mainly along the Ghandoor beach, are found in depths ranging between 10 m and 35 m (PR21, PR22, and PR23). Eels were located in Yamaniyyah beach to the south of the 1st bay south dive site. This area is characterized by the strongest currents and sandy habitats, which seems to be the perfect environment for eels according to divers (PR23, PR24). Algae are significant due to their nutritional and therapeutic attributes (PR4), such as the brown algae, its location was identified by divers along the north coastline at depths of 30 m and higher (PR21, PR22). However, no maps are presented for those resources as sponges and algae were mapped by 2 local divers only (PR21, PR22), and eels by one local diver only (PR23).

5.7. Coverage Areas for Coastal Resources within the Coastal Profile

Coverage areas of corals, fish, seagrass, and sandy bottoms were calculated based on the PGIS maps (Figure 5.12). Calculations capture the entire area mapped by each stakeholder group (officials, researchers, and locals).

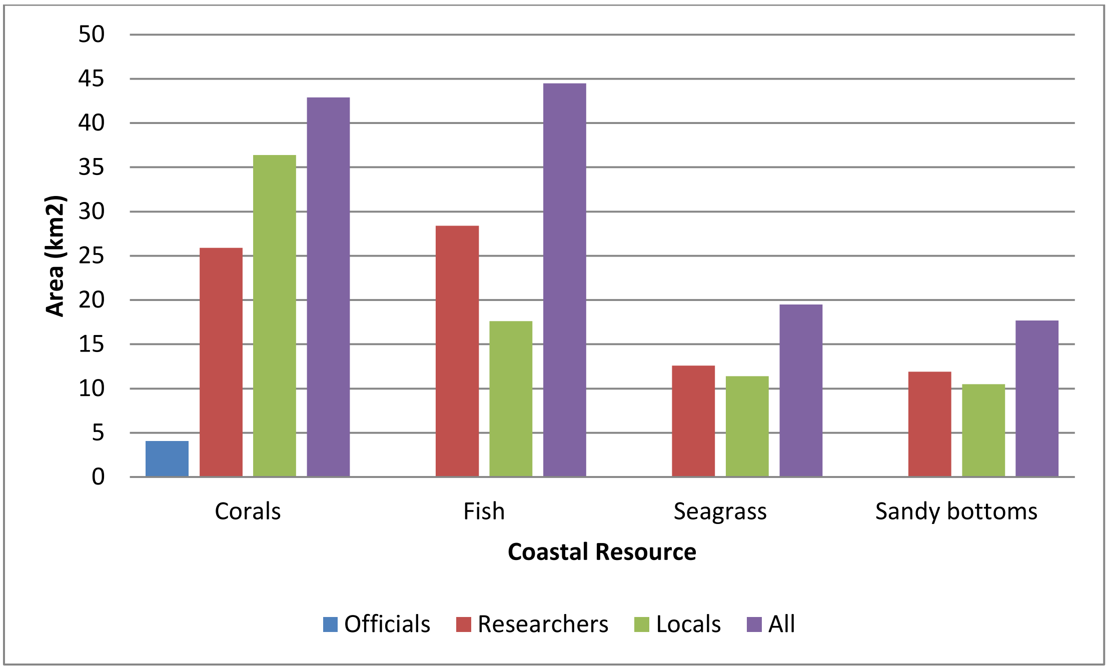


Figure 5.12: Estimated total area in (Km^2) for coastal resources based on PGIS stakeholders' perceptions.

Figure 5.12 shows that corals was the only coastal resource mapped by all three stakeholders groups, while fish, seagrass and sandy bottoms were mapped by researchers and locals. Respondents perceive fish stock and corals as the dominant resources in the coast, with similar results in area coverage. Similarly, seagrass and sandy bottoms occur in similar areas along Aqaba coastline, and therefore the total coverage area is also similar.

Figure 5.13a shows that the highest coral coverage is in the AMP, about 20 km^2, followed by the port zone (11 km^2) and the industrial zone (7 km^2). The lowest coral coverage (2 km^2 is in the touristic zone, which is characterized mainly by seagrass and sandy bottoms. The zone with higher coverage of fish stock is the port zone (Figure 5.11b); a possible explanation for this finding might be that the researcher who mapped fish stock had covered large area reaching 28 km^2 out of the total area of fish coverage along the port zone (30 km^2). Fish coverage areas are similar in the touristic and AMP zones. Areas which the fishermen have not accessed, and therefore have little knowledge of, (special zone and the industrial zone), were identified as those with the lowest coverage areas for fish stock. Finally, Figure 5.11c shows that the highest coverage for seagrass is along AMP (7 km^2), followed by the touristic zone (5 km^2) and the port zone (4 km^2). Similarly, inaccessible zones for locals (special and industrial), were identified as areas with the lowest seagrass coverage.

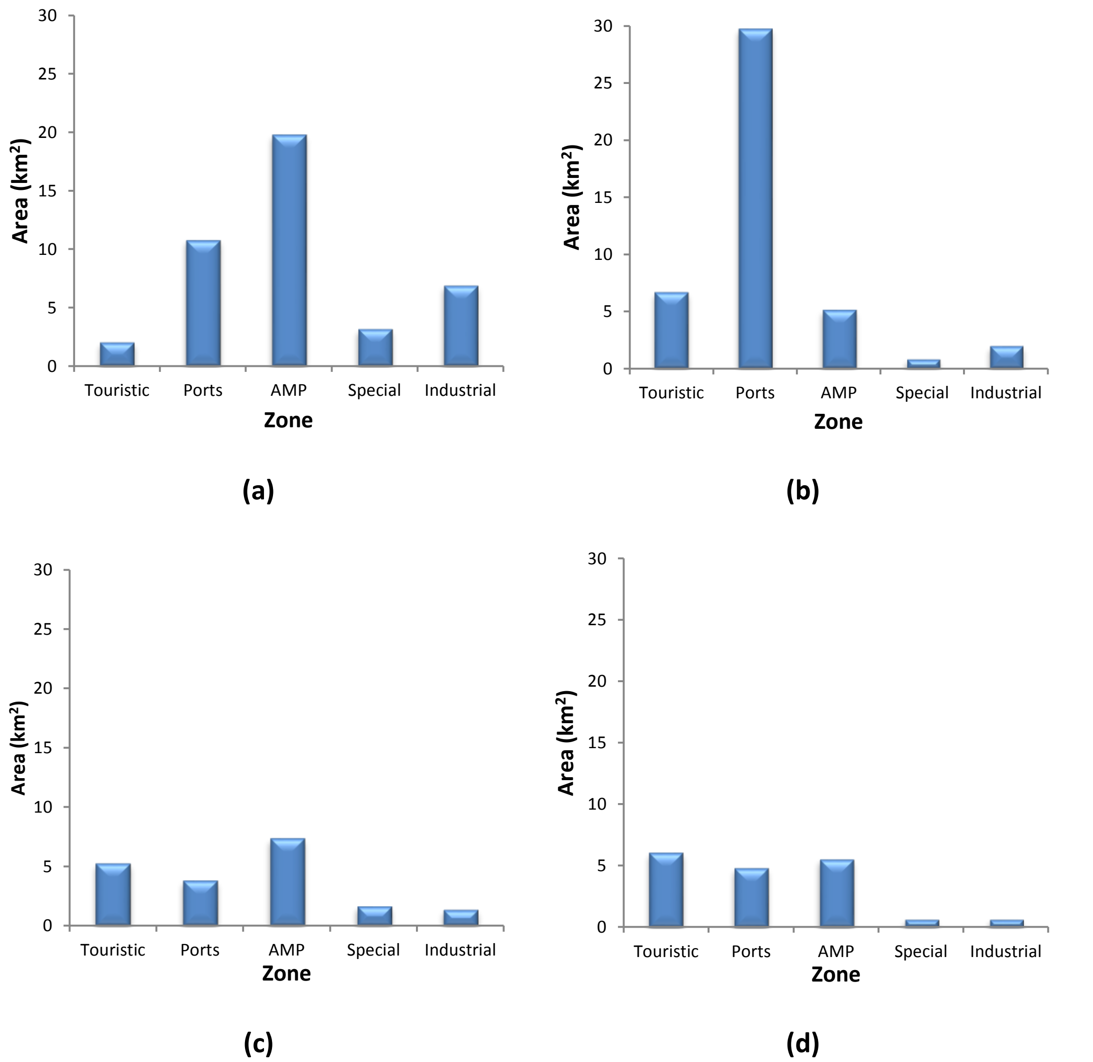


Figure 5.13: Overall coverage area of coastal resources for each zone along the coast of Aqaba according to the level of consensus among stakeholders of the PGIS, (a) Corals, (b) Fish, (c) Seagrass, and (d) Sandy bottoms.

5.8. Identifying Priority Areas for the ICZM

Recognizing coastal resources abundant areas means the ability to identify priority areas requiring higher management focus. In this respect, priority areas are identified for the conservation of coastal resources following two different criteria: First, the highest response rate for mentioning and mapping the resource; and second, the highest level of consensus achieved in mapping the resources.

Figure 5.14 shows that the highest response rate is for corals (73% mentioned, 56% mapped), followed by fish (41% mentioned, 27% mapped).

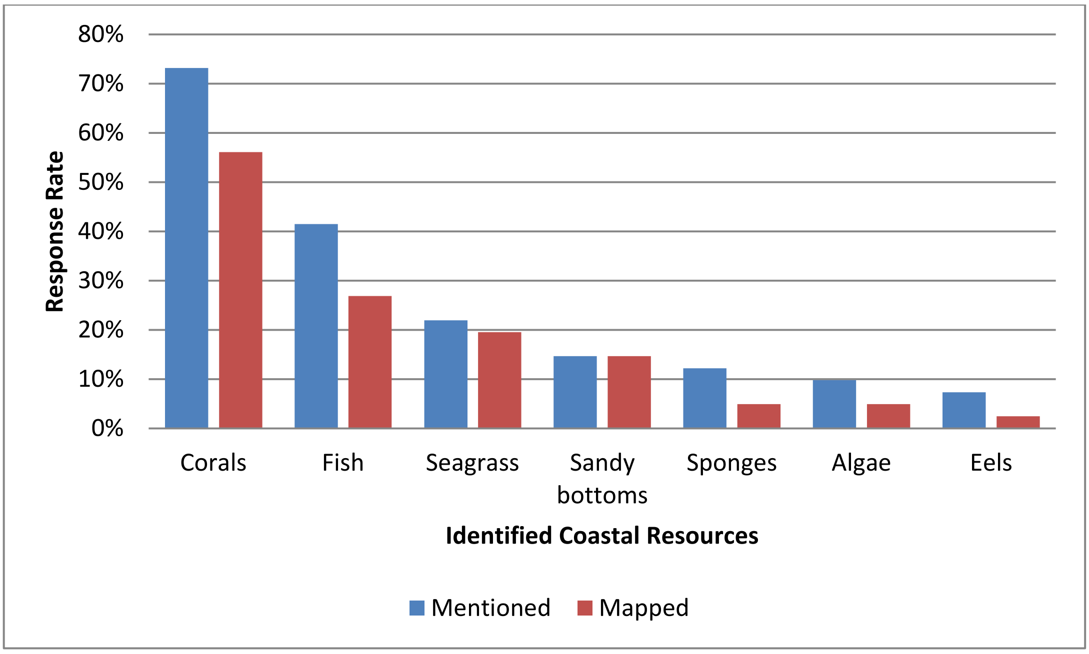


Figure 5.14: Response rate for stakeholders who mentioned and mapped coastal resources, as being identified during the PGIS meetings.

The identification of priority areas based on the highest level of spatial consensus was achieved by integrating the maps for the areas of corals, fish, seagrass, and sandy bottoms along the coast (Figure 5.15). According to this criterion, priority areas would be the entire AMP zone, specifically along the public beaches like Yamaniyyah and the national campsite with the highest agreement reaching 63%. This is followed by Ghandoor public beach area in the touristic zone with the highest consensus reaching 45%.

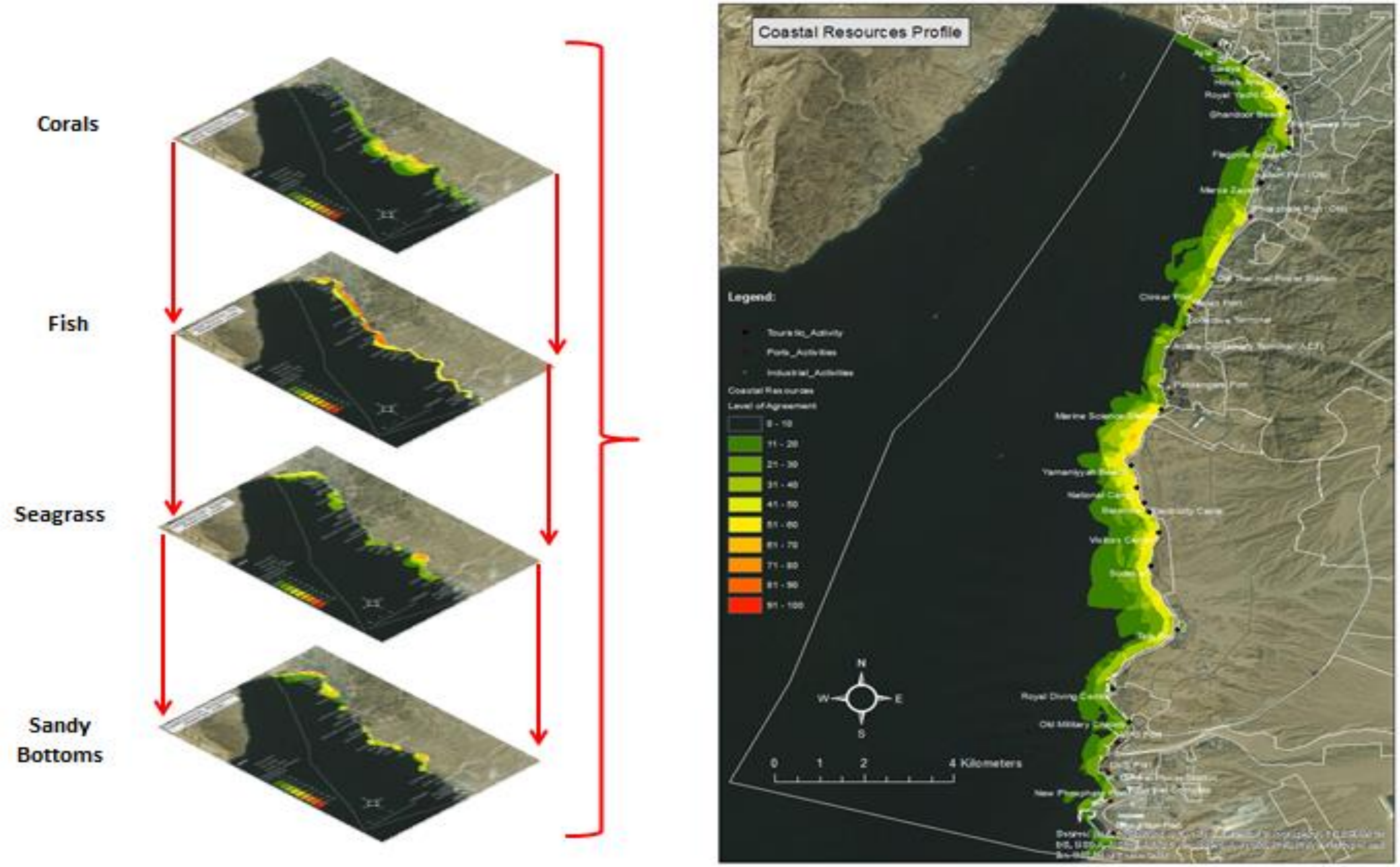


Figure 5.15: Priority areas attributed to the spatial distribution of coastal resources as a result of consensus among all stakeholders.

5.9. Discussion

This Chapter developed a coastal profile for Aqaba coastal natural resources, following the IZCM literature (e.g. González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; Christie *et al*., 2006; ATKINS, 2004; EC, 2002; GEF/UNDP/IMO, 1996), and spatially identified these resources using a PGIS approach (e.g. EC, 2007; Anuchiracheeva *et al*., 2003). The importance of coastal natural resources is well acknowledged in the literature. These include corals, mangroves, seagrass, wetlands and estuaries, beaches and dunes, marine habitats (e.g. fish, prawn, crabs, and molluscs), coastal forests and woods, fresh water, marshes, lagoons and salt ponds, and kelp forests (Das and Mandal, 2016; Lagbas and Habito, 2016; Kotb *et al*., 2015; UNEP, 2011; EC, 2009; Waycott *et al*., 2009; Orth *et al*., 2006; Agardy *et al*., 2005; Kochzius, 2002; Moberg and Floke, 1999; World Bank, 1996). The results of this Chapter show that corals, fish, seagrass, and sandy bottoms are the most common coastal resources in Aqaba. Corals were found to be the predominant coastal resource; identified by nearly three-quarters of the respondents, and the only resource recognized and mapped by the three stakeholder groups.

The overall estimate for the coral reef coverage over the world is around 0.1 – 0.5% of the ocean floor (Moberg and Floke, 1999) and considered as the most productive coastal ecosystem (Lagbas and Habito, 2016; Agardy *et al*., 2005). Coral reefs provide important ecosystem services, that includes: protecting coastlines from storms and erosion, preventing flooding, providing habitat and nursery grounds for fish species on which local communities depend on, providing local income through recreation and tourism, in addition to the significant cultural and aesthetic importance, and reflecting a key for biodiversity conservation (Barbier, 2015; Ferrario *et al*., 2014; Agardy *et al*., 2005; Moberg and Floke, 1999). However, 75 percent of the world's coral reefs are now rated as threatened (Burke *et al*., 2011).

The findings in this study are consistent with Kotb *et al*. (2015), which also demonstrated that coral reefs are the most significant resource in Aqaba marine environment. They are considered as the northern-most latitude reefs in the Western Indo-Pacific. There are many factors that contribute to the development of such unique corals in Aqaba, including extensive sunlight, high water visibility and light penetration and the warm water (Al-Rousan *et al*., 2016). The Gulf of Aqaba hosts fringing reefs as the predominant coral type with 138 hard coral species (Alhorani *et al*., 2006; Kochzius, 2002; Gabri and Montaggioni, 1982). Abundant coral species in Aqaba include: *Pseudanthias squamipinnis* (24.1%), *Pomacentrus trichourus* (16.1%), *Paracheilinus octotaenia* (6.4%), *Neopomacentrus miryae* (6.2%), *Chromis dimidiata* (5.6%), *Dascyllus marginatus* (5.0%), *Chromis viridis* (2.7%) and *Dascyllus aruanus* (2.3%) (Khalaf, 2004).

The coastal profile developed in this Chapter shows a lack of corals along the touristic zone, consistently with the literature (AL-rousan *et al*., 2005). Lack of corals in this area is the result of an absence of hard substrate that supports the existence of corals and the high concentration of suspended matter (AL-rousan *et al*., 2005). The spatial distribution of corals shows a gradual increase in the coral abundance while heading southward and reaches its highest abundance along AMP zone. Al-Horani *et al*. (2006) and Khalaf and Kochzius (2002a) also found that the highest coral coverage is along MSS and the public beaches of AMP, specifically at 15 m depth. Corals are occasionally intercepted by sandy bottoms (Al-rousan *et al*., 2005), and so, consequently, corals and sandy bottoms can occur in nearby locations. This seems to be the case in the Aqaba coastal profile, where corals and sandy bottoms were mapped at similar locations (see Figures 5.1 and 5.9). Khalaf (2004) described that corals appear as fringing reefs starting from 5 km to the south of the northern borders (nearby the old phosphate port) and extend southward to the borders with Saudi Arabia. However, the highest cover percentage for hard corals can be found along MSS, AMP public beaches and Assodasiat (Al-horani *et al*., 2006). This is consistent with the findings from the mapping process in this Chapter, whereby respondents reached a high spatial consensus on those locations (MSS - 65%, AMP beaches – 83%, and Assodasiat - 74%). Al-horani *et al*. (2006) found that the coverage of hard corals along Tala Bay is less than 10%, which is also in agreement with our findings, whereby the consensus on mapping this site is just 22%. The findings are also consistent with Khalaf *et al*. (2012), which compared the live substrate coverage for hard and soft corals in three locations; hotels' area, old phosphate port, and Tala Bay, and found the highest coverage along the old phosphate port, followed by Tala Bay, and hotels' area.

Local fishermen and researchers highlighted fish resources. However officials perceive the fishing industry as not economically feasible, and seem to neglect these resources. This perception can be justified by the lack of studies that assess the impact of fishing on the local livelihoods (Khalaf and Kochzius, 2002a). Khalaf *et al*. (2012) and Khalaf (2004) concluded that there are 507 fish species (i.e., more than 40% of the total number of fish species along the entire Red Sea), which belong to 109 families in Aqaba, of which more than 89% are considered benthic while the rest are pelagic. The most common benthic fish species in Aqaba are *Ago amanuensis*, *Rhinobatos punctifer*, *Mureanesox cereus*, *Carangoides equal*, *Paracaesio sordid*, *Polysteganus coeruleopunctatus*, *Argyrops spicier*, *Upends davidaromi*, *Trichiurus lectures,* and *Thyrsitoides Marley*, while *Atherinomorous lacunosus* and *Spratelloides gracias* are the most common pelagic fish species (Khalaf, 2004). The high diversity of fish species in Aqaba may be due to the diversity of habitats in this coastline. Khalaf (2004) also clarified that habitat occupation for Jordanian fish occurs in corals (for 51% of the fish species), sandy bottoms (11.7%), and seagrass (8.3%).

Fish abundant areas were mapped by respondents along the entire coastline with a high consensus of 82% in almost all the areas within the touristic, port zones and northern part of AMP zones. The high consensus for the spatial distribution of fish seems to be associated with the local knowledge of the location of suitable habitats to accommodate them, including corals and seagrass. The touristic zone is rich with the seagrass according to interviewed researchers and local divers. Khalaf and Kochzius (2002a) reported that around 294 fish species can be found in the shallow water in coral, seagrass and the sandy environment in Aqaba; and Khalaf *et al*. (2012) found that the hotels' area is characterised by abundant seagrass, acting as a nursery for the juvenile before becoming adults and moves to the coral environment. These studies support the perceptions of the fishermen, as highlighted in this Chapter, they mentioned that the hotels' area host a high number of small fish species. Moreover, Khalaf *et al*. (2012) also indicated that the presence of the nearby fish cages along the nearby Israeli borders further enhances the presence of small fish along this area, because nutrients are discharged from those cages. The high stakeholder consensus of the presence of fish stock in at the AMP can be explained by the abundant coral coverage in this area (Khalaf, 2004).

The level of awareness of seagrass resources was found to be low compared to corals and fish. This is consistent with Orth *et al*. (2006) and Nordlund *et al*. (2016) that recognised that although the number of studies on the role of seagrass habitats on well-being is increasing, there is still, a low level of awareness relatively to other coastal ecosystems. Seagrass are marine flowering plants that colonize along soft bottom areas of temperate, sub-tropical, and tropical seas (Orth *et al*., 2006; Agardy *et al*., 2005; Al-rousan *et al*., 2005), one of the most productive ecosystems on the earth (Lagbas and Habito, 2016; Waycott *et al*., 2009; Al-rousan *et al*., 2005). Seagrass provides various types of ecosystem services such as conserving the biodiversity, waste processing, flood protection, and cultural and amenity (Nordlund *et al*., 2016; Orth *et al*., 2006; Agardy *et al*., 2005). Ecosystem services provided by the seagrass were estimated as 1.9 trillion dollars/year in the form of nutrient cycling (Waycott *et al*., 2009). Seagrass provides also nursery areas, especially for coral reef fish and invertebrates, are important food source for many marine organisms, and trap the sediments and stabilize the shoreline (e.g. Khalaf *et al*., 2012; Al-Rousan *et al*., 2011; Waycott *et al*., 2009; Orth *et al*., 2006; Agardy *et al*., 2005).

In Aqaba, the richness of seagrass along Tala Bay serves as a nursery for the fish larvae (Khalaf, 2004), as also reported as part of the local knowledge in this Chapter. Moreover, *Novaculichthys macrolepidotus* which is an extremely rare fish species can only be found in the seagrass environment along Al-Mamlah (currently occupied by Tala Bay) (Khalaf, 2004). There are three types of seagrass in Aqaba; namely *Halodule uninervis*, *Halophila ovalis*, and *Halophila stipulacea*. The first two types are specifically abundant along Tala Bay at low depths, while the latter is abundant along the entire coastline (Al-Rousan *et al*., 2011; Al-rousan *et al*., 2005; Khalaf and Kochzius, 2002a; Wahbeh, 1982). Seagrass in the Red Sea can be found from mid-tidal level to around 70 m depth (Khalaf *et al*., 2012; Al-Rousan *et al*., 2011; Al-rousan *et al*., 2005). *Halophila stipulacea* can be found at varying depths ranging from intertidal to more than 70 m depth (Khalaf *et al*., 2012; Al-Rousan *et al*., 2011; Schwarz and Hellblom, 2002). However, *Halophila stipulacea* is rarely found in shallow water at depths of less than 7 m in Aqaba (Schwarz and Hellblom, 2002). This means that the common seagrass in Aqaba can extend beyond the shore but with some adaptations. As clarified by Al-Rousan *et al*. (2011), density and biomass of seagrass decrease with depth as a result of the decrease in the light penetration, however, leaves' length can increase with depth as kind of adaptation to the limited available light.

The produced PGIS map for seagrass ecosystems indicates that they are present mainly along the touristic and AMP zones, and to a lesser extent in the port zone. More specifically, respondents agreed by 89% on the presence of seagrass along Tala Bay, 67% along the hotels' area and RYC, and 56% along the old phosphate port. Khalaf *et al*. (2012), Al-Rousan *et al*. (2011), Al-horani *et al*. (2006), and Al-rousan *et al*. (2005) also found that abundant seagrass areas along Aqaba coastline include the hotels' area, the old phosphate port, and Tala Bay, with Tala Bay as the highest coverage area for seagrass. Al-Rousan *et al*. (2011) showed that the most abundant type of seagrass in Tala Bay is *Halophila stipulacea* (37% of the total coverage for seagrass. It also indicated that seagrass in Aqaba cannot be found on the reef flat and have to be submerged in water. This study analysed seagrass coverage on 12 m depth, while in Al-horani *et al*. (2006), seagrass was studied on 8 and 15 m depth. The absence of seagrass on reef flat can be explained by the intense swimming and boating activities in, for example, Tala Bay and the hotels' area (Al-rousan *et al*., 2005). It is worth mentioning that the mapped seagrass was offshore in some locations, and this may contradict the limit of 70 m depth for their existence. Potential explanations can be the level of mapping accuracy by respondents or the effect of applying the buffer. Another explanation is the specificity of Aqaba Gulf described by the divers during the meeting, they mentioned that one can dive for a long distance, and still be in shallow water.

The coastal profile also includes sandy bottoms. In Aqaba, sandy bottoms originate from two sources; firstly, the remains of marine living organisms such as reefs and calcareous algae which transferred either through precipitation or settling by the water column; and secondly, onshore clastic sediments composed of fragmented rocks due to weathering and erosion (Al-Saqarat *et al*., 2017; AL-rousan *et al*., 2005). Aqaba sandy bottoms are characterised by the low concentration of calcium carbonate and organic nitrogen and high concentration for total phosphorus, indicating that mostly they originate from onshore sediments (Al-rousan *et al*., 2005). This resource plays an important role in coastal areas. It acts as a natural reserve for substances and contaminants, is key for regulatory processes occurring on the seafloor, and is a source of nutrients (Al-Saqarat *et al*., 2017).

This Chapter shows that the most abundant areas for sandy bottoms are the areas within the touristic zone. With reference to the literature, this zone is located at the mouth of Wadi Araba that receives all the fine sediments carried by the wind (90% of wind cases are northern) (Al-rousan *et al*., 2005). Kotb *et al*. (2015) also found that the north beach of Aqaba consists primarily of sand and gravel beaches, and Khalaf (2004) clarified that the sandy bottoms extend from the northern borders till almost 5 km south. PGIS respondents agreed by over 80% on the presence of sandy bottoms along Saraya, RYC, and Ghandoor beach, and this may be due to the construction and dredging work (e.g. Saraya and Ayla) during the time of the interviews. This would mean that this is a temporary situation and do not reflect the normal situation. Corals cannot be found in this zone due to lack of hard substrate bottoms; however, the high concentration of sandy bottoms also plays a major role. The presence of sandy bottoms increases resuspension near the bottom, which in turn, decreases the light availability and the required space for coral growth, and enhance the mucus production by corals, an energy consuming process for corals (Al-rousan *et al*., 2005). Therefore, the touristic zone is dominated by seagrass and sandy bottoms (Al-rousan *et al*., 2005). Moreover, PGIS respondents reached a fairly high consensus of 67%

on the presence of sandy bottoms along Tala Bay and the old phosphate port. Those findings match the ones in Al-Horani *et al*. (2006), who found that the sandy bottoms coverage can reach 50% in Tala Bay at 8 and 15 m depths, and along the old phosphate port at 15 m depth. Moreover, in this Chapter, respondents agreed by 67% on the presence of sandy bottoms along MSS and AMP public beaches, similar to the findings of Al-Horani *et al*. (2006) who found that those areas are rich with sandy bottoms and their coverage can reach 40% at 15 m depth.

The spatial distribution of corals and seagrass show that those two resources are occasionally located in the same sites. In reality, corals and seagrass may not overlap; however, the fringing reefs of Aqaba which extend along 13 km and 50 m maximum width are developed around headlands and separated either by sandy bottoms and/ or seagrass (Khalaf and Kochzius, 2002a; Gabri and Montaggioni, 1982). This issue was also described by the researchers participated in this study. In the sandy bottom PGIS map, participants tried drawing sandy bottoms on the outlets of the valleys between two adjacent mountains. This is consistent with Gabri and Montaggioni (1982) that explained that the presence of sandy bottoms corresponds to the river beds mouths in Aqaba in which sandy bottoms are colonizing by relying on the scattered coral heads (such as *Stylophora, Seriatopora*,) and seagrass (such as *Halophila, Halodule*). Therefore, both corals and seagrass can be found in the same area without overlapping, for example, *Halophila stipulacea,* the common seagrass species in Aqaba is an integral part of the coral reef ecosystem in Aqaba (Schwarz and Hellblom, 2002). Khalaf and Kochzius (2002a) also described that Aqaba shallow water habitats are fringing coral reefs mixed with seagrass meadow. This mixed habitat is perfect for the fish richness. For example, Khalaf *et al*. (2012) reported that the number of fish species in seagrass habitat mixed with corals is higher compared with seagrass habitat with low coral coverage, indicating that both systems exchange fish.

Similarly, the fact that the spatial distribution of seagrass and sandy bottoms largely match in the PGIS maps is also in agreement with the literature. Seagrass in the Red Sea is usually abundant in shallow water areas due to the presence of soft-bottom sediment (Al-Rousan *et al*., 2011). More specifically, *Halophila stipulacea in* Aqaba usually grow on sediments ranging between fine sand/silt (with 125 – 500 micrometre) to sand (with 1mm diameter) (Al-Rousan *et al*., 2011; Schwarz and Hellblom, 2002). For example, Al-rousan *et al.* (2005) reported that the touristic zone hosts both, seagrass and sandy bottoms with varying percentages starting from Ayla till Ghandoor. The MSS area also hosts a mix of habitats, including corals, seagrass, and sandy bottoms, in addition to gravels; with similar percentage coverage (Al-rousan *et al.*, 2005).

5.10. Conclusion

This Chapter identified marine coastal resources for the coastal profile of the coast of Aqaba. Key coastal resources are corals, fish, seagrass, sandy bottoms and other resources (sponges and eels). This Chapter has shown the significance of the local knowledge acquired by the locals, who engaged in spatially identifying all the coastal resources, in contrast with officials, who identified just one resource (corals). This illustrates the need of strengthening the role of local participation in order to enhance the state of the coast and the level of ICZM implementation. Moreover, the coastal profile developed in this Chapter is consistent with the available limited literature about coastal resources in Aqaba. This strengthens the trustworthiness of LK in filling the current spatial gap for ICZM implementation and gives an indication that the gained knowledge from locals is comparable with the officials as well as the researchers' knowledge.

The findings of this Chapter also revealed a decline in the overall status of the coastal resources over time. Coral coverage areas are decreasing along many areas within the port, the special, and the industrial zones. The same applies to the status of fish, where most of the fishermen and researchers stated that the fish stock is decreasing. However, stakeholders highlighted the lack of scientific evidence for the declining status of coastal resources, particularly, corals, fish, and seagrass due to the limited assessment studies.

Priority areas for conserving the key four identified coastal resources are Yamaniyyah and national campsite public beaches within AMP, as well as, but with a lower level of consensus, Ghandoor public beach in the touristic zone. These areas require special management attention in the planning phase (2nd phase) in the ICZM cycle. Thus, specifically, priority locations for corals are all the areas between MSS and Assodasiat. Special management areas for conserving fish could be AMP shore as well as the hotels' area and Ghandoor public beach. These findings are the results of a participatory approach on the analysis of the rich coastal resources areas in Aqaba, which legitimates future decision-making process, increases the level of credibility and decreases the level of uncertainty for the management of natural resources (Volkery, 2008; Close 2003; Fletcher, 2003).

6. Environmental Pressures and Impacts to Aqaba Coastal Zone

6.1. Introduction

Evaluating the state of the coast is important because of the following factors, 1) coastal zones are experiencing population growth and migration (UNEP/MAP, 2012; Agardy *et al*., 2005; World Bank, 1999) to areas where a diversity of sectors need to be accommodated (e.g. transportation, energy, and tourism). 2) The observed current deterioration of the coastal zones, as a result of multiple pressures, and the expectation that the pressures will increase over time (e.g. Lewison *et al*., 2016; Sekovski *et al*., 2012; UNEP/MAP, 2012; Ness *et al*., 2010; EC, 2009; González-Riancho *et al*., 2009; Halpern *et al*., 2008).

ICZM was developed to enhance the quality of coastal ecosystems and society (Olsen *et al*., 1999). Phase one of the ICZM cycle (Issue identification and assessment) requires recognizing environmental (e.g. coastal pollution), social (e.g. poverty), and institutional (e.g. conflicts among users) issues which can alter the coastal environment and society (Olsen *et al*., 1999; GESAMP, 1996). While GESAMP (1996) and Olsen (1999) use the term "coastal issues", which also include opportunities (e.g. from tourism and infrastructure developments), González-Riancho *et al*. (2009) and Christie *et al*. (2006) use the terms "coastal problems", and "coastal threats", respectively, to refer to the importance of issue-driven analysis in the first ICZM phase, which includes the involvement of all stakeholder.

Identifying the coastal issues within phase one can help in the recognition of priority issues and areas in which the management initiatives of the ICZM program will focus. This, in turn, will aid in building the program, including the specific targets to be monitored and assessed in the latter phases of the program (González-Riancho *et al*., 2009; Olsen *et al*., 1999; GESAMP, 1996). Identifying priority areas on an ICZM program is key to improving the benefits from a limited supply of funding and resources (Juárez and Jiang, 2016; Hao *et al*., 2015; Teran *et al*., 2006). For conservation purposes, the criteria for selecting the priority areas usually rely on biological and ecological indicators, such as species abundance, uniqueness, endangered property and/or ecological functions (Hao *et al*., 2015; Teran *et al*., 2006). However, social, political, economic, and cultural criteria could also be used, as a part of the process of identifying priority areas, after the identification of biologically important areas (Teran *et al*., 2006). Threat analysis, by identifying the least or the most impacted areas by anthropogenic impacts, can also help in identifying priority areas.

This Chapter conducts this issue-driven analysis using the DPSIR (Driver – Pressure – State – Impact – Response) framework, which is generally utilized to analyze causes and consequences of environmental problems (see Chapter One). This framework was selected for the following reasons. 1) It provides a simple way for a better understanding of human impacts on the coastal environment. 2) It links the causes of and the consequences of environmental impacts. 3) It helps in unifying the terms used (Lewison *et al*., 2016; Bi *et al*., 2014; Azevedo *et al*., 2013; Atkins *et al*., 2011; Ness *et al*., 2010). More specifically, this Chapter addresses issue identification and issue assessment for the case of Aqaba, through 1) recognizing coastal impacts and the pressures which cause them, 2) spatially identifying impacts and pressures, and 3) identifying priority areas for the coming ICZM programs, based on the significant coastal pressures and impacts. To achieve this, stakeholders were asked questions during the PGIS meetings that can help identify and map coastal problems (Pressure) and their causes (Driving force) and consequences (Impact) along the coast (State), thus allowing the development of priority areas that require special management (Response).

This Chapter presents a map for each type of coastal pressure and its consequent impact, as perceived by respondents, using the gathered qualitative and spatial knowledge from the PGIS meetings. For the purpose of identifying priority areas, maps were combined to assess the accumulative impacts from different types of pressures. Thus, this Chapter proceeds as follows. The second section classifies coastal problems, their causes, and consequences based on DPSIR. The third and the fourth sections describe the pressures causing coastal pollution and coastal ecosystems degradation, respectively. The fifth section focuses on flooding as a natural pressure. The sixth section identifies priority areas, and finally, the last two sections include the discussion and the conclusion.

6.2. Classifying Negative Coastal Impacts and the Associated Coastal Pressures

The PGIS respondents raised concerns about various types of pressure posing two main groups of negative environmental impacts: coastal pollution and degradation of coastal ecosystems. The main themes from the identified impacts and their causing pressures were categorized following the thematic analysis (provided in Chapter Two) and spatial analysis (provided in Chapter Three) as shown in Table 6.1. This table summarises the links between various driving forces leading to the pressures, as identified by the PGIS respondents, and the resultant negative environmental impacts on the quality of the environmental conditions of the coastal zone. The pressures causing coastal pollution impacts are classified according to the change in the environmental conditions of the coastal zone (State): seawater quality (water pollution), air quality (air pollution), and aesthetic value of the beach (solid waste pollution). While, the pressures causing coastal ecosystems degradation impacts are categorized based on the pressure that causes the degradation; intensive land-based touristic, port, industrial, and diving activities. All the categorized pressures are considered anthropogenic; with the exception of flooding as the only natural pressure (although it is intensified by anthropogenic activities).

Table 6.1: Driving forces, pressures, state, and impacts on Aqaba coastline after the qualitative and spatial analysis for the local knowledge from the PGIS participants.

Driving Force		Pressure	State	Impact
Land-based coastal activities	Touristic activities	Expansion of touristic activities	Sea water quality	Water pollution
			Marine protected areas	Degradation of coastal ecosystems
			Coral ecosystem	Degradation of coastal ecosystems
		Accidental discharge of pollutants	Sea water quality	Water pollution
		Lagoons of the touristic activities	Sea water quality	Water pollution
		Generation of solid waste	Sea water quality	Water pollution
			Aesthetic value of the beach	Solid waste accumulation
	Port activities	Expansion of port activities	Sea water quality	Water pollution
			Air quality	Air pollution
			Coral ecosystem	Degradation of coastal ecosystems
		Under-maintained operating ports	Sea water quality	Water pollution
			Air quality	Air pollution
		Accidental spillage of pollutants	Sea water quality	Water pollution
		Leakage while ships fuelling	Sea water quality	Water pollution
		Leakage of swage from septic tanks	Sea water quality	Water pollution
		Dumping of solid waste	Sea water quality	Water pollution
			Aesthetic value of the beach	Solid waste accumulation
	Industrial activities	Expansion of industrial activities	Sea water quality	Water pollution
			Air quality	Air pollution
			Coral ecosystem	Degradation of coastal ecosystems
	Wastewater treatment plant	Accidental leakage of wastewater	Sea water quality	Water pollution
Marine - based coastal activities	Diving activities	Intensive diving activities	Sea water quality	Water pollution
			Coral ecosystem (specifically)	Degradation of coastal ecosystems
			Marine life (generally)	Degradation of coastal ecosystems
		Wrong practices by divers	Sea water quality	Water pollution
	Boating activities	Intensive boating activities	Sea water quality	Water pollution
		Leakage while boats fuelling	Sea water quality	Water pollution
		Boat washing	Sea water quality	Water pollution
		Dumping of solid waste by boaters		
			Aesthetic value of the beach	Solid waste accumulation
	Fishing activities	Leakage while boats fuelling	Sea water quality	Water pollution
		Boat washing	Sea water quality	Water pollution
		Dumping of solid waste by fishermen		
			Aesthetic value of the beach	Solid waste accumulation
Visitors and swimmers		Touristic activities associated with the high number of visitors and swimmers	Sea water quality	Water pollution
			Aesthetic value of the beach	Solid waste accumulation

6.3. Coastal Pollution

Nearly 60% of the PGIS participants (90% of officials, 86% of researchers, and 38% of locals) identified and raised concerns over three types of pollution along Aqaba coastline; pollution of sea water (referred to as water pollution throughout this Chapter), air pollution, and solid waste pollution as a result of the pressure from either expansion and/or poor environmental practices during land and marine-based coastal activities' operation.

6.3.1. Water Pollution

Even though ASEZA has a "Zero Discharge" policy (PR4, PR7), about 40% of respondents (6 officials, 6 researchers, and 5 locals) identified a number of potential water pollution sites along the land-based coastal activities (see Chapter Four), associated mainly with the mega touristic projects, hotels, ports, and industrial activities (Figure 6.1 and Table 6.2). Two respondents discussed water pollution incidents without mapping them. Figure 6.2 summarises the information regarding the pressure causing water pollution and the types of pollutants. Different stakeholder groups mapped driving forces causing water pollution at different locations. Officials focused on the entire touristic and industrial zones, and some parts of the ports and park zones (Figure 6.3a). Researchers mapped some locations opposite to coastal activities (touristic, ports, and industrial) (Figure 6.3b). Locals mapped Ghandoor beach, passengers' port and the entire park zone (Figure 6.3c).

In the touristic zone, water pollution is mentioned to be accidental and localized (PR1, PR5, PR7, and PR19). However, two officials (PR7, PR19) stated that existing studies and regular sea water quality analysis, conducted as part of the "Zero Discharge" policy (PR7, PR19), showed that water quality in this zone is within the acceptable range for both international and local standards. In this context, another two officials who are working in the environment department of ASEZA said:

> *"Water monitoring program is being carried out for public beaches, and results show that water pollution is not significant, but the pressure may arise when there are a high number of visitors "(PR14, PR15).*

In the port zone, the identified pressures causing water pollution are mainly associated with the potential of leakage or dumping of pollutants in the normal operations of the ports (Figure 6.1). The main pollutants include oil, sewage, tap water and phosphate dust.

Nearly 40% of respondents identified the operations of the old phosphate port as a key pressure for water pollution in the port zone (Figures 6.1 and 6.2, and Table 4.2). This under-maintained port, which is currently working at the minimum level of activity, produces large amounts of phosphate dust (PR7) which forms layers on the sea surface (PR5, PR6, PR7, and PR9). Generation of phosphate dust from the old phosphate port was mentioned as one of the main environmental pressures along the entire coastline because it impacts not only water quality, but also on air quality (PR5, PR6, PR7, and PR9). Two officials stated that the seawater surface is covered with phosphate dust in addition to sulphur (by-product from phosphate handling), and layers of dust can reach 30 – 40 cm depth on the water surface; however, they also clarified that phosphate pollution will decrease after relocating the port to the industrial zone (PR14, PR15). Some respondents also identified another pressure related to the phosphate port activities associated with the occasional presence of enterococcus. Its source is unclear, as swimming is not allowed in this area, and the most likely cause seems to be sewage water from the old septic tanks (PR6, PR14, and PR15). Water pollution from port activities was identified as the main reason for the decision of relocating most of the ports within the current port zone into the industrial zone (PR1, PR7, and PR9). An official (PR12) mentioned that once the old phosphate port is completely relocated and dismantled, water quality is expected to improve dramatically. Two divers confirmed that by stating that corals have already started to appear along the old phosphate port, due to the decrease in water pollution by phosphate dust as the old port is operating at minimum levels (PR21, PR22). Water quality along this area is also expected to increase after relocating the main port to the industrial zone (PR16).

At the AMP reserved zone, water pollution can be observed as a consequence of various touristic activities, especially around public beaches (Figure 6.1 and Figure 6.2). Therefore, the pressure impacting water quality is mainly organics from visitors and swimmers, but also hydrocarbons and oil leakages from boating activities (PR1, PR6, PR14, PR15, and PR25). Two officials (PR14, PR15) explained that although organic water pollution may increase at high touristic seasons, it remains under control with water quality being regularly monitored through the National Monitoring Program (NMP) described in Chapter Two. The NMP includes the Marine Science Station (MSS), which serves as the "no pollution" reference point which other monitoring sites can compare to (PR2, PR6, and PR7).

Information on water pollution along the special zone is not available, as it does not fall under the jurisdiction of ASEZA (PR14, PR15, and PR16).

Pollution in the industrial zone is expected to increase as a consequence of the ports re-location (PR1, PR6, PR13, PR14, PR15, and PR19). Moreover, the LNG and the thermal power station pose a pressure, by the discharge of heating/cooling water that impacts the water temperature. In the case of LNG port, the effluent water used for heating has lower temperature compared to the seawater, while the opposite happens in the case of the thermal power station (PR1, PR2, PR6, and PR12).

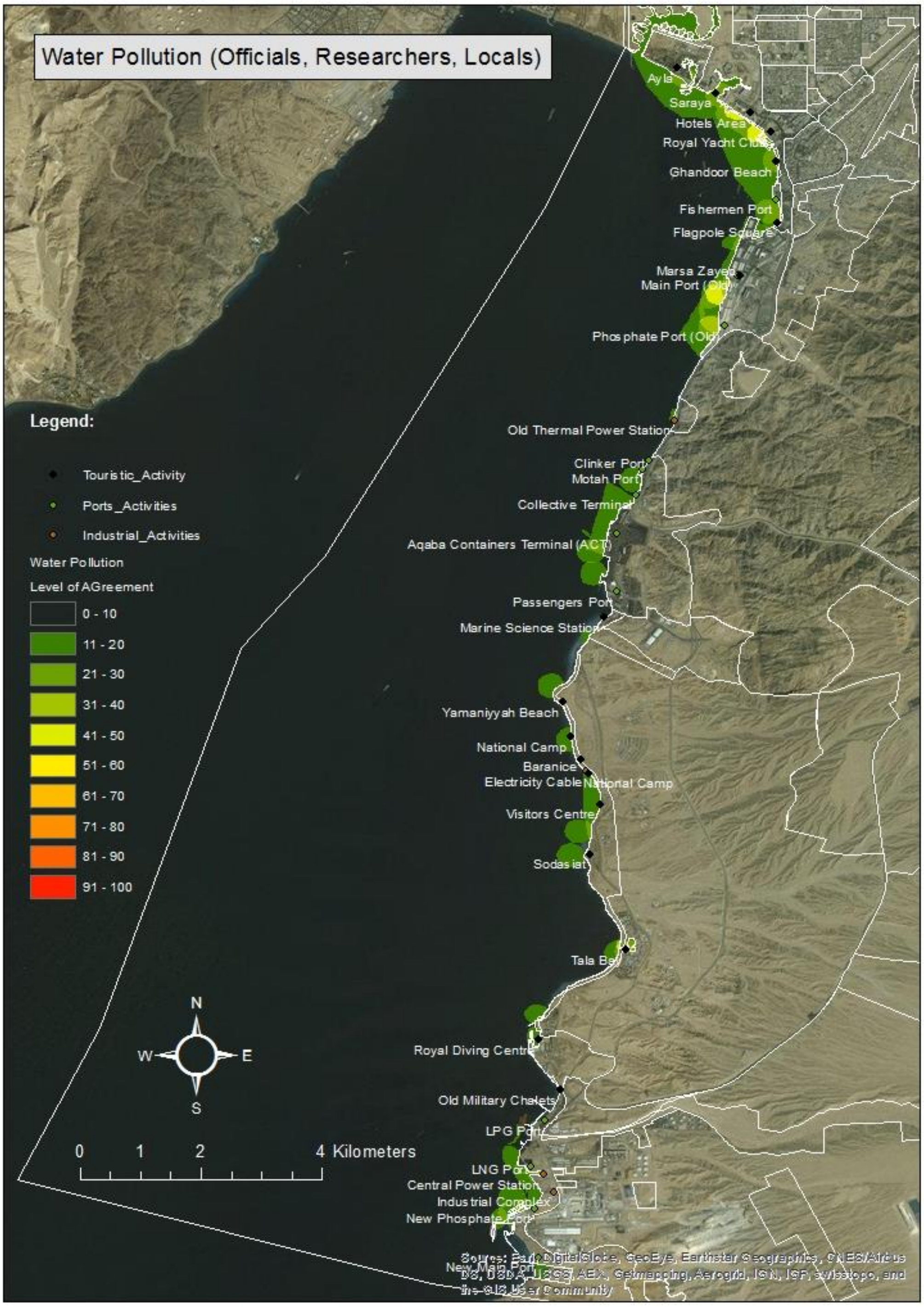


Figure 6.1: Water pollution locations due to the pressure from coastal activities generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 6.2: Level of awareness on the locations of water pollution due to the pressure from coastal activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of water pollution	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	WWTP	1	0	0	1	1	0	0	1	13%
	Ayla Project	3	3	1	7	3	2	1	6	38%
	Royal Palace	0	0	0	0	0	0	0	0	0%
	Saraya	2	3	1	6	2	2	1	5	38%
	Hotels' area	2	2	1	5	2	2	1	5	38%
	Royal Yacht Club	2	3	1	6	2	2	1	5	38%
	Ghandoor beach	2	2	3	7	2	1	3	6	19%
	Fishermen's port	2	3	0	5	2	2	0	4	25%
Port Zone	Main port	4	3	1	8	4	3	0	7	44%
	old Phosphate port	6	5	4	15	4	4	3	11	31%
	Old Thermal Power Plant	0	2	0	2	0	2	0	2	13%
	Clinker port	0	4	2	6	0	3	0	3	Less than 10%
	Collective terminal	5	1	0	6	4	1	0	5	13%
	Aqaba Containers' Terminal	4	4	0	8	2	4	0	6	25%
	Passengers port	2	1	0	3	0	1	0	1	13%
Aqaba Marine Park Zone	Marine Science Station	1	1	1	3	0	0	0	0	0%
	Between MSS and Yamaniyyah	2	0	1	3	2	0	1	3	13%
	Yamaniyyah Beach	2	2	1	5	2	2	1	5	19%
	National Campsite	0	3	1	4	2	3	1	6	13%
	Berenice	2	1	1	4	2	1	1	4	0%
	Visitors' centre	2	4	1	7	2	3	1	6	19%
	Assodasiat	2	3	1	6	2	2	1	5	13%
	between Assodasiat and Tala Bay	2	0	1	3	2	0	1	3	0%
	Tala Bay	3	4	1	8	2	4	1	7	44%
Special Zone	New Military chalets	0	0	1	1	0	0	1	1	Less than 10%
	Royal Diving Centre	1	0	0	1	1	1	0	2	13%
	Military Chalets	1	0	0	1	1	1	0	2	Less than 10%
Industrial Zone	LPG	3	3	0	6	1	2	0	3	13%
	LNG	3	3	0	6	1	2	0	3	25%
	Thermal power Station	2	5	0	7	2	5	0	7	25%
	Industrial Complex	1	3	0	4	1	3	0	4	31%
	Fertilizers Port	0	5	0	5	0	5	0	5	19%
	New Phosphate Port	1	2	0	3	1	2	0	3	25%
	New Main Port	1	2	0	3	1	1	0	2	13%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

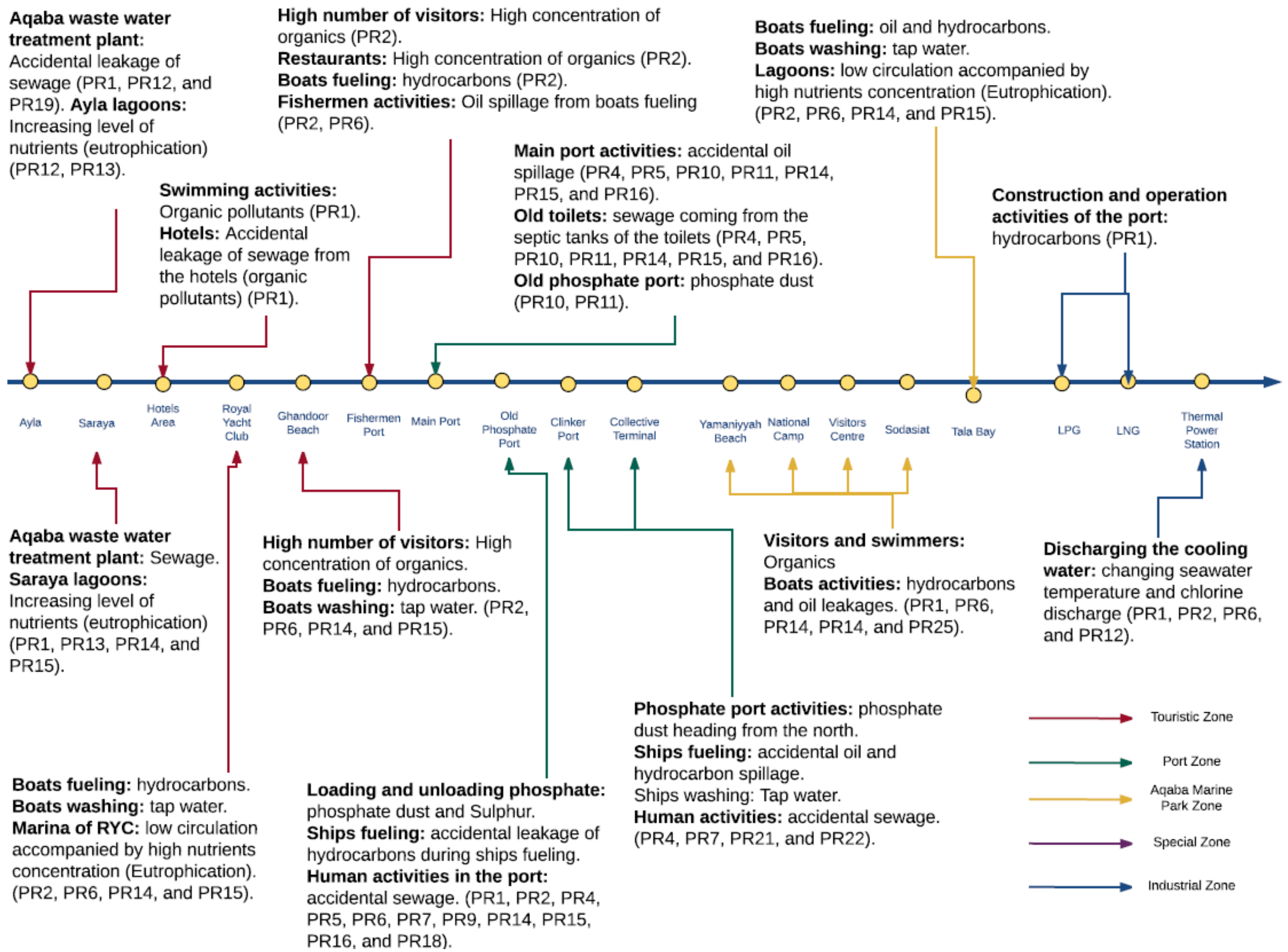
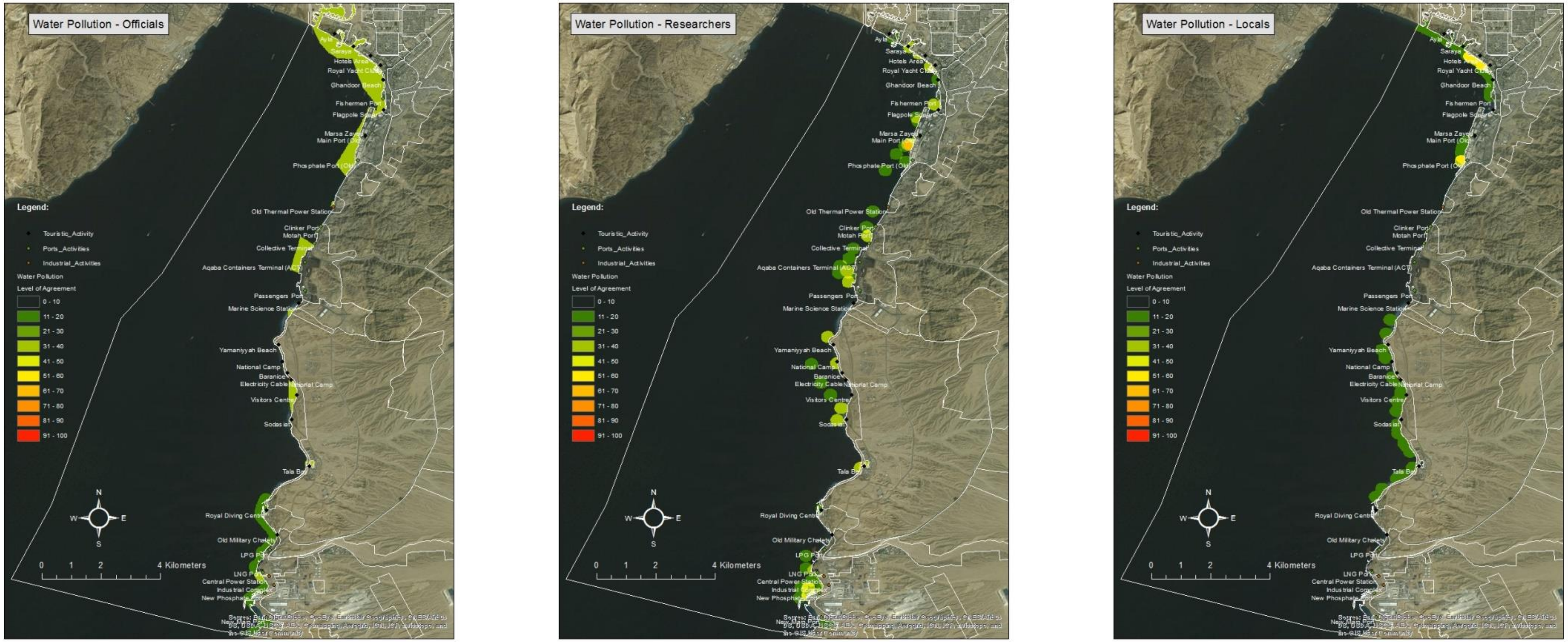


Figure 6.2: Key descriptive local knowledge about the locations of water pollution, including the pressure (bold text) and type of pollutant (normal text) where available.



(a) (b) (c)

Figure 6.3: Spatial knowledge on the locations of water pollution according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

6.3.2. Air Pollution

Respondents had concerns about some anthropogenic driving forces, including port and industrial activities, which pose a pressure on air quality. They identified a high concentration of emissions of pollutants such as sulphur dioxide (SO_2), nitrogen oxides (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), particulates (PM_{10}), ammonia (NH_3), and hydrogen sulphide (H_2S) (Figure 6.4). Respondents stated that most days (90%), Aqaba faces northerly winds (PR6, PR14, PR15, and PR19) which carry air pollutants to the south. However, on the few occasions of southerly winds, air pollution can be a significant impact to the residential and touristic areas in the north of Aqaba, as well as the AMP zone (PR6, PR14, PR15, and PR19).

Around 32% of respondents (6 officials, 4 researchers, and 3 locals) participated in mapping air pollution sites as a result of the pressures from specific coastal activities (Figures 6.4 and 6.5, Table 6.3). In addition, five respondents discussed air pollution and its causes without mapping. They indicated that the main sources of air pollution are hydrocarbons and phosphate dust (Figure 6.4), and identified that air pollution is resulting mainly from the activities within the port and industrial zones (Figure 6.5). The old phosphate port was a key driving force for this pressure based on the statements of 32% and mapping of 24% of respondents (Table 6.3). A researcher (PR5) stated: "*Although filters are being installed in the old phosphate port, their maintenance is not efficient*" (PR5). A local stakeholder asserts this concern adding:

> "*Air pollution is resulting from phosphate dust generated from the port, environmental impacts are not being taken into consideration and with the wind direction heading to the south; large areas are being polluted* (PR18).

Other major driving forces for air pollution are the thermal power station, fertilizers port, and the new phosphate port. In the past, the thermal power plant used to work on imported gas from Egypt, and so, the plant's operations was a major pressure causing air pollution, specifically Sulphur (SO_2), but since the recent political events in Egypt; Jordan stopped importing gas from this country and so, the pollution by sulphur has been reduced dramatically (PR12). A researcher (PR6) said, *"When the phosphate port is relocated to the industrial zone, air pollution will be limited due to the use of new technology including filters that can reduce the dust to the minimum*".

A researcher (PR1) pointed out that ASEZA is aiming to use more efficient technologies (such as filters to absorb toxic gases) to reduce the emissions from various activities, especially industrial facilities. He mentioned a compulsory monitoring system by ASEZA for facilities that have a potential of polluting the air like the phosphate company. Nevertheless, it was also noted that even if the emissions from the industrial facilities are within the allowed limits of Jordanian standards, the aggregate level of emissions from all the facilities is recognized to be an issue (PR19). Key pollutants mentioned are ammonia, sulphur and phosphate dust (PR4, PR7, and PR12) (Figure 6.4).

The spatial knowledge on the pressures causing air pollution varies across stakeholders. Officials mapped air pollution along the entire touristic and port zones, and most of the industrial zone (Figure 6.6a); while researchers mapped smaller areas within the port and industrial zones (Figure 6.6b); locals mapped this impact only in small areas within the port zone (Figure 6.6c).

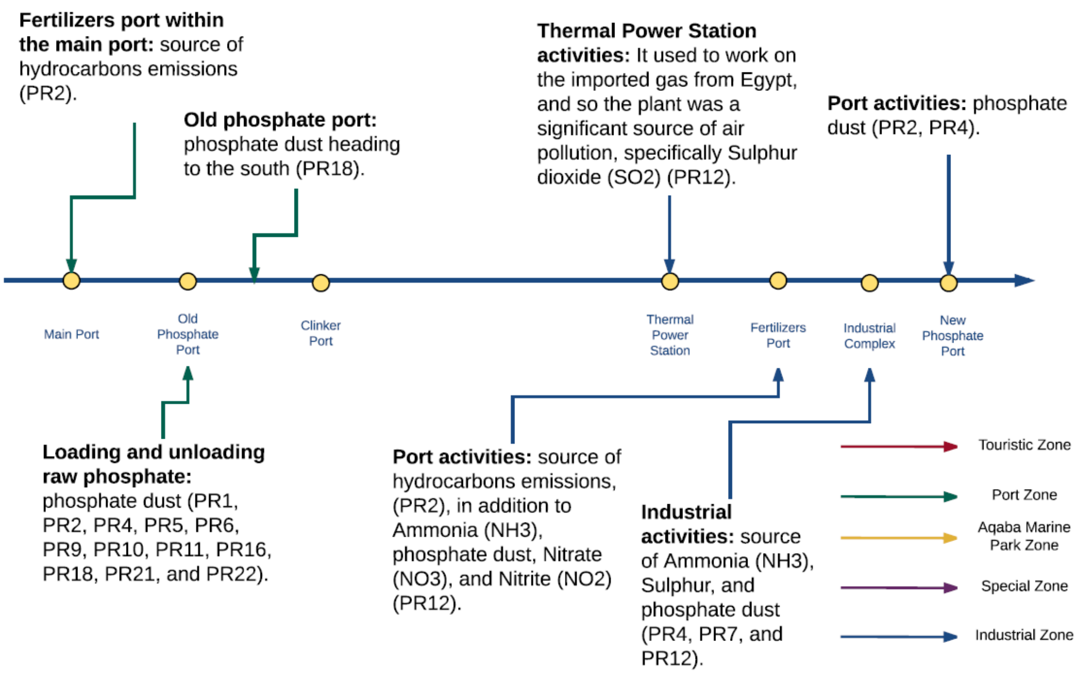


Figure 6.4: Key descriptive local knowledge about the locations of air pollution, including its pressure source (bold text) and type of pollutant (normal text) where available.

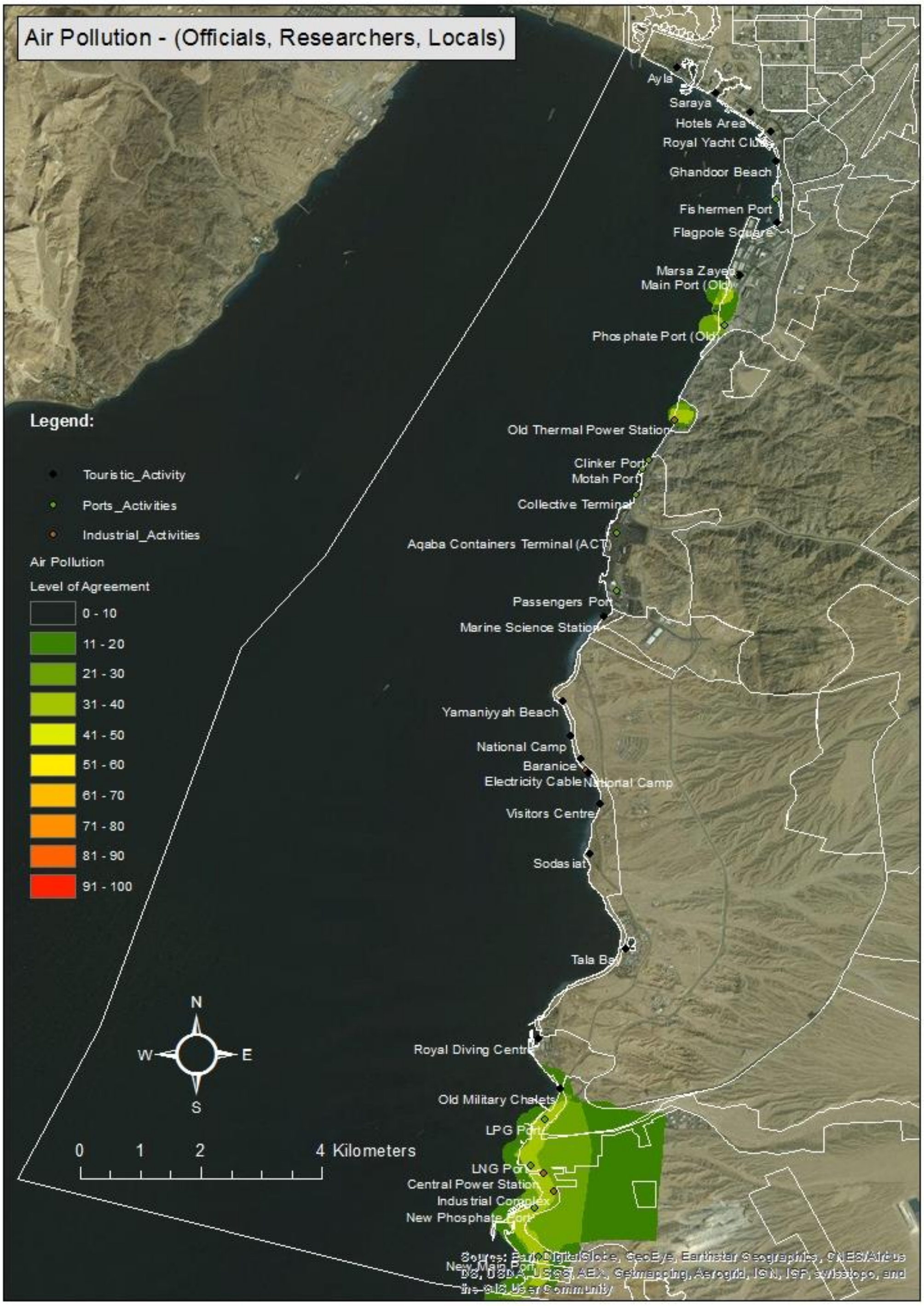


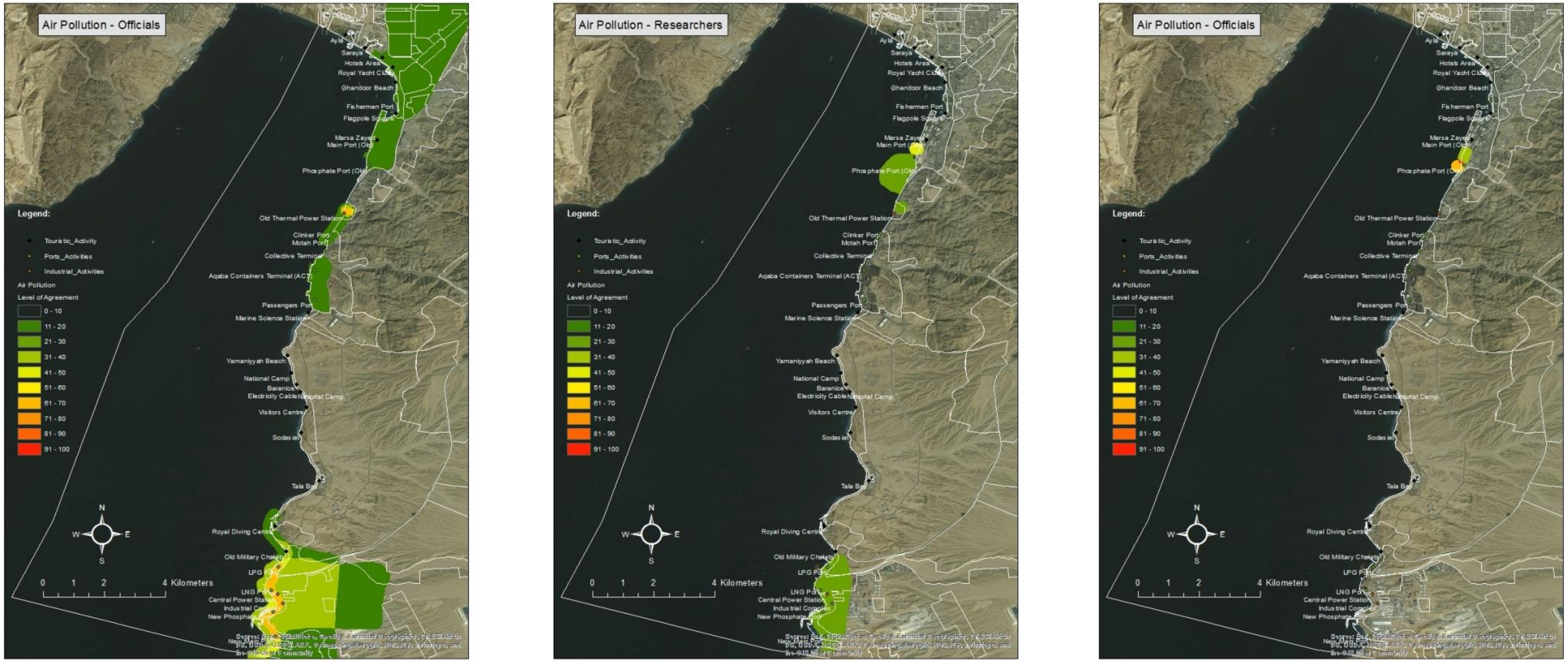
Figure 6.5: Air pollution locations due to the pressure from coastal activities generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 6.3: Level of awareness on the locations of air pollution due to the pressure from coastal activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of air pollution	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Hotels' area	1	0	0	1	1	0	0	1	NA
	Royal Yacht Club	1	0	0	1	1	0	0	1	NA
	Ghandoor Beach	1	0	0	1	1	0	0	1	NA
	Fishermen's Port	1	0	0	1	1	0	0	1	NA
Port Zone	Main port	1	2	1	4	1	1	1	3	31%
	Old Phosphate Port	4	5	4	13	4	3	3	10	38%
	Area Between Phosphate Port and Clinker Port	1	1	0	2	1	1	0	2	Less than 10%
	Old thermal Power Station	0	1	0	1	0	1	0	1	NA
	Collective Terminal	1	0	0	1	1	0	0	1	NA
	Aqaba Containers Terminal	1	0	0	1	1	0	0	1	NA
	Passengers port	1	0	0	1	1	0	0	1	NA
Industrial Zone	LPG	4	1	0	5	4	1	0	5	38%
	LNG	4	1	0	5	4	1	0	5	38%
	Thermal power station	4	1	0	5	4	1	0	5	38%
	Industrial Complex	4	3	0	7	4	1	0	5	38%
	Fertilizers port	4	1	0	5	4	1	0	5	38%
	New phosphate port	4	3	0	7	4	1	0	5	38%
	New Main Port	3	1	0	4	3	1	0	4	38%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) (b) (c)

Figure 6.6: Spatial knowledge on the locations of air pollution according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

6.3.3. Solid Waste Pollution

Pollution by solid waste was confirmed by 13 PGIS respondents, who mapped it (5 officials, 3 researchers, and 5 locals), plus 4 respondents without mapping it (Table 6.4). In this research, solid waste reflects the marine litter, which is basically any man-made object that accumulates along the shore or in the sea within the coastal zone. Figure 6.7 shows the spatial distribution of solid waste pollution and the pressure causing it along the coast as perceived by the respondents. Figure 6.8 captures the local knowledge on this topic, which mainly relates to the pressures and type of solid waste.

Ghandoor beach (mentioned by 20% of respondents with an agreement of about 50%), the fishermen's port (17% of respondents and consensus about 50%), and to a lower extent, the public beaches within AMP (15%, and consensus of 23%) were key locations for the solid waste accumulation (Table 6.4 and Figure 6.7). In addition, Figure 6.9 indicates that officials identified a larger area impacted by solid waste than researchers and locals.

The high numbers of visitors (the driving force) that use Ghandoor beach (as reported also in Chapter Four) generate a high volume of solid waste (e.g. PR5, PR17). A local respondent mentioned that artificial breaks, which were placed to maintain the beach (made from sand and rocks), are trapping solid waste, particularly when there are strong currents (PR18). The type of solid waste found along the AMP and the touristic zones is similar (Figures 6.7 and 6.8). Two respondents mentioned that the generation and accumulation of solid waste in AMP is high (PR5, PR25). This was also confirmed by the manager of the park (PR7), who stated that solid waste generation is a crucial pressure that AMP staff tries to solve by carrying regular clean-up campaigns. Accumulation of solid waste is also a problem along Yamaniyyah beach, national campsite, visitors' centre, and Assodasiat (PR2, PR24) (Figure 6.7).

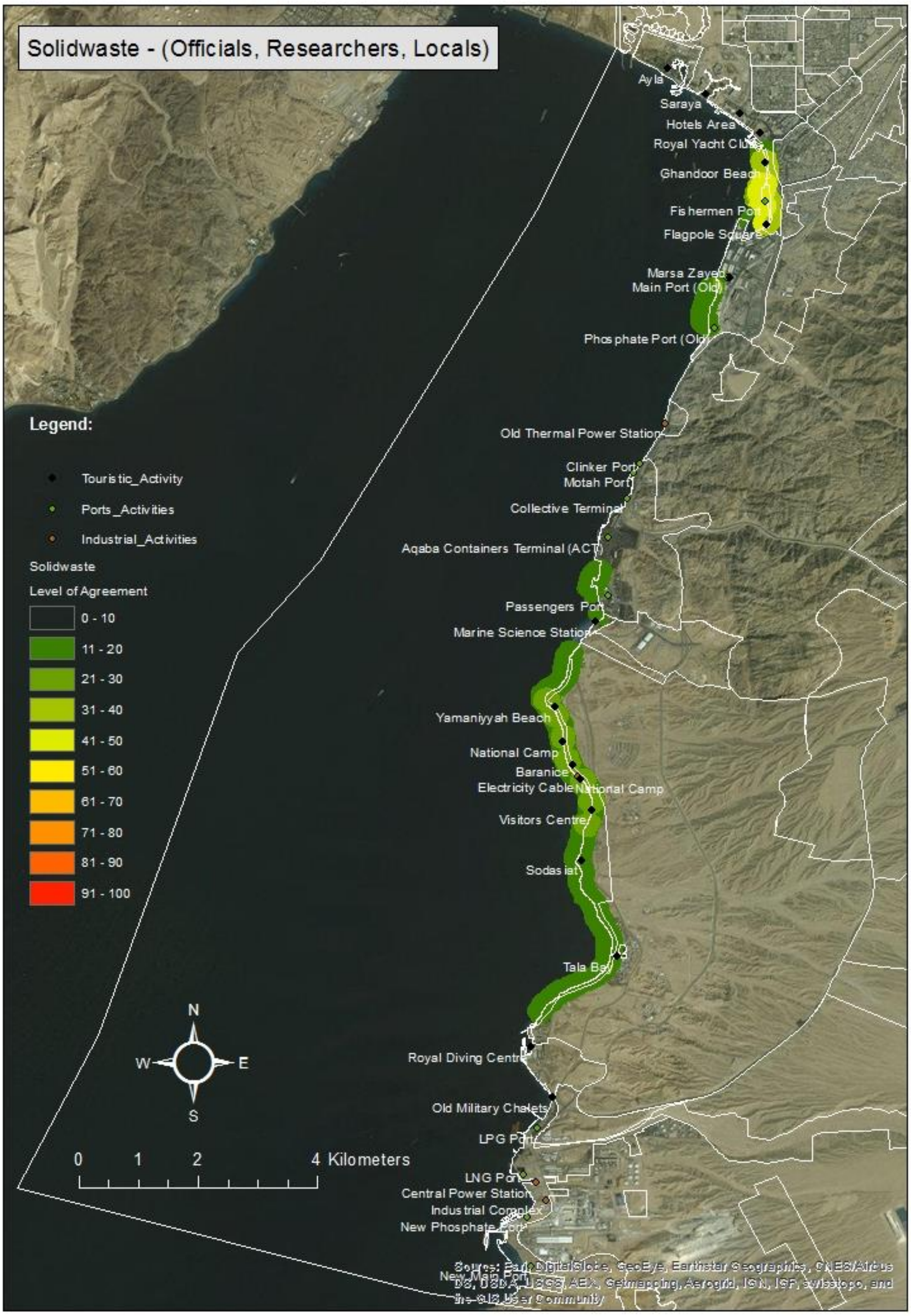


Figure 6.7: Solid waste pollution locations due to the pressure from coastal activities generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 6.4: Level of awareness on the locations of solid waste pollution due to the pressure from coastal activities along Aqaba coastline based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of solid waste pollution	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Ghandoor beach	3	1	4	8	2	1	3	6	46%
	Fishermen's Port	2	2	3	7	2	2	3	7	46%
Port Zone	Main Port	1	0	0	1	1	0	0	1	23%
	Old Phosphate Port	0	0	1	1	0	0	1	1	NA
	Old thermal power plant	0	1	0	1	0	0	0	0	NA
	Clinker port	1	1	0	2	1	0	0	1	NA
	Collective Terminal	1	0	0	1	1	0	0	1	NA
	Aqaba Containers Terminal	1	0	0	1	1	0	0	1	NA
	Passengers port	2	2	0	4	2	1	0	3	15%
Aqaba Marine Park Zone	Marine Science Station	1	0	0	1	1	0	0	1	NA
	Area between MSS and Yamaniyyah Beach	2	0	0	2	2	0	0	2	15%
	Yamaniyyah beach	2	3	1	6	2	2	0	4	23%
	National campsite	2	3	0	5	2	2	0	4	23%
	Berenice	2	2	1	5	2	2	0	4	23%
	Visitors' centre	2	3	0	5	2	2	0	4	23%
	Assodasiat	2	1	0	3	2	0	0	2	15%
	between Assodasiat and Tala Bay	2	0	1	3	2	0	1	3	15%
	Tala Bay	2	0	1	3	2	0	0	2	15%
Industrial Zone	LPG	1	0	0	1	1	0	0	1	NA
	LNG	1	0	0	1	1	0	0	1	NA
	Industrial complex	1	0	0	1	1	0	0	1	NA
	Thermal power Station	1	0	0	1	1	0	0	1	NA
	Fertilizers Facilities	1	0	0	1	1	0	0	1	NA
	New Phosphate Port	1	0	0	1	1	0	0	1	NA
	New Main Port	1	0	0	1	1	0	0	1	NA

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

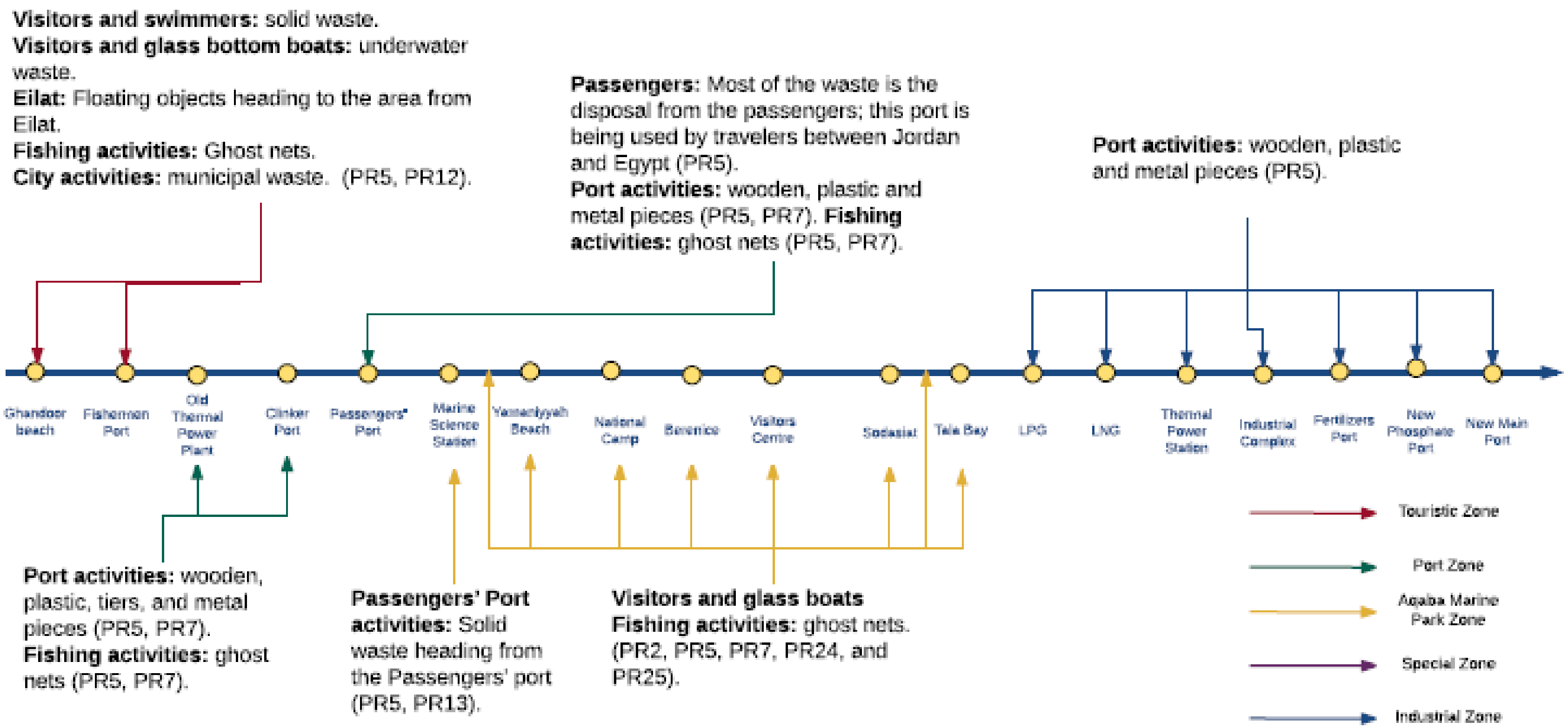
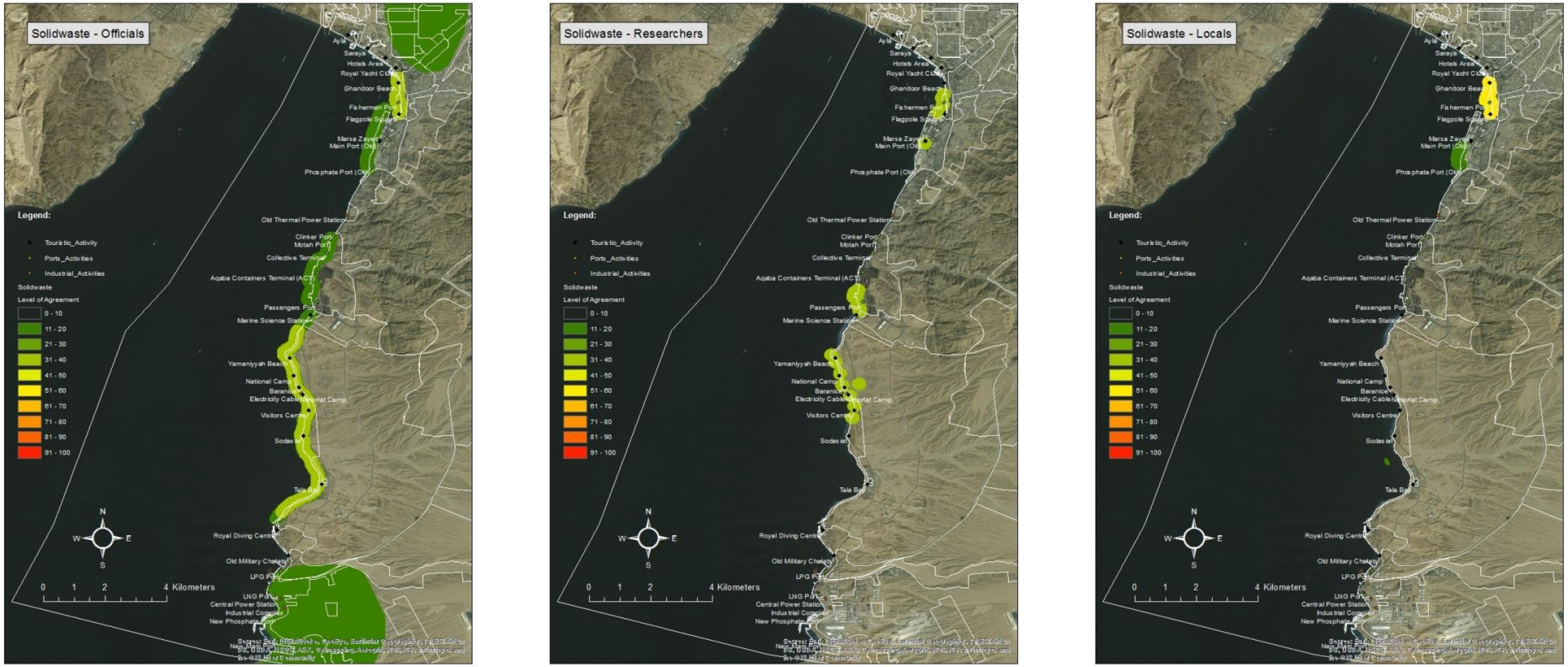


Figure 6.8: Key descriptive local knowledge about the locations of solid waste pollution, including its pressure (bold text) and type of pollutant (normal text) where available.



(a) (b) (c)

Figure 6.9: Spatial knowledge on the locations of solid waste according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

6.4. Coastal Ecosystems Degradation

ASEZA has the difficult task of balancing investment encouragement with environmental conservation. Even though any new project should acquire the EIA approval to ensure the protection of coastal and marine life (PR13), expansion of touristic, ports and industrial activities are becoming important pressures facing Aqaba's limited coastline (PR10, PR11, PR17, and PR19). A decision-maker in ASEZA mentioned: "*Aqaba is not only a touristic city, but it also has ports and industry, making environmental protection is a huge challenge*" (PR19). A local diver also said: "*I can notice the change in the status of corals since 1999, corals are being destroyed by time and their areas becoming less and less*" (PR25). Moreover, in order to satisfy the demand of investors and governmental institutions of coastal lands along AMP, ASEZA has plans to change the route of the coastal road eastward to expand coastal lands to fulfil current needs (PR9).

Around 80% of the PGIS respondents (80% of officials, 43% of researchers, and 88% of locals) discussed their concerns about ecosystem degradation (mainly coral ecosystems) due to four types of pressure; intensive land-based touristic, port, industrial, and diving activities.

6.4.1. Coastal Ecosystems Degradation Due to Intensive Land-based Touristic Activities

Nearly 70% of the sample (6 officials, 3 researchers, and 19 locals) mentioned the expansion of touristic activities causing ecosystems degradation. Figure 6.10 illustrates examples for this impact along several sites occupied by Ayla, Saraya, the old main port, Berenice, Tala Bay, and the new military chalets. Figures 6.11 and Table 6.5 show that nineteen respondents (2 officials, 2 researchers, and 15 locals) identified the spatial distribution for this impact as a result of the expansion of land-based touristic activities. Figure 6.12 shows that officials spatially identified this impact and the associated pressure within four zones (touristic, ports, AMP, and the special). Locals focused on the touristic and AMP zones. The two researchers agreed on this impact along the port zone. The construction of the new General Intelligence Services chalets was seen as a key pressure, identified by 29% of respondents (9 locals, 2 officials and 1 researcher). It was mentioned that its location used to be MPA and accommodate some of the best diving sites (e.g. PR8, PR9, PR18, and PR23). The fishermen's port, Ghandoor beach, and the main port are also highlighted as other key locations for this impact by respondents with a spatial consensus of 53%, 47%, and 42%, respectively (Table 6.5).

The small exclusion area between the AMP protected zone and the newly constructed General Intelligence Services chalets on the northern borders of the special zone is a source of concern for respondents (PR3, PR8, PR9, PR18, PR21, PR22, and PR23). One official (PR8) mentioned that the requested 50 m buffer zone between AMP and the chalets is not enough for the AMP marine protected area. A local said: "*The diving site between the royal diving centre and Tala Bay is now closed after the construction of the new chalets*" (PR18). Another diver also said: "*Aquarium dive site is now damaged as a result of constructing the new chalets*" (PR23).

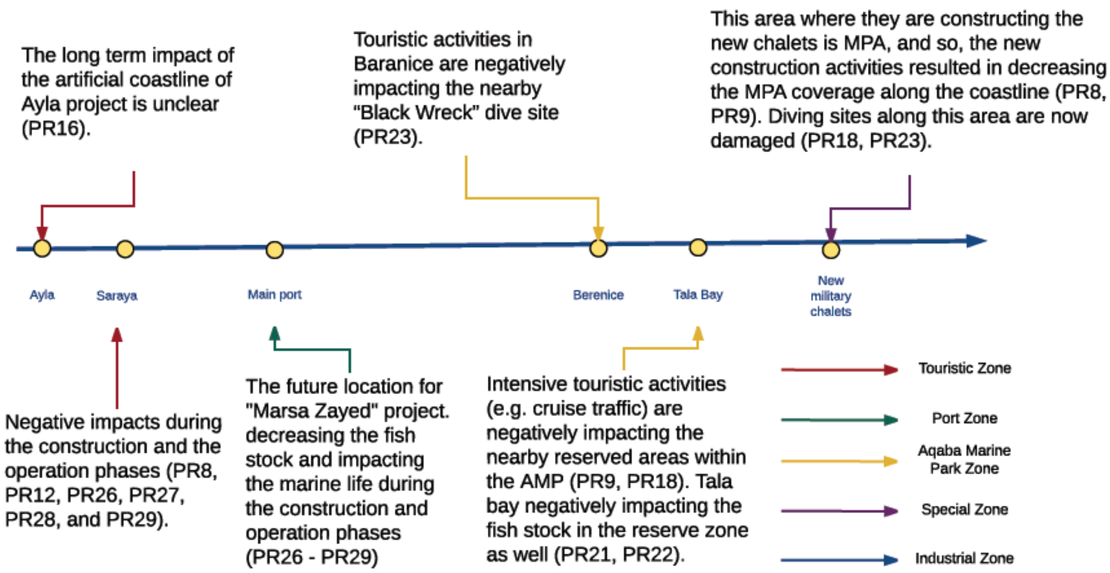


Figure 6.10: Key descriptive local knowledge about the locations of land-based touristic activities posing pressure on the coastal ecosystems.

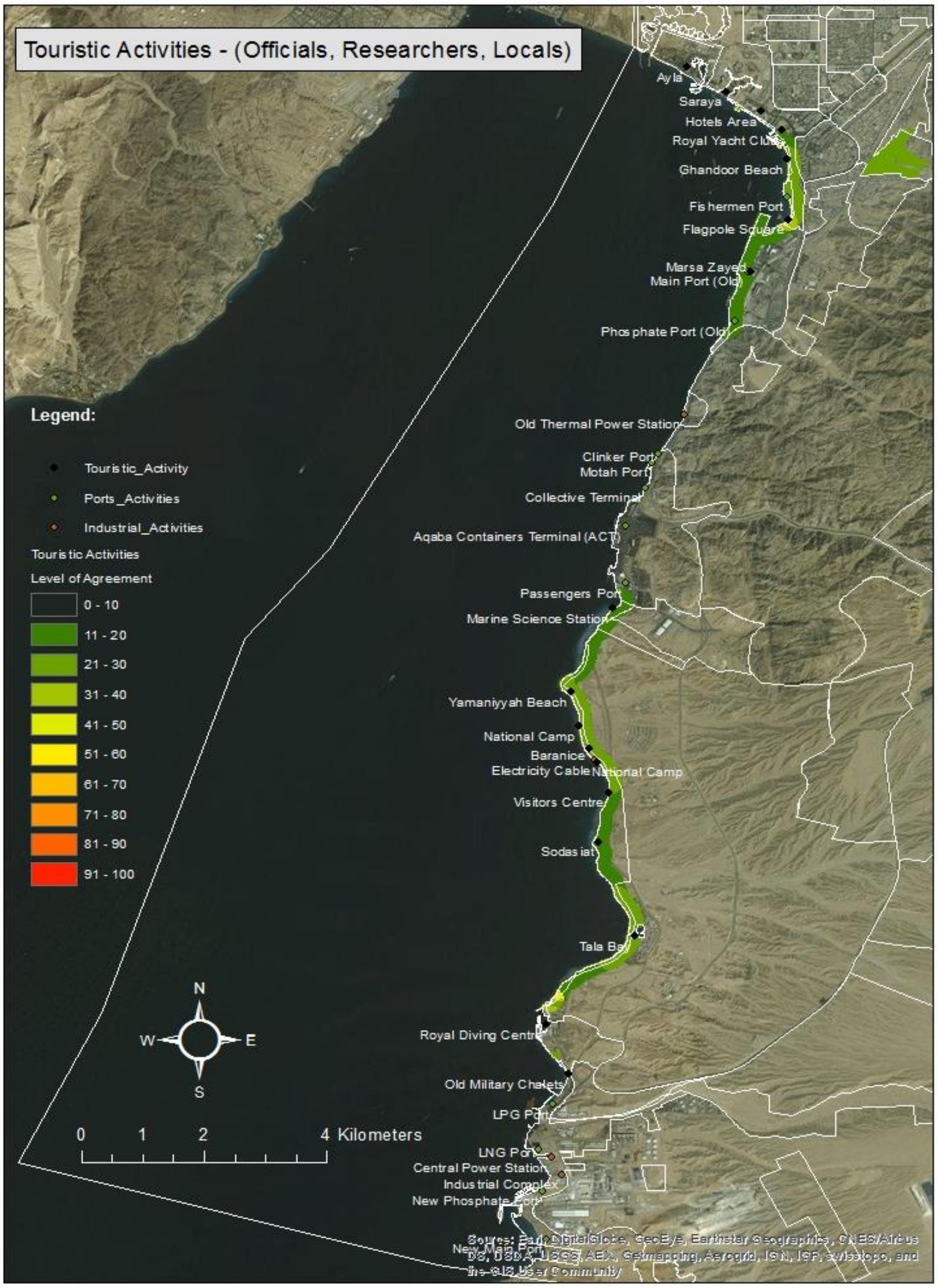


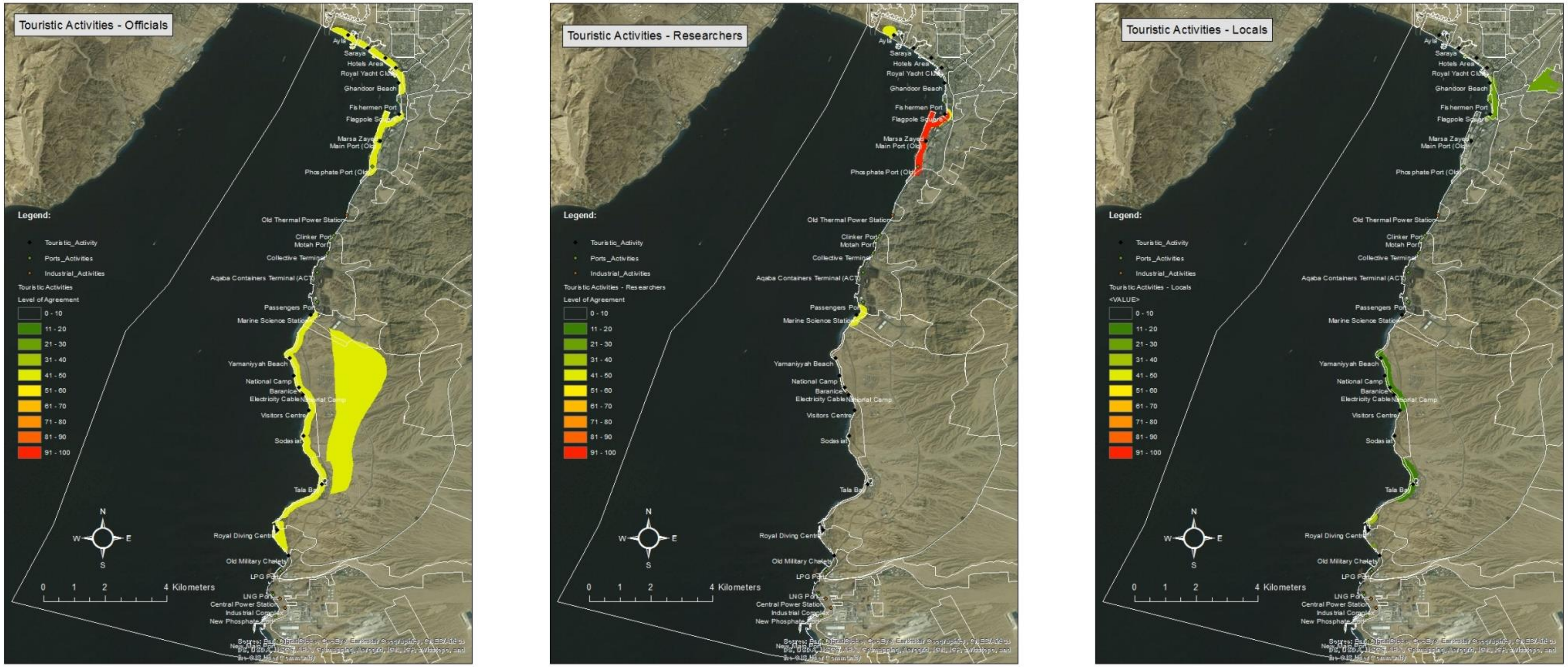
Figure 6.11: Impacted coastal ecosystems locations due to the pressure from touristic activities generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 6.5: Level of awareness on the locations of impacted coastal ecosystems due to expansion of land-based touristic activities based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of impacted coastal ecosystem	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Ayla	1	0	1	2	1	0	1	2	Less than 10%
	Saraya	1	0	0	1	1	0	0	1	NA
	Hotels' area	1	0	4	5	1	0	4	5	26%
	Royal Yacht Club	1	0	4	5	1	0	4	5	32%
	Ghandoor Beach	1	0	8	9	1	0	8	9	47%
	Fishermen's Port	1	0	8	9	0	0	8	8	53%
Port Zone	Main port/ Marsa Zayed	3	1	5	9	1	1	1	3	11%
	Old Phosphate Port	1	1	1	3	1	1	1	3	11%
Aqaba Marine Park Zone	Marine Science Station	1	1	1	3	1	1	1	3	16%
	Area between MSS and Yamaniyyah Beach	1	0	1	2	1	0	1	2	21%
	Yamaniyyah Beach	1	0	2	3	1	0	2	3	21%
	National Campsite	1	0	2	3	1	0	2	3	21%
	Berenice	1	0	3	4	1	0	3	4	26%
	Visitors' Centre	1	0	2	3	1	0	2	3	21%
	Assodasiat	1	0	1	2	1	0	1	2	16%
	Between Assodasiat and Tala Bay	1	0	1	2	1	0	1	2	21%
	Tala Bay	1	0	4	5	1	0	2	3	21%
Special Zone	New Military chalets	2	1	9	12	1	0	5	6	42%
	Royal Diving Centre	1	0	0	1	1	0	0	1	NA
	Military Chalets	1	0	0	1	1	0	0	1	NA

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) **(b)** **(c)**

Figure 6.12: Spatial knowledge on the locations of touristic activities impacting coastal ecosystems according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

6.4.2. Coastal Ecosystems Degradation Due to Intensive Port Activities

Jordan's economy relies heavily on its only seaport in Aqaba (PR8), especially for its energy imports through the LNG and LPG ports (PR12). Around 40% of the sample (7 officials, 3 researchers, and 7 locals) provided examples of negative impacts on the coastal ecosystems resulting from the pressure posed by the expansion of port activities (Table 6.6). As Figure 6.13 illustrates, port activities as the driving force pose pressures related to construction and expansion of current ports, as well as the ship traffic (PR1, PR3, PR8, PR17, PR18, PR21, and PR22). However, just over 20% of the sample (6 officials, 1 researcher, and 3 locals) spatially identified this impact (Figure 6.14 and Table 6.6).

A major impact for the relocation of the main port, recognised by 20% of respondents, was the damage caused to large areas of corals in the industrial zone (see Chapter Four) (PR3, PR18, PR23, PR24, and PR25). One respondent mentioned:

> "*Around 32 thousand m^2 of corals were negatively impacted by the relocation of the main port (Dirrah bay), however, only 2000 – 2500 m^2 of corals were transplanted in AMP.* […] *"Destroying corals means destroying the habitat of various types of marine life like fish."* (PR18).

A local diver confirmed this by saying:

> "*Corals were transplanted from the Saudi border wall to the Japanese garden in AMP, which represents only around 1% of the total area of corals damaged by constructing the new main port*." (PR23).

Another impact was the damage caused to the corals opposite the containers' port after its expansion (Table 6.6). A local (PR18) said: "*Around 4500 m^2 of corals were transplanted in AMP from containers' port and passengers' ports, while 90% of the transplanted corals died.*" More corals may be impacted in the future if the containers' port goes through additional expansion (PR8).

Two divers confirmed this view: "*Corals are completely damaged up to 45 m depth along the containers' port as a result of construction, ships traffic, and dumping containers and large pipes*."

Similar locations for coastal ecosystems degradation from port activities were identified by officials and locals (Figure 6.15). Officials mapped the largest area, which suggest that they are aware of the negative impacts of expanding, relocating and constructing new ports.

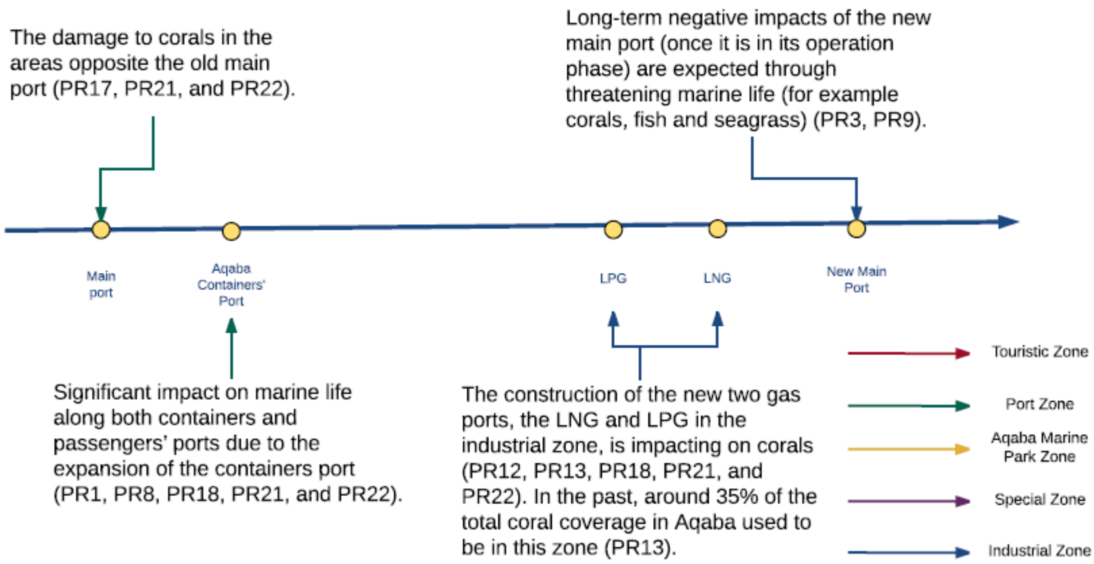


Figure 6.13: key descriptive local knowledge about the locations of port activities posing pressure on the coastal ecosystems.

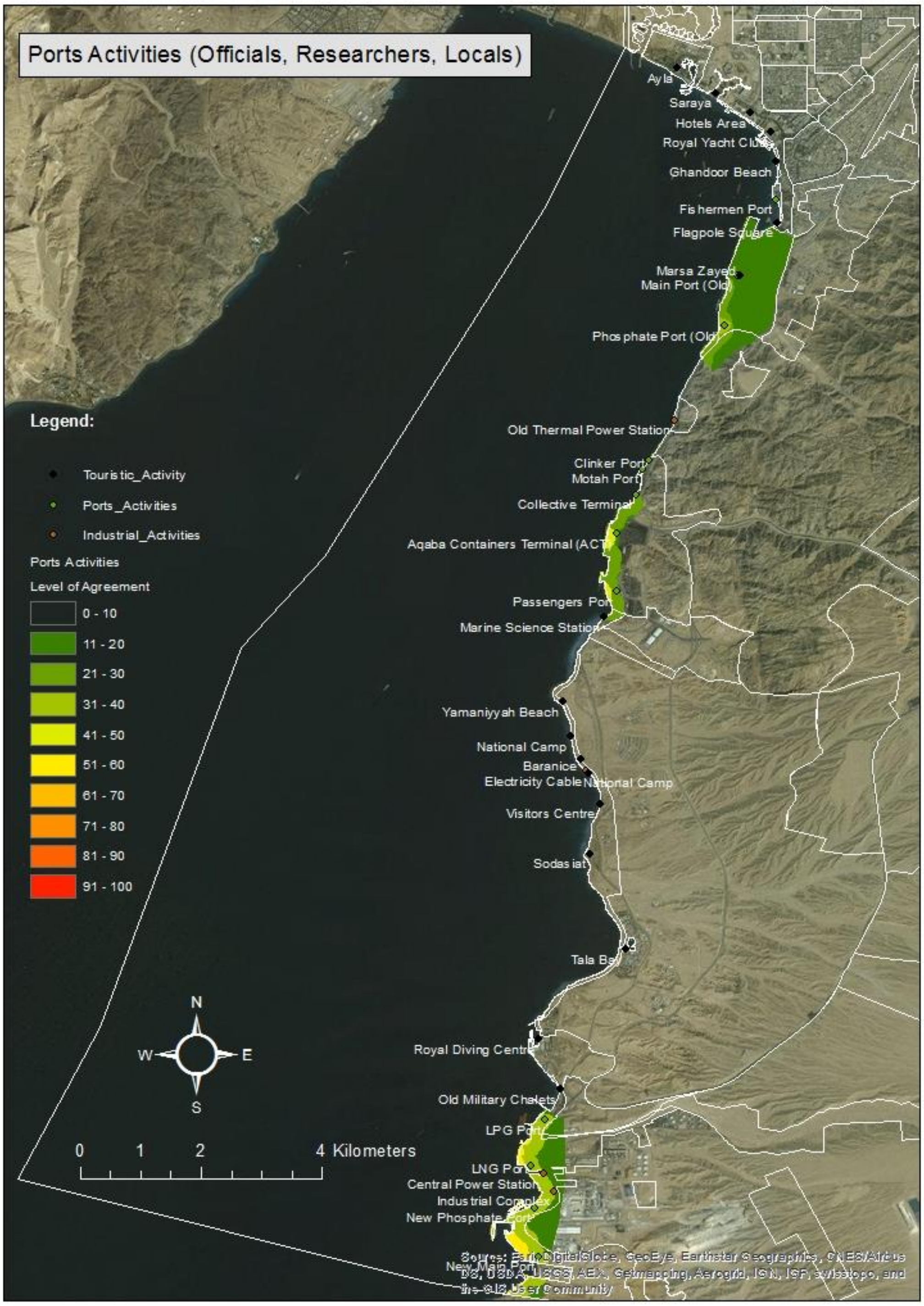


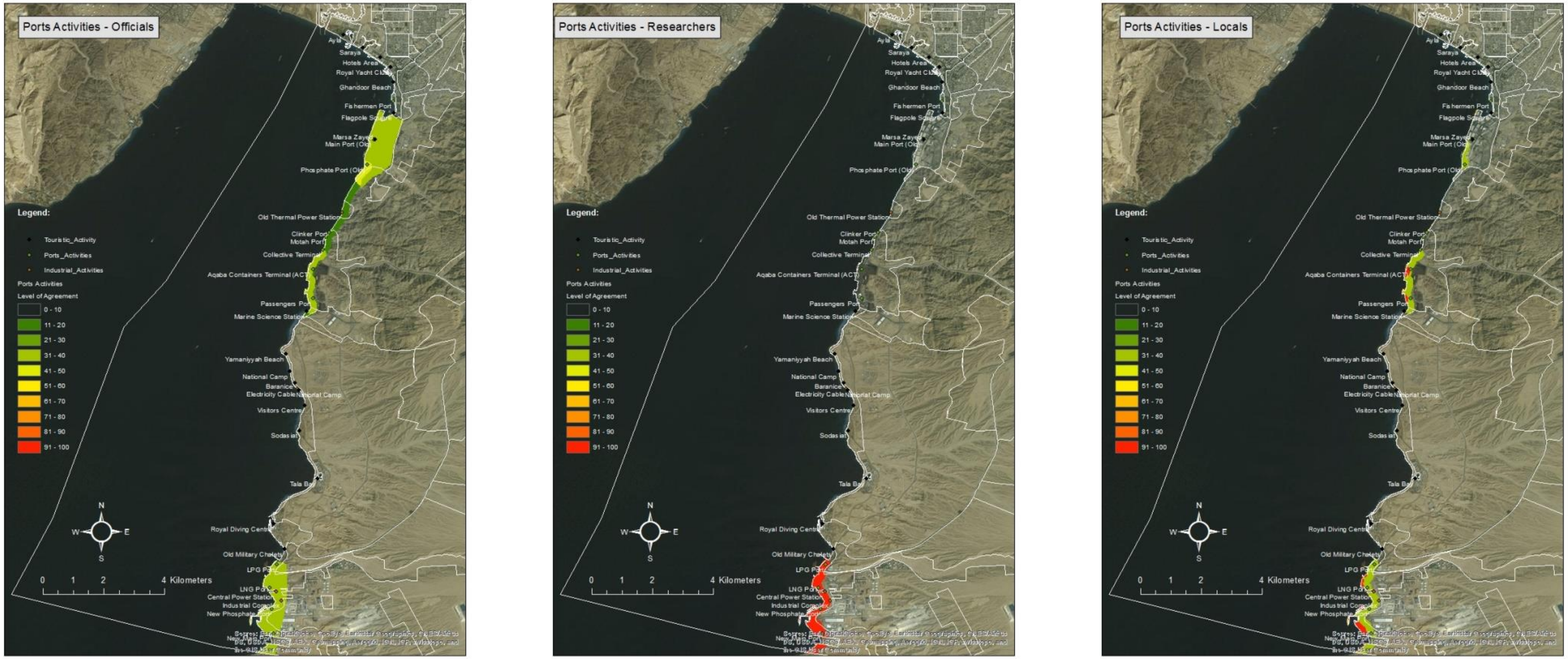
Figure 6.14: Impacted coastal ecosystems locations due to the pressure from port activities generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 6.6: Level of awareness on the locations of impacted coastal ecosystems due to expansion of port activities based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of impacted coastal ecosystem	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Hotels' area	2	0	0	2	2	0	0	2	Less than 10%
	Royal Yacht Club	2	0	0	2	2	0	0	2	Less than 10%
	Ghandoor Beach	2	0	0	2	2	0	0	2	Less than 10%
	Fishermen's Port	2	0	0	2	2	0	0	2	Less than 10%
Port Zone	Main port	2	0	2	4	2	0	2	4	40%
	Old Phosphate Port	3	0	2	5	3	0	2	5	40%
	Area between phosphate port and clinker port	1	0	2	3	1	0	0	1	NA
	Old thermal Power Station	1	0	0	1	1	0	0	1	NA
	Clinker port	1	0	0	1	1	0	0	1	NA
	Collective terminal	2	0	2	4	2	0	2	4	30%
	Aqaba Containers Terminal	2	1	3	6	2	0	2	4	50%
	Passengers port	2	0	3	5	2	0	2	4	50%
Industrial Zone	LPG	3	1	3	7	2	1	0	3	40%
	LNG	3	1	0	4	2	1	0	3	60%
	Thermal Power Station	2	1	0	3	2	1	0	3	60%
	Industrial complex	2	1	0	3	2	1	0	3	60%
	New Phosphate Port	2	1	0	3	2	1	0	3	60%
	New main port	3	1	4	8	2	1	0	3	60%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%



(a) **(b)** **(c)**

Figure 6.15: Spatial knowledge on the locations of port activities impacting coastal ecosystems according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

6.4.3. Coastal Ecosystems Degradation Due to Intensive Industrial Activities

Figure 6.16 and Table 6.7 show that some stakeholders (3 officials, 1 researcher, and 3 locals) recognised that the expansion of industrial activities is posing pressure and negatively impacting the coastline and coastal resources. However, only three respondents were able to spatially identify this impact (Figure 6.16). A decision-maker at ASEZA (PR19) stated: "*With the water shortage in Jordan, Aqaba is the* only *option to operate heavy industrial activities that require large amounts of water".*

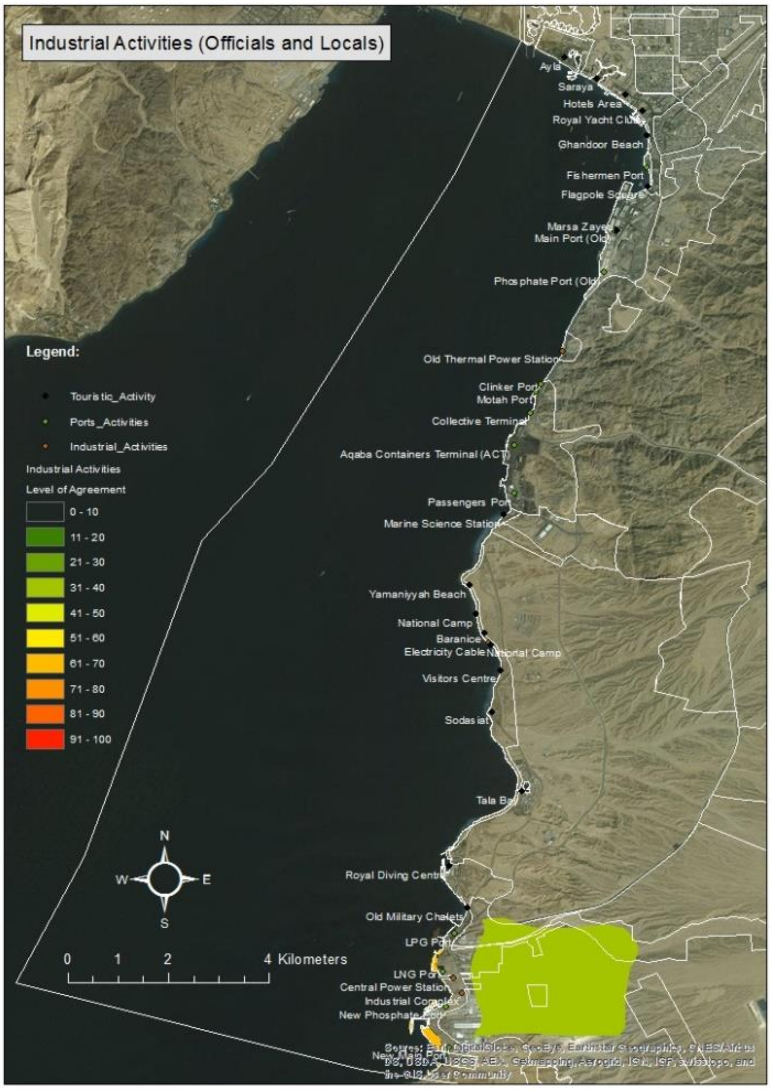


Figure 6.16: Impacted coastal ecosystems locations due to the pressure from industrial activities generated during the PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

Table 6.7: Level of awareness on the locations of impacted coastal ecosystems due to expansion of industrial activities based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of impacted coastal ecosystem	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Aqaba Marine Park Zone	Jordan- Egypt electricity cable	0	0	2	2	0	0	0	0	NA
Industrial Zone	LPG	3	0	3	6	1	0	2	3	Less than 10%
	LNG	3	0	3	6	1	0	2	3	67%
	Thermal power Station	3	0	3	6	1	0	2	3	33%
	Industrial complex	3	0	3	6	1	0	2	3	67%
	New Phosphate Port	3	0	3	6	1	0	2	3	67%
	New Main Port	3	0	3	6	1	0	2	3	67%

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

6.4.4. Coastal Ecosystems Degradation Due to Intensive Diving Activities

Degradation of coastal ecosystems by intensive diving activities was reported by one official and four locals. Three local divers mapped this impact within the AMP zone (especially by the visitors' centre) and opposite the new chalets in the special zone (Table 6.8 and Figure 6.17). The impacted corals from diving activities match the identified diving locations mapped in Chapter Four. Respondents indicated that diving is not governed efficiently by ASEZA (PR1, PR2, PR17, and PR25). A local diver said:

> *"The licensing requirements to open a diving centre are very easy, which allowed a high number (22) of diving centres to operate in Aqaba and negatively impact the marine life and corals specifically" (PR25).*

A location that illustrates the negative impacts caused by heavy diving was the "Aquarium" dive site, near the Royal Diving Centre (PR23). Most popular diving sites had been split into two (i.e., each has two separate entrances) in order to decrease the diving pressure (see Chapter Four for further details).

Table 6.8: Level of awareness on the locations of impacted coastal ecosystems due to intensive diving activities based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of impacted coastal ecosystem	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Aqaba Marine Park	Yamaniyyah Beach	0	0	1	1	0	0	1	1	NA
	National Campsite	0	0	5	5	0	0	3	3	33%
	Berenice	0	0	5	5	0	0	3	3	33%
	Visitors' Centre	0	0	5	5	0	0	3	3	100%
	Assodasiat	0	0	5	5	0	0	3	3	33%
	Between Assodasiat and Tala Bay	0	0	5	5	0	0	3	3	67%
	Tala Bay	0	0	4	4	0	0	1	1	NA
Special Zone	New Military chalets	0	0	4	4	0	0	1	1	NA

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

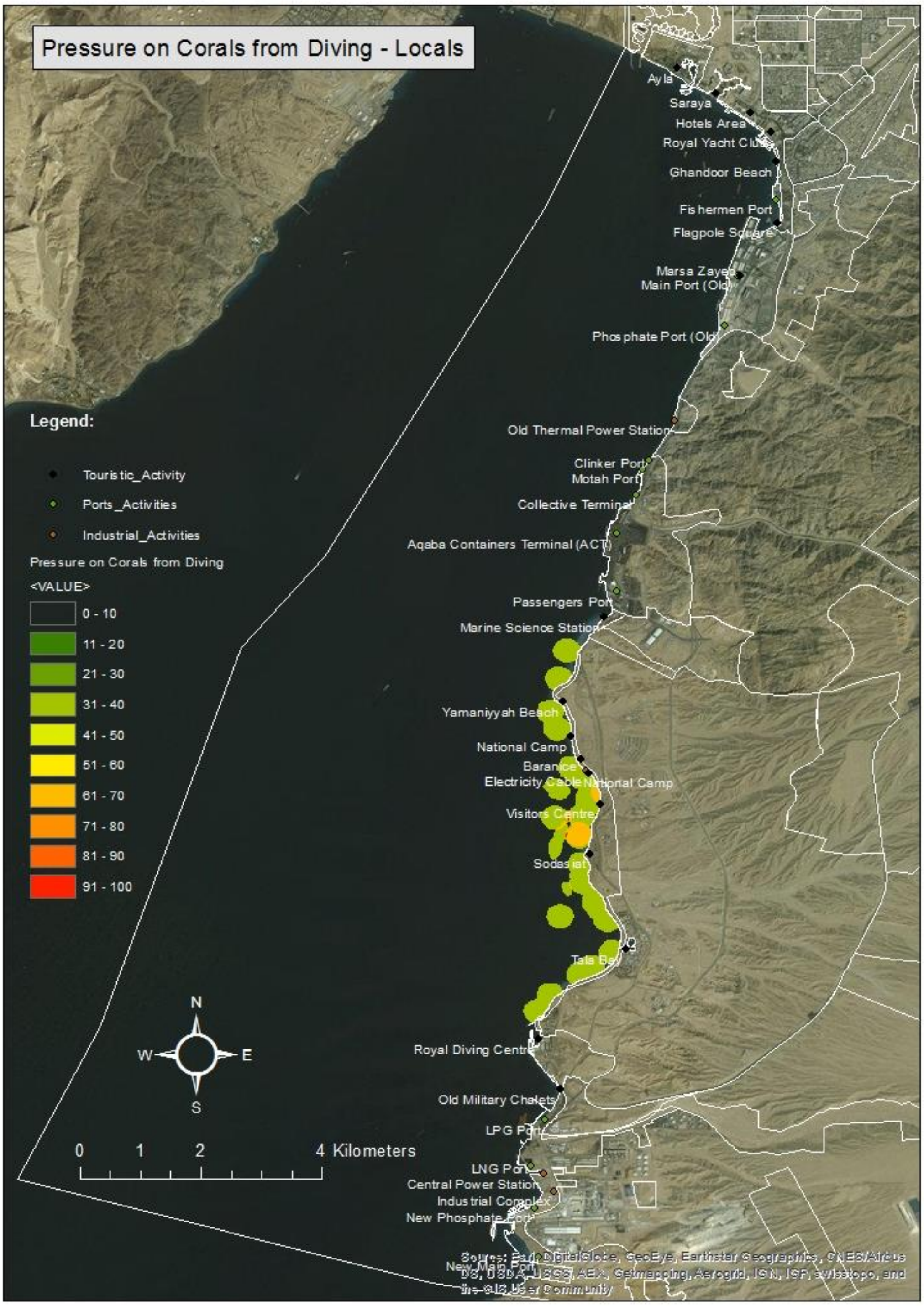


Figure 6.17: Impacted coastal ecosystems locations due to the pressure from intensive diving activities generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.

6.5. Flooding: A Pressure Causing Negative Environmental Impacts on Aqaba Coastal Zone

Flooding was expressed as a concern by eight respondents (4 officials, 2 researchers, and 2 locals), with most of them able to spatially identify the regular flooding sites with a high consensus of 60% (Table 6.9, and Figure 6.18). Figure 6.19 shows that locals mapped flooding site near the hotels within the touristic zone only, even though it was acknowledged that intensive flooding incidences coupled with the expansion of land-based activities can occur along the entire coastline (PR1, PR9) and specifically along the valleys (PR1, PR5, PR9, PR14, and PR15). Flooding poses a pressure to the marine resources like corals and impacting the sea water quality (PR1). Flooding negatively impacted the corals along the touristic zone, the area between the passengers' port and MSS, and the area of the transplanted corals opposite to visitors' centre (PR14, PR15, PR18, PR21, and PR22).

Table 6.9: Level of awareness on the locations of flooding potential sites based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Zone	Location of flooding	Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped				Consensus in Spatial Location
		Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)	
Touristic Zone	Hotels' area	3	1	2	6	2	1	2	5	57%
	Royal Yacht Club	2	0	0	2	2	0	0	2	29%
	Ghandoor beach	1	0	2	3	0	0	0	0	NA
	Fishermen's Port	1	0	0	1	1	0	0	1	NA
Port Zone	ACT	2	0	0	2	1	0	0	1	NA
	Passengers' port	2	1	2	5	2	1	0	3	29%
Aqaba Marine Park Zone	MSS	2	2	2	6	2	0	0	2	14%
	Visitors' centre	1	0	1	2	0	0	0	0	NA
	Assodasiat	0	1	0	1	0	1	0	1	NA
	Tala Bay	1	0	2	3	1	0	0	1	NA
Special Zone	New Chalets	1	1	0	2	0	1	0	1	NA

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

Consensus %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

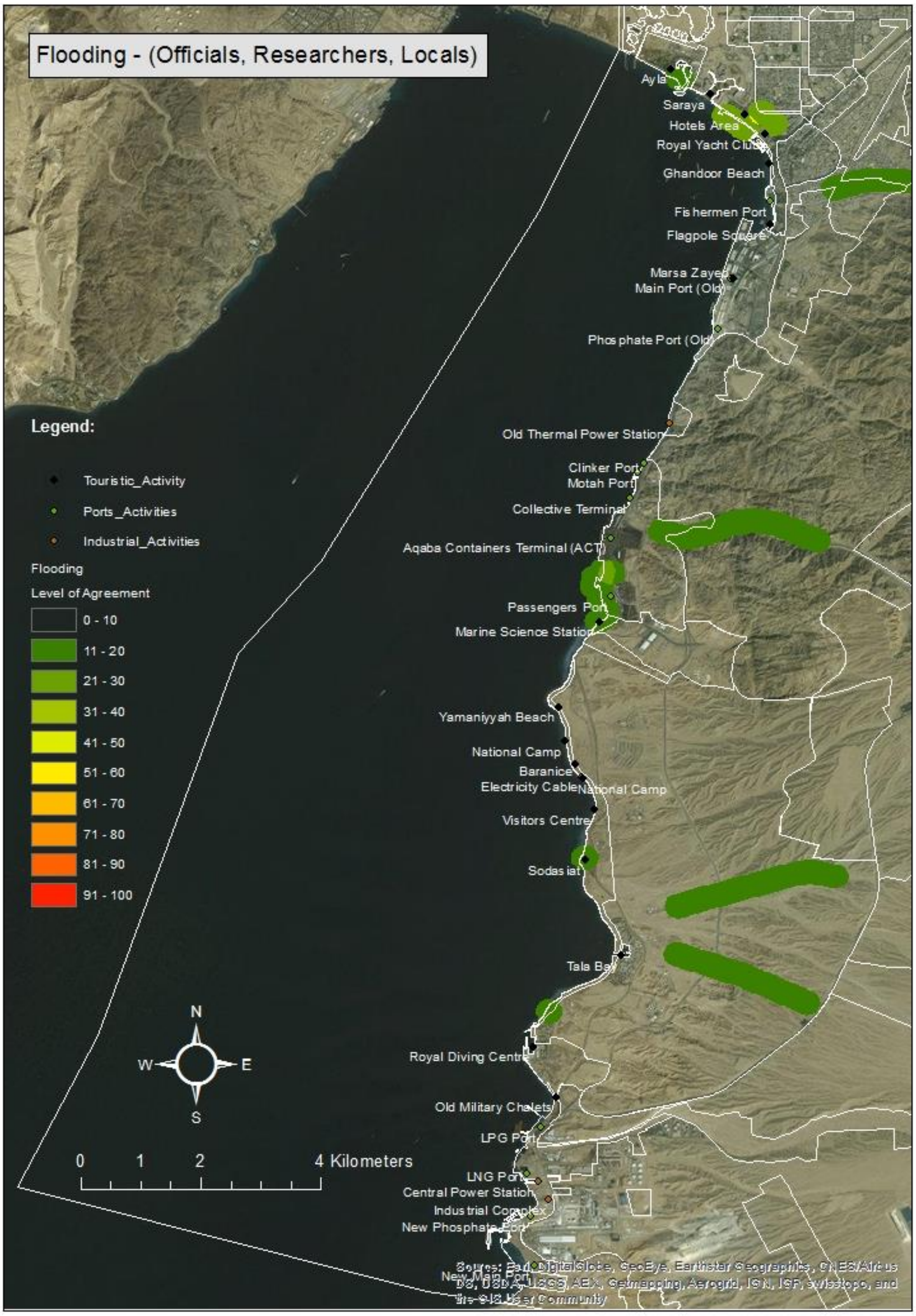
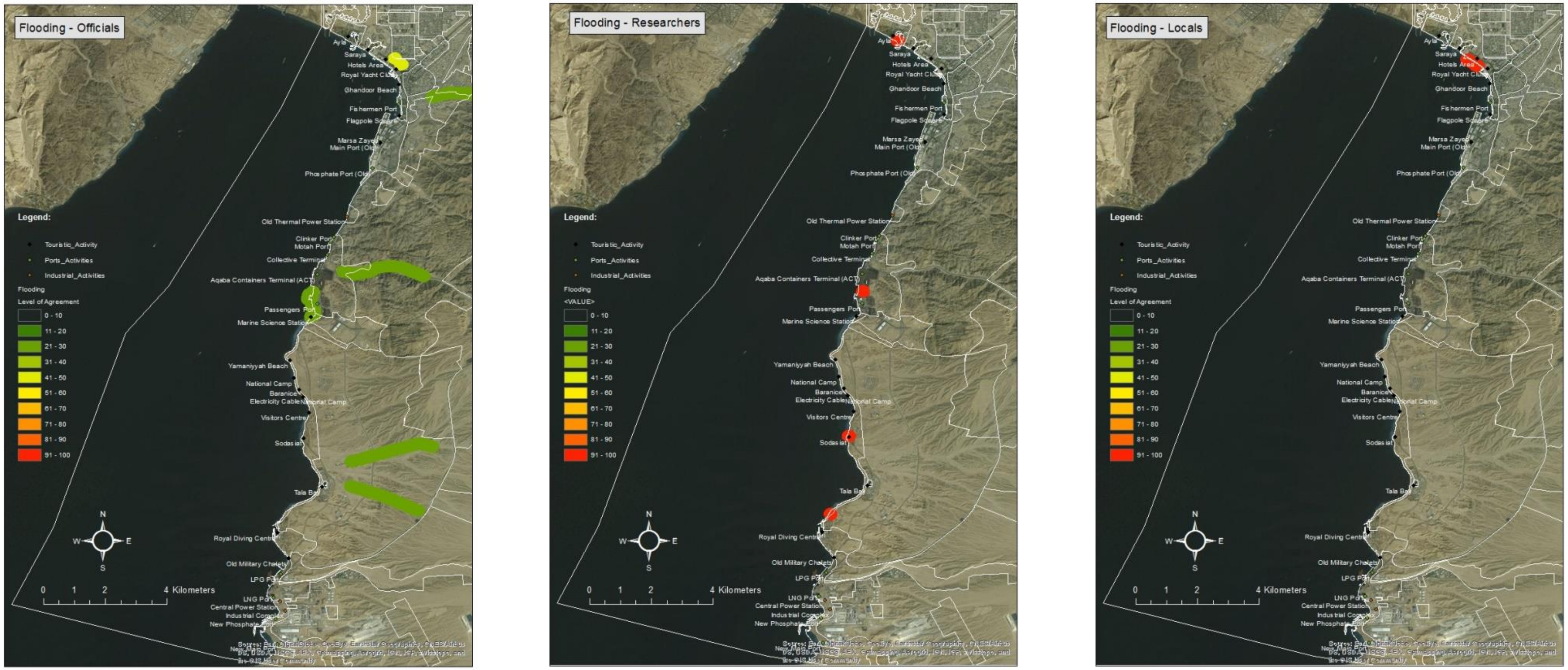


Figure 6.18: Flooding potential sites generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.



(a) **(b)** **(c)**

Figure 6.19: Spatial knowledge on the locations of flooding events according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

6.6. Identifying Priority Areas for the ICZM

In this research, the gathered qualitative and spatial knowledge from the PGIS meeting allowed the researcher to present a map for each type of coastal pressure and its consequent impact as perceived by respondents. To identify priority areas, different maps were combined to assess the accumulated impacts from different types of pressures.

For identifying the priority areas, the number of responses who mentioned the impacts and the associated pressure where used, along with the values of spatial consensus obtained by overlaying the maps of the different identified impacts.

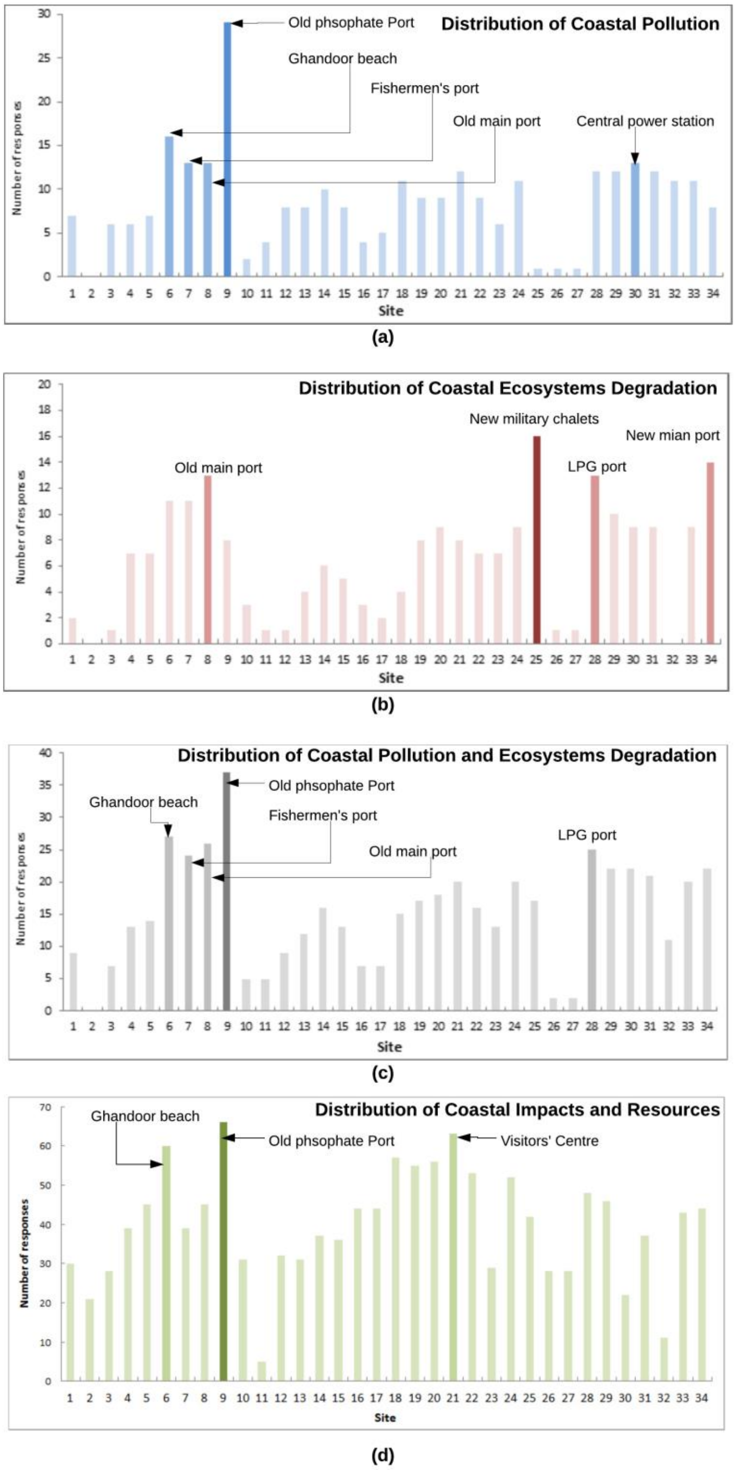
In a simple scenario where the manager uses a single criterion, for example, a single coastal impact for defining priority areas, this can be done for all the identified impacts by the respondents in which the predominant pressure causing the specific impact was presented in the previous sections. For example, in case an ICZM program is proposed to solve solid waste pollution along Aqaba coastline, then, the developed coastal profile for the solid waste pollution as shown above (Section 6.3.3 and Figure 6.7) would be the starting point, and the predominant polluted areas with solid waste would be the target. Consequently, the first priority area then, would be Ghandoor beach followed by the fishermen's port based on the number of responses for mentioning and the highest spatial consensus.

Priority areas for overall coastal pollution in Aqaba were based on the occurrence of all impacts, water, air, and solid waste pollution together. Figure 6.20a presents the overall responses for coastal pollution. Figure 6.21 shows the resultant map from overlaying the three types of pollution. Table 6.10 presents the resulting identified priority areas.

Priority areas for coastal ecosystems degradation based on stakeholders' concern (responses) are shown in figure 6.20b. The first priority is the area where the new military chalets are located, while other priority areas are presented in Table 6.10. Figure 6.22 shows priority areas based on spatial consensus (i.e., overlaying the produced PGIS maps for the four coastal activities causing the ecosystems degradation). It shows that the first priorities are the areas nearby Ghandoor beach and the new military chalets, while the second priority areas are presented in Table 6.10. Combining response rate and spatial consensus, the priority locations for the coastal ecosystems degradation from all types of coastal activities are the area where the new military chalets are located, followed by the area of the new main port.

Total coastal impacts are assessed by considering all respondents responses on any impacts and by overlaying maps of all impacts. This shows that the first priority location is the old phosphate port, while the second, third, fourth, and fifth priority locations are Ghandoor beach, old main port; LPG port, and fishermen's port consequently (Figure 6.20c and Table 6.10). Similar areas emerge if spatial consensus is used with areas surrounding the fishermen's port and the old phosphate port as first priority; followed by Ghandoor beach as the second priority area, followed by the new phosphate port as the third priority area (Figure 6.23 and Table 6.10). By combining both types of information, then the area surrounding the old phosphate port is the first priority, followed by the areas nearby the Ghandoor beach and the fishermen's port (Table 6.10).

Priority areas impacted by various coastal activities and located in resources abundant areas (impacts and resources) for the proposed ICZM program are shown in Figure 6.20d. These areas are identified using information on the total responses for both identified overall impacts and coastal resources. It shows that the first priority is the area where the old phosphate port is located, followed by the area surrounding visitors' centre as the second priority area and Ghandoor beach as the third priority area. While based on information of spatial consensus of impacts and resources distribution, the first priorities are the areas of Ghandoor beach and the old phosphate port, and the second priorities are the areas between Yamaniyyah beach and the visitors' centre, and the fishermen's port area (Figure 6.24). The old phosphate port and Ghandoor beach emerge as a priority if managers combine information on both information on locations with highest responses and spatial consensus.



Site No.	Coastal activitiy in the site
1	Ayla
2	Royal Palace
3	Saraya
4	Hotels area
5	Royal Yacht Club
6	Ghandoor beach
7	Fishermen's port
8	Old main port/ Marsa Zayed
9	Old phosphate port
10	Area between phsophate port and clinker port
11	Old thermal power plant
12	Clinker port
13	Collective terminal
14	Aqaba container's terminal
15	Passengers' port
16	Marine Science Station
17	Area between MSS and Yamaniyyah beach
18	Yamaniyyah beach
19	National camp
20	Berenice
21	Visitors' centre
22	Sodasiate
23	Area betweenSodasiat and Tala Bay
24	Tala Bay
25	New military chalets
26	Royal Diving Centre
27	Military chalets
28	LPG port
29	LNG port
30	Central Power Station
31	Industrial complex
32	Fertilizers facilities
33	New phsophate port
34	New main port

Figure 6.20: Total responses for (a) coastal pollution, (b) coastal ecosystems degradation, (c) coastal pollution and ecosystems degradation, and (d) coastal impacts and resources as identified by the PGIS respondents. The darkest shade is the highest number of responses; next darkest shades are the next highest numbers of responses, and the light shade are others.

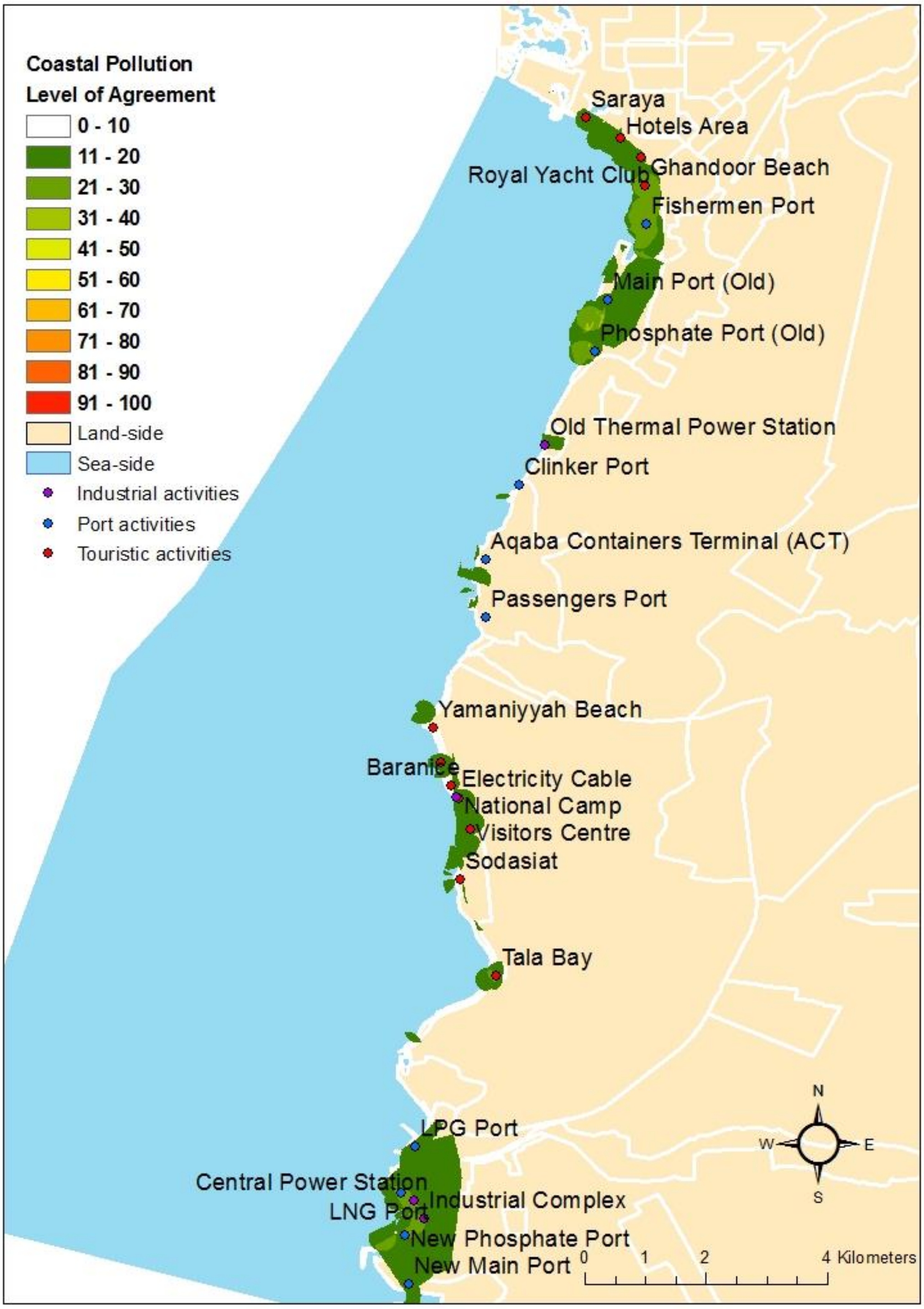


Figure 6.21: Priority areas surrounding specific coastal activities, attributed to the spatial distribution of coastal pollution as a result of overlaying the maps for the three types of pollution; water (Figure 6.1), air (Figure 6.5) and solid waste (Figure 6.7).

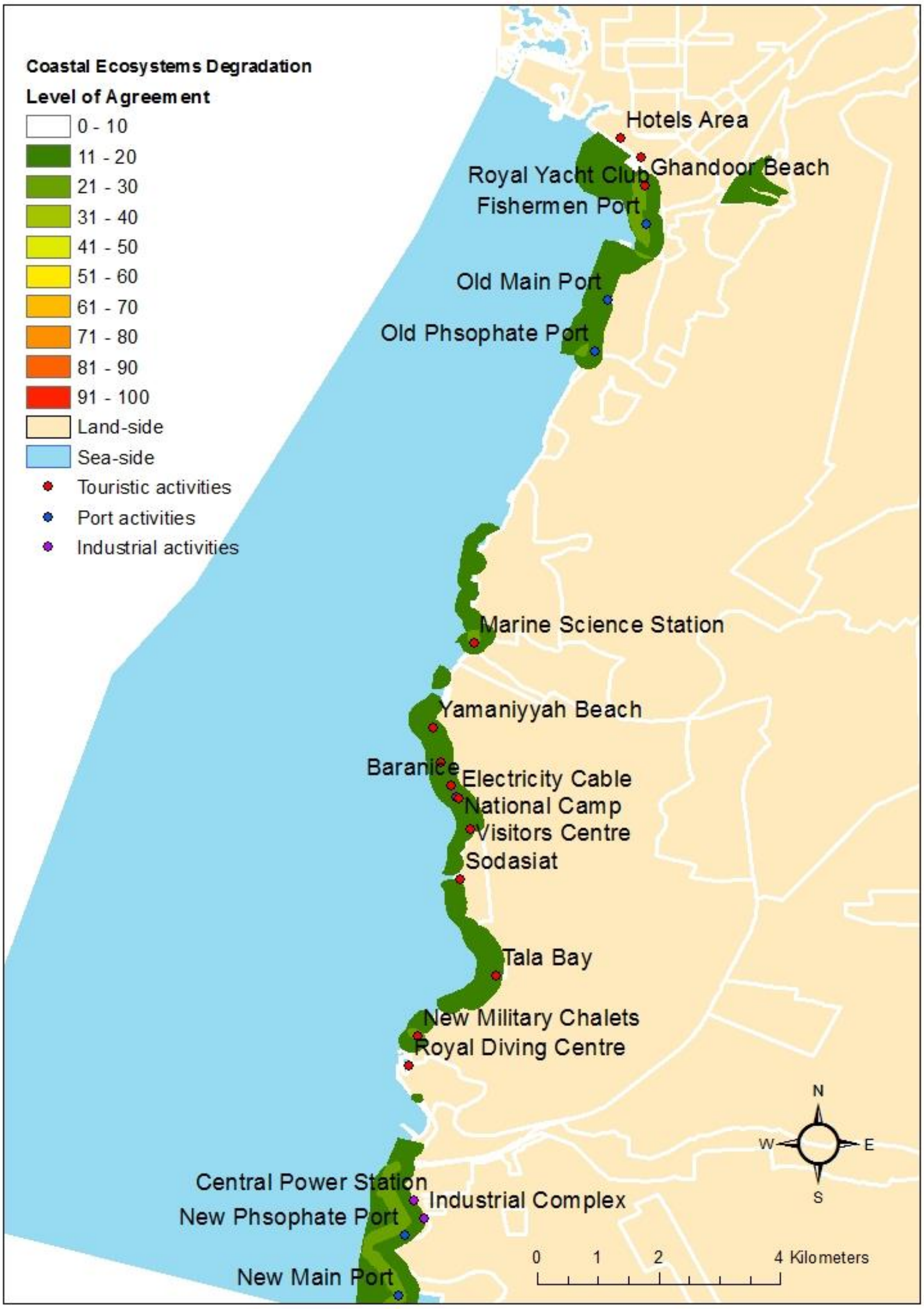


Figure 6.22: Priority areas surrounding specific coastal activities, attributed to the spatial distribution of coastal ecosystems degradation as a result of overlaying the maps for the four sources of degradation; touristic (Figure 6.11), ports (Figure 6.14), industrial (Figure 6.16), and diving (Figure 6.17).

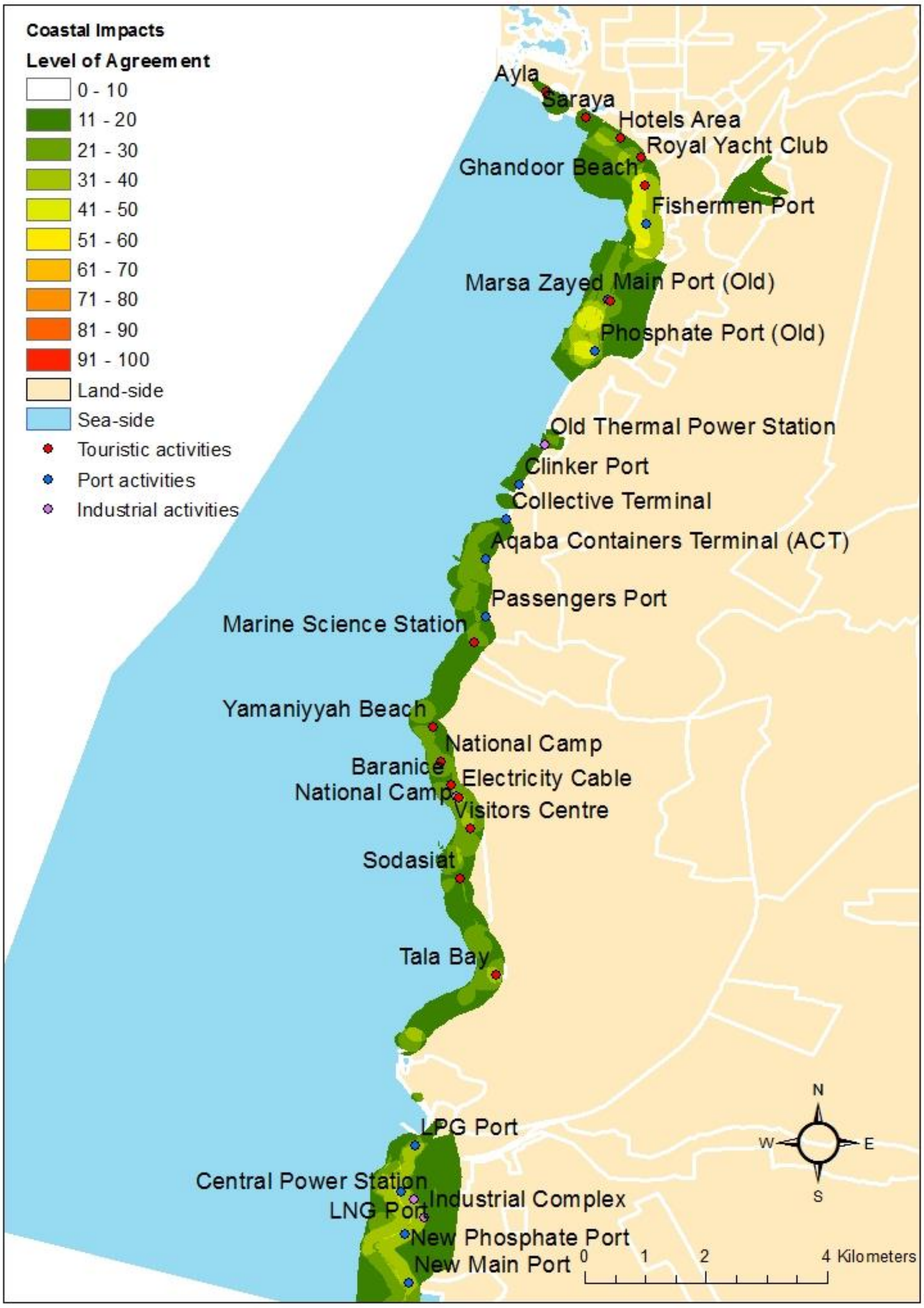


Figure 6.23: Priority areas surrounding specific coastal activities, attributed to the spatial distribution of total coastal impacts, as a result of overlaying the maps for the coastal pollution (Figure 6.21) and coastal ecosystems degradation (Figure 6.22).

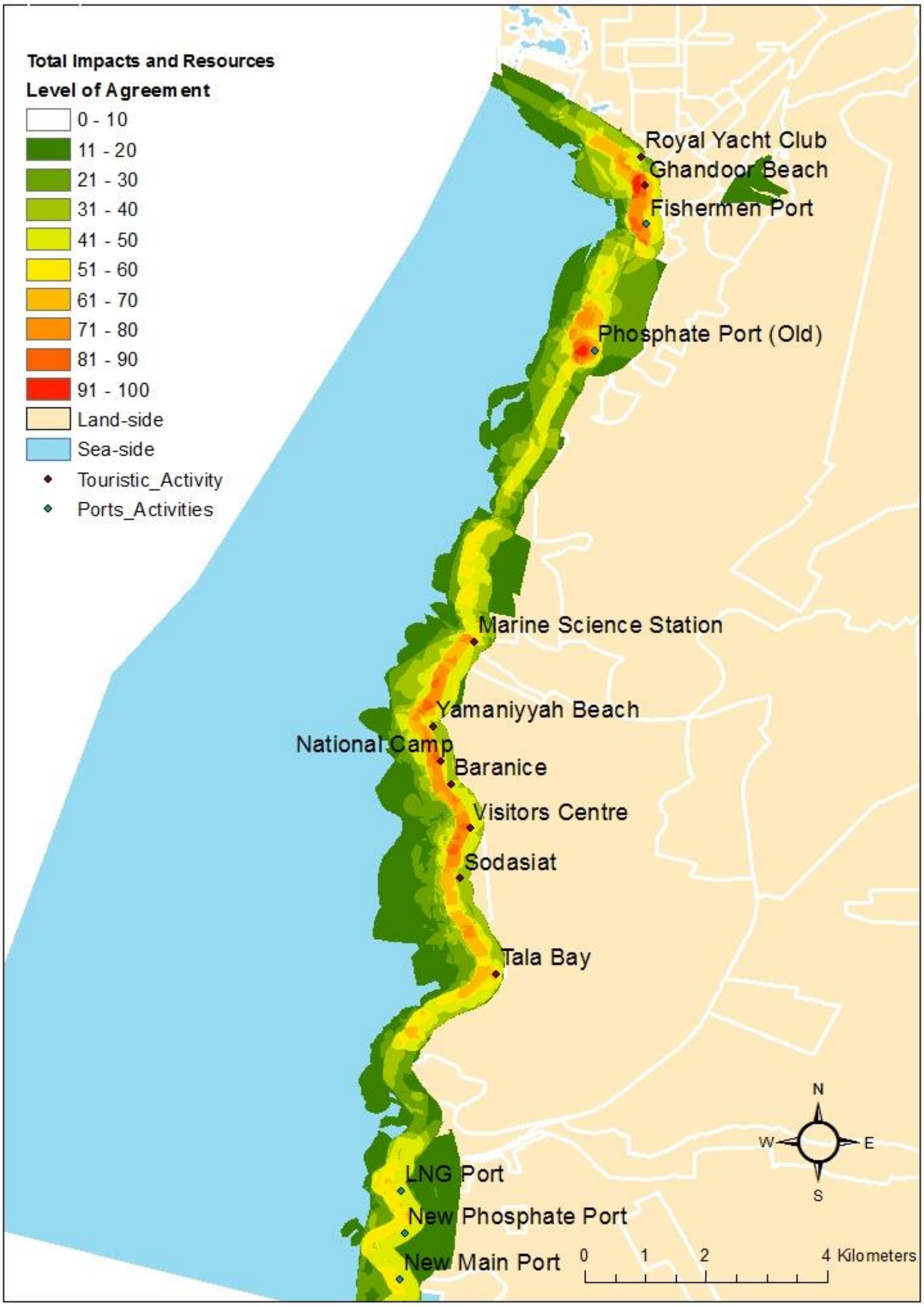


Figure 6.24: Priority areas surrounding specific coastal activities, attributed to the spatial distribution of total coastal impacts in abundant coastal resources areas, as a result of overlaying the priority areas in Figure 6.23 and the total coastal resources distribution (from Chapter Five – Figure 5.15).

Table 6.10: Priority areas based on different objectives, where specific coastal activities occur, using information about the highest number of responses along with the highest spatial consensus, obtained after overlaying the maps for the identified impacts in the PGIS interviews.

Objective for priority area	**Data used**	**Selected priority areas (where the coastal activity occur) based on the:**		
		Highest number of responses	**Highest spatial consensus**	**Highest number of responses and spatial consensus**
Total coastal pollution	The occurrence of water, air, and solid waste pollution	*First priority area:* Old phosphate port *Second priority area:* Ghandoor beach *Third priority areas*: Fishermen's port, old main port, and the central power station	*First priority area:* Old phosphate port *Second priority areas:* Ghandoor beach, the fishermen's port, the central power station, and the new phosphate port	*First priority area:* old phosphate port *Second priority areas:* Ghandoor beach
Total coastal ecosystems degradation	The occurrence of degradation from touristic, ports, industrial, and diving activities	*First priority area:* New military chalets *Second priority area:* New main port *Thrid priority areas*: Old main port and the LPG port.	*First priority area:* Ghandoor beach and the new military chalets *Second priority areas:* Fishermen's port, old phosphate port, central power station, the new phosphate and the new main port	*First priority area:* new military chalets *Second priority areas:* the new main port
Total coastal impacts	The occurrence of total coastal pollution and ecosystems degradation	*First priority area:* old phosphate port *Second priority area:* Ghandoor beach *Third priority area:* Old main port *Fourth priority area:* LPG port *Fifth priority area:* Fishermen's port	*First priority area:* Fishermen's port and the old phosphate port *Second priority area:* Ghandoor beach Third priority areas: New phosphate port *Fourth priority areas*: Central power station, industrial complex, and the new main port.	*First priority area:* old phosphate port *Second priority areas:* Ghandoor beach and the fishermen's port.
Total coastal impacts in resources abundant areas	The occurrence of coastal pollution and ecosystems degradation in resources abundant areas	*First priority area:* Old phosphate port *Second priority areas:* Area surrounding the visitors' centre *Third priority area*: Ghandoor beach	First priority area: Ghandoor beach and the old phosphate port Second priority areas: areas between Yamaniyyah beach and the visitors' centre, and the fishermen's port area.	*First priority area*: the old phosphate port *Second priority areas*: Ghandoor beach

6.7. Discussion

The concept of ICZM was introduced with the main objective of addressing the pressures along the coast worldwide and to reduce their adverse impacts on the coastal ecosystems (Papageorgiou, 2017; Breen and Hynes, 2014). In order to do so, pressures should be recognized in the first phase of the ICZM cycle (issue identification and assessment) which in turn, constituting part of the coastal profile (e.g. Christie *et al*., 2006; GESAMP, 1996; GEF/UNDP/IMO, 1996). However, this type of management is complex and multidisciplinary (González-Riancho *et al*., 2009). Capobianco (1999) argued that to help focus the efforts in identifying ICZM priorities, the following elements are needed: (a) defining problems at the proper level (regional, national, and local), (b) managing these problems at spatial levels, and (c) using mixed instruments (in terms of technology). In this thesis, the usage of the PGIS, which implies a mix of mapping process together with a participatory approach, allowed the spatial identification of coastal pressures and impacts as perceived by Aqaba ICZM stakeholders and coastal resource users, specifically at the local level. This Chapter developed a coastal profile for those pressures and impacts relying on stakeholders' experiences and knowledge.

There is a continuous acceleration of environmental, social, and economic pressures in coastal zones worldwide (Malone *et al*., 2014). This is also the case of Aqaba which faces multiple coastal pressures, associated with drastic changes that have happened in this city due to the political instability in the entire region (Badran and Foster, 1998); and the expansion of major development activities in the last decades, facilitated by policies that incentive capital investment, and intensified by a limited coastline (Abu-Hilal and Al-Najjar, 2004). Aqaba was declared as a special economic zone after the establishment of ASEZA in 2001, leading to a heavily port and industrial coastal area (Khalaf and Kochzius, 2002b).

The findings of this Chapter are thus consistent with the multiple driving forces facing coastal ecosystems all over the world, such as ports and industrial development, tourism resort development, sporting and recreational activities, urban and maritime transport, food production including agriculture, fishing, and aquaculture, energy consumption and power generation, mining-related activities, coastal deforestation, and wars (e.g. Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010; EC, 2009; Halpern *et al*., 2008; International Ocean Institute, 2006; Agardy *et al*., 2005). Examples of pressures on coastal zones from those driving forces include generation of waste (solid, liquid, and oil spills), gas emissions, and pressures on groundwater resources, and on the coastal and marine habitats (e.g., Lewison *et al*., 2016; Sekovski *et al*., 2012; Ness *et al*., 2010). Negative impacts well acknowledged worldwide include pollution by toxic and pathogens from land-based activities, health risk specifically from water pollution, eutrophication, marine litter, marine noise, coastal and marine habitat loss, diminishing fish stock and decreasing fishing revenues, coastal erosion, introduction of invasive non-indigenous species, overexploitation, climate change and sea level rise, impacts on the seafloor integrity, changes on the hydrographic conditions, and impacts the marine food web (e.g., Lewison *et al*., 2016; Sekovski *et al*., 2012; UNEP/MAP, 2012; Ness *et al*., 2010; EC, 2009; González-Riancho *et al*., 2009; Halpern *et al*., 2008; International Ocean Institute, 2006; Agardy *et al*., 2005).

This Chapter identifies the locations of multiple anthropogenic negative environmental impacts along Aqaba coastline: mainly water, air, and solid waste pollution, and degradation of coastal ecosystems. These impacts are associated with the pressures caused by intensive touristic, ports, industrial, and diving activities. These findings are consistent with existing research on environmental degradation in Aqaba, which highlight decreasing coastal habitats, diminishing fish stock, water contamination, and sewage discharge (e.g. Al-Saqarat *et al*., 2017; Khalaf *et al*., 2012; Al-Rousan *et al*., 2011; AL-Horani *et al*., 2006; Abu-Hilal and Al-Najjar, 2004; Khalaf and Kochzius, 2002b; Badran and Foster, 1998).

Note however that well acknowledged coastal impacts worldwide, such as degradation of historical heritage, coastal erosion (Areizaga *et al*., 2012; Storbjörk and Hedrén, 2011; González-Riancho *et al*., 2009) and increasing ocean temperatures and mean sea level associated with global climate change (Malone *et al*., 2014; Storbjörk and Hedrén, 2011) were not recognized in the context of this research. This could be either because respondents are more concerned about pressing issues that relate directly to their daily life, or because they were not aware of those impacts. Population growth was also not identified as a coastal pressure by stakeholders in this research, even though it is a major concern worldwide, with more than 50% of the world's population settling within 60 km of the coast (World bank, 1996). Agardy *et al.* (2005) stated that on average, the population density in coastal areas was 99.6 people/ km^2 in 2000. In the Mediterranean region, this density varies between more than 1000 people/ km^2 in the Nile Delta to less than 20 people/ km^2 in Libya (UNEP 2012). In Aqaba, population density is high with 500 people/ km^2, which is due to the limited area (375 km^2 in total) and the short coastline (27 km). The annual population growth rate is 5.6%, a high percentage compared to the average annual growth rate (3.7%) in Jordan (Department of statistics, 1994, 2016; Al-Bakri *et al*., 2013).

The coastal profile developed in this Chapter is coherent with a number of studies, which argued that Aqaba is witnessing an accelerating development including land and marine touristic activities, intensive port activities and heavy industry, and the commercial fishing. Those activities are posing accelerating pressures associated with the construction activities, sedimentation, wastewater disposal, spillage of oil and hazardous materials, and dumping of litter, which in turn pose direct and indirect impacts on the coastal ecosystems (Al-Rousan *et al*., 2011; Abu-Hilal and Al-Najjar, 2004; Khalaf and Kochzius, 2002a; Khalaf and Kochzius, 2002b; Badran and Foster, 1998).

According to nearly 70% of respondents, the predominant coastal pressures in Aqaba are the intensive land-based touristic activities, which cause coastal ecosystems degradation. This was also shown in Agardy *et al*. (2005) who stated that loss of habitats as a result of development activities is the main impact on coastal ecosystems. Waycott *et al*. (2009) argued that coral reefs and seagrass meadows have declined due to the pressure posed by development activities. Moreover, development expansion can alter the physical structure of the coastline (Tamburri *et al*., 2002), and impact on coastal resources through other indirect pressures associated with increasing transport intensity and the high consumption of energy and water (Sekovski *et al*., 2012). Al-Rousan *et al.* (2011) and Abu-Hilal and Al-Najjar (2004) expected that proposed and ongoing mega-touristic projects will have further direct and indirect impacts on Aqaba coastal ecosystems. Similar concerns were shown in the results of this research in relation to three proposed projects, namely Ayla and Saraya located in the touristic zone and Marsa Zayed in the port zone, two ongoing touristic resorts located in AMP; Berenice and Tala Bay, as well as the new military chalets (which were under construction during the time of the interviews).

Water pollution impacts were related to the pressure from touristic, ports, and industrial activities. Almost all the researchers had concerns about this type of pollution, while it was less of concern for locals. Even though ASEZA is responsible for monitoring seawater quality, results from ASEZA water analysis are not publically available, and was not possible to obtain them in the context of this research. This confirms one of the highlighted ICZM challenges mentioned in Chapter Two. Existing literature on water pollution along Aqaba coastline focuses especially on pollution by phosphate (Al-Saqarat *et al*., 2017; Al-Rousan *et al*., 2016; Al-Sawalmih, 2016). For example, Al-Rousan *et al*. (2016) reported a high sedimentation rate along the old phosphate port as a result of the high phosphate concentration in the water; and a high Total Organic Matter (TOM) due to port activities and discharge of wastewater. Nearly 40% of the respondents show concern for the impacts of the old phosphate port, even though the spatial consensus on the location of these impacts was fairly low (31%). This unexpected spatial consensus is due to the fact that although respondents identified the “old phosphate port” as the source of water pollution, they mapped the water pollution from this port in two different locations. Phosphate dust is highly soluble, which enable its settlement in the water and dramatically increases the phosphate concentration in the water (Al-Sawalmih, 2016). According to Al-Saqarat *et al*. (2017), the highest concentration of phosphate can be found along the old phosphate port, where phosphate dust forms a layer on the sea water surface. Water pollution by phosphate could be also intensified when the winds carry the dust to the surrounding area. The main consequences of phosphate pollution include increasing the levels of eutrophication, impacting coral reefs through decreasing the calcification process (low calcium concentration in the skeletons of the corals), decreasing the light intensity, and increasing the sedimentation levels, which in turn, affects the productivity and the coral growth, and in some cases may lead to corals death (Al-Rousan *et al*., 2016; Al-Sawalmih, 2016). Consequently, damaging corals means impacting other coral-associated species that are abundant in such areas looking for food and shelter (Al-Sawalmih, 2016). Increasing the sediment concentration from phosphate pollution can also enhance the accumulation of heavy metals in the bottom sediments, which may be remobilized and re-suspended, and so, heavy metals can return to the water column (Al-Rousan *et al*., 2016). Interestingly, Al-Saqarat *et al*., (2017) stated that dissolved reactive phosphate concentration has been reduced due to wiser management actions, coupled with the usage of chalk feeders and better training for the operators. PGIS respondents also mentioned that phosphate pollution has been declining, because the old phosphate port works at minimum levels since the decision of relocating it to the industrial port and the enhancement of the handling process for the raw phosphate.

Air pollution causes a major impact according to PGIS respondents. Even though, ASEZA carries out a compulsory air quality monitoring to ensure that the air quality is within the Jordanian Ambient Air Quality Standards (see Chapter Two), respondents expressed their concerns about air pollution, specifically along the port and the industrial zones. Aqaba is a significant commercial shipping centre and the main exporter for phosphate, cement, potash, and petrochemicals (Al-Khlaifat and Al-Khashman, 2007). Various anthropogenic activities along the coastal zones intensify the emissions of many pollutants such as CO, NOx, SO_2, O_3, H_2SO_4, HCOH, particulate matter, volatile and non-volatile organic (Chan and Yao, 2008; Al-Khlaifat and Al-Khashman, 2007). This is consistent with the emissions identified in the coastal profile developed here, which are associated to phosphate handling, chemical and fertilizers industry, and ships' diesel engines. Specifically, the old phosphate port was identified by 44% of the respondents as a key pressure causing air pollution (with similar spatial consensus as water pollution), together with other activities such as the thermal power station and the fertilizer industries, in the industrial zone. Al-Khlaifat and Al-Khashman (2007) evaluated the atmospheric heavy metal along different locations in Aqaba and concluded that the industrial zone had the highest concentration of iron (Fe), lead (Pb), and zinc (Zn). In addition, the industrial zone hosts some ports including the new phosphate port, the LNG, and the LPG. Thus, even though, energy consumption and power generation are main drivers of pressure on the air quality along coastal cities (Sekovski *et al*., 2012), the only power generation activity in Aqaba is the thermal power station, in addition to importing LPG and LNG. When the Kingdome used to import the gas from Egypt (imports stopped due to the unstable political conditions after the Arab spring events in 2011), the central power station worked on the Egyptian gas and produced a large amount of sulphur that decreased air quality dramatically as stated by respondents. The current dependence on the LNG and LPG as the main energy sources has enhanced air quality. Finally, note that however, in few occasions, there is a southern wind (also called Khamaseen wind) in Aqaba (Al-Saqarat *et al*., 2017; Abu-Hilal and Al-Najjar, 2004), occurring mainly in early and late summer as a result of sandstorms in the southern Jordan and the nearby region (Al-Saqarat *et al*., 2017), it can carry significant amounts of sediments (Al-Saqarat *et al*., 2017; Al-Rousan *et al*., 2016) as well as heavy metals such as Cd and Zn sourced from the phosphorite deposits in North African Sahara and eastern Mediterranean (Abed *et al*., 2009).

Solid waste pollution is another impact acknowledged in the coastal profile. The source of such waste is either land-based activities mainly, illegal dumping from visitors and locals (e.g. glass, plastic bags and containers, bottles, cans) or marine-based activities such as fishing and shipping (e.g. wood pieces, ropes, fishing nets, oil cans); it can also be from local sources inside Aqaba or regional sources from the neighbouring countries *(*Abu-Hilal and Al-Najjar, 2009). Distribution of the solid waste can be attributed to a variety of factors like the proximity of the pollution source to the shore and the beach type, usage, slope, and orientation, as well as wind direction, surface waves and currents (Abu-Hilal and Al-Najjar, 2004). Thus, some respondents stated that surface waves and currents induce transferring floating materials from the neighbouring countries to the northern coastline. The pressure caused by accumulation of solid waste include impacts on the aesthetic values for beaches, on marine animals and birds (e.g. strangulation and entanglement), on the coral reefs directly and indirectly (e.g. damaging coral substrate by fishing gear), on the health and safety of locals and tourists (e.g. human injuries), and on the local economy in general (e.g. damaging foul nets, blocking water pipes, and the coast for clean-up campaigns) (Abu-Hilal and Al-Najjar, 2009; Abu-Hilal and Al-Najjar, 2004). ASEZA through the Commission of Environment is the responsible entity for protection of Aqaba marine environment by implementing and enforcing a set of regulations that prohibit dumping of solid waste either on the land-side or the sea-side. Examples of those legislations include ASEZA law No. 32 (2000), Agriculture Law No. 20 (1973), Shipping Law No. 5 (1961), and the Aqaba Port Law No. 32 (1972). However, illegal dumping occurs, and the most polluted sites with solid waste are the Ghandoor public beach, the fishermen's port, and the public beaches within AMP. These findings are comparable with Abu-Hilal and Al-Najjar (2009) who found that Yamaniyyah public beach in AMP faces a high solid waste accumulation with values of 5.9 item/m^2 and 0.06 kg/m^2 respectively, and Ghandoor public beach and the fishermen's port are polluted with values of 4.9 item/m^2 and 1.06 kg/m^2, respectively. These authors also concluded that along Ghandoor beach, it is possible to find heavy waste such as rubber tires, most probably coming from the nearby old main port or the city centre. While in the public beaches, specifically, in the areas with abundant corals along Yamaniyyah beach, (identified as a restricted fishing area in Chapter Four), fishing gears constitute 31% of their count of total solid waste along AMP. Examples of fishing gear waste include gillnets, hand-lines, hand-reels, wire mesh traps, and plastic-made fishing items that have a great impact on corals, especially the wire mesh traps (Abu-Hilal and Al-Najjar, 2004).

The results also showed that forty percent of respondents had concerns about the pressure from ports expansion and relocation, with a special attention to the relocation process for the main port to the Dirrah Bay in the industrial zone. Al-Horani *et al*. (2006) also asserted on the necessity of using high-quality control measures to preserve the coral cover along the industrial zone. Kotb *et al*. (2015) describes this area, specifically along the Dirrah Bay, as one of the most important diving sites in Aqaba that includes unique corals with high biodiversity. This is also consistent to the LK acquired from the local divers in this study. Al-Horani *et al.* (2006) reported that the coral cover was 20% at reef flat, around 25% at 8m, and more than 30% at 15 m, while the soft coral coverage is 40% at 8 m depth. Kotb *et al*.

(2015) showed that the relocation process to the Dirrah Bay (near the borders with Saudi Arabia) resulted in the destruction of around 40,000 m^2 of high-quality corals. Similarly, the coastal of profile of impacts shows that the status of corals had already changed as a result of relocating the main port to this area.

Particularly, in the case of mapping the pressure from intensive diving activities, the spatial agreement reached 100% was actually mapped by three local divers only. Possible explanations for this could be that: 1) there is a low pressure from diving, 2) respondents had more pressing issues to focus on compared with the pressure from diving, 3) divers have more knowledge about the current status of corals along the dive sites compared to other respondents due to lack of knowledge. It is interesting to highlight that the produced map for the pressure from diving activities looks almost identical to the diving locations mapped in Chapter Four (with the exception of the diving sites located in the port zone). Thus, when expressing their concerns about the pressures, divers focused on AMP because they perceive that those marked sites face significant pressure from 1) the divers, specifically nearby the visitors' centre, 2) the visitors, who dump their solid waste along the beaches (which are nearby the marked dives sites), and 3) the construction activities for the new chalets in the special zone.

6.8. Conclusion

This Chapter presented the coastal profile of the impacts from the expansion of coastal activities in Aqaba using the PGIS; and based on the LK from the officials who give the approvals for investments, researchers who are involved in conducting the monitoring for the coastal resources and locals who spend their day in the sea. This the first study that investigates pressures and impacts along the entire coastline, even including the special zone. Moreover, this Chapter complements the existing limited information about coastal pressures and impacts in Aqaba, which focuses mainly on water and solid waste pollution along specific sites, and it is not georeferenced (e.g. Al-Saqarat *et al*., 2017; Al-Rousan *et al*., 2016; Al-Sawalmih, 2016; Abu-Hilal and Al-Najjar, 2009). In fact, the predominant coastal impact is the ecosystem degradation for the expansion of land-based touristic activity. Priority areas depend on management ICZM objectives to mitigate the different impacts, but highlight that old phosphate port and Ghandoor beach are recommended priority areas of ICZM planning to address both pollution and coastal ecosystem degradation.

7. Chapter Seven: Coastal-Use Conflicts along Aqaba Coastline

7.1. Introduction

Management under an ICZM implementation is a complex dynamic process that includes a wide range of different actors, overlapping objectives (Bracken and Oughton, 2013) and conflicting laws (Duavin *et al*., 2004). As the previous Chapters have shown, various coastal activities operate along the short coastline of Aqaba; therefore, conflicts among groups who either use or manage the coastal zone (ICZM actors) are expected (Tuda *et al*., 2014). However, recognizing the main ICZM stakeholders and their scope of work, along with any potential conflicts among them in the early stages of the ICZM cycle can help in resolving issues between them and preserving the rights of the marginalized groups (Ramirez-Gomez *et al*., 2017; Young and Gilmore, 2017; Brown and Kytta, 2014).

Coastal conflicts can be either user – environment or user-user conflicts (Moore *et al*., 2017; Tuda *et al*., 2014). User – environment conflicts were considered in Chapter Six. Chapter Seven focuses on potential user-user conflicts and spatially identifying them among ICZM stakeholders and coastal resource users. User-user conflict can be classified into two themes: interpersonal and social value conflicts (Brown *et al*., 2017b; Karimi and Brown, 2017; Vaske *et al*., 2007). Interpersonal conflicts occur when the actual physical presence or behaviours of groups and individuals interfere with the goals and behaviours of other groups or individuals. Social value conflicts occur as a result of having different norms and values about an activity among individuals or groups, the physical presence of conflicting parties is not required (Miller, 2015; Vaske *et al*., 2007) and could be a philosophical disagreement about the activity. In both situations, the elements of the conflict could be 1) individuals or groups with incompatible interests, 2) geographical location, and 3) consequences (usually negative) (Brown *et al*., 2017b).

This Chapter focuses on the interpersonal user-user conflicts along the coast of Aqaba that occur as a result of the physical presence of different coastal user groups (e.g. fishermen and divers) who have different goals and/or behaviours, competing over the coastal resources in the same location (e.g. Brown *et al*., 2017b; Vaske *et al*., 2007). The output of this analysis will allow for an identification of the most conflicting activities and areas, which could be prioritized in the development of management plans during the first phase of the ICZM cycle (González-Riancho *et al*. 2009; UNSD, 1992).

In particular, this Chapter (i) identifies and classifies coastal-use conflicts, (ii) provides and contrasts spatial information on the location of these conflicts among stakeholders, (iii) and identifies intense conflict areas as priority areas for the future development of ICZM programs. PGIS was used as a methodological approach to discuss and map with stakeholders their daily work challenges when managing (e.g. officials) or using the coastal resources (e.g. fishermen).

7.2. Spatial Distribution for the Coastal-Use Conflicts Between Coastal Resource Users in Aqaba

Nearly all the stakeholders (95%) involved in the PGIS expressed their concerns on conflicts between coastal resource users. Thirty one respondents (representing 60% of officials, 100% of researchers, and 75% of locals) identified the location of existing conflicts along the Aqaba coastline, which were mainly located along Ghandoor public beach (71%), Berenice (68%), National campsite (61%), hotels' area (58%), RYC (56%), fishermen's port (55%), and MSS (52%) (Figure 7.1). Figure 7.2 illustrates that officials and researchers mapped the conflicts in similar clustered locations, while locals identify conflicting areas scatter along the whole coastline. Locals show high levels of consensus on existing conflicts along MSS and national campsite. In fact, all locals (100%), more than 80% of the officials, and nearly 60% of the researchers are aware that there are conflicts along Ghandoor public beach (Figure 7.2a, 7.2b, and 7.2c).

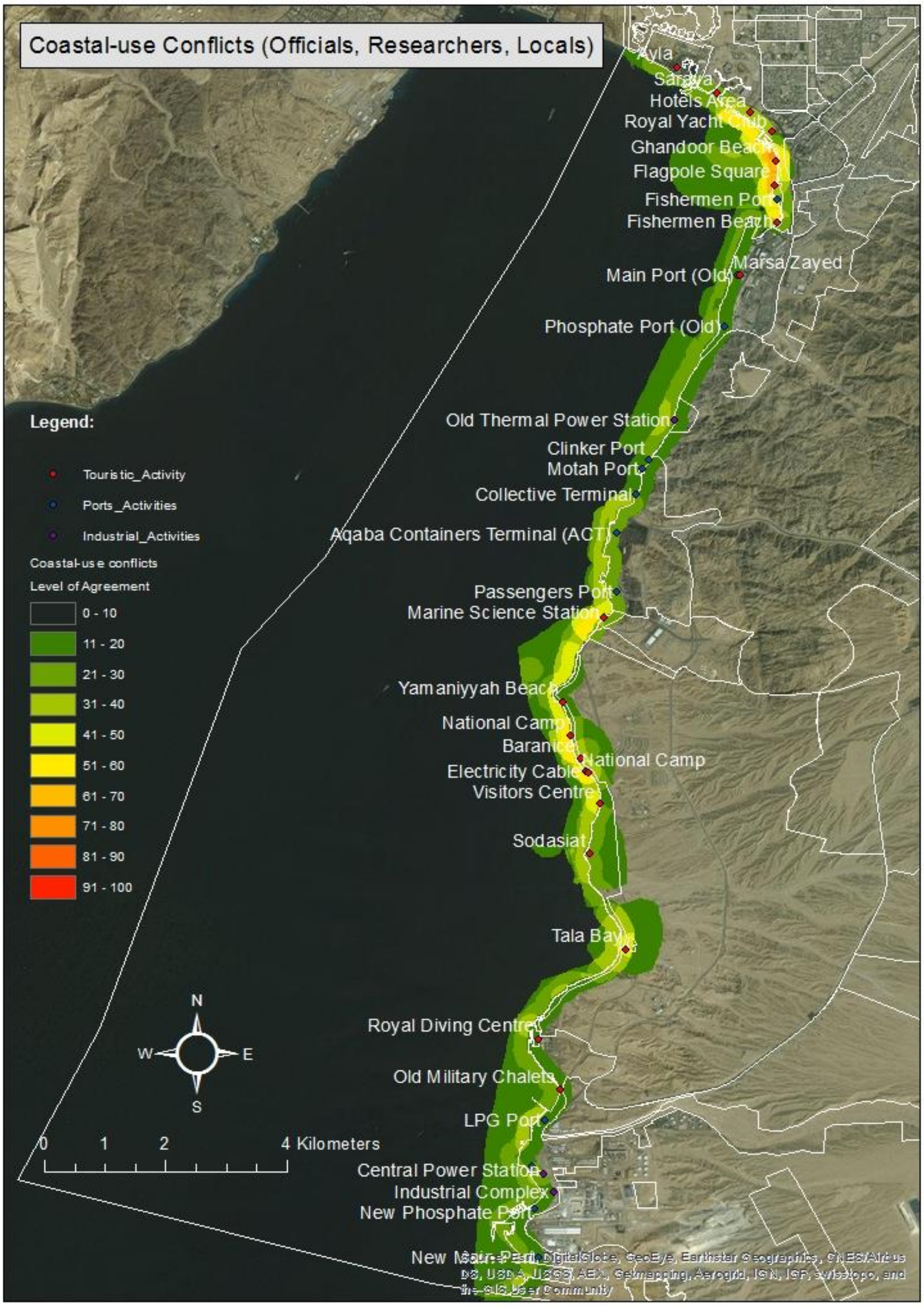
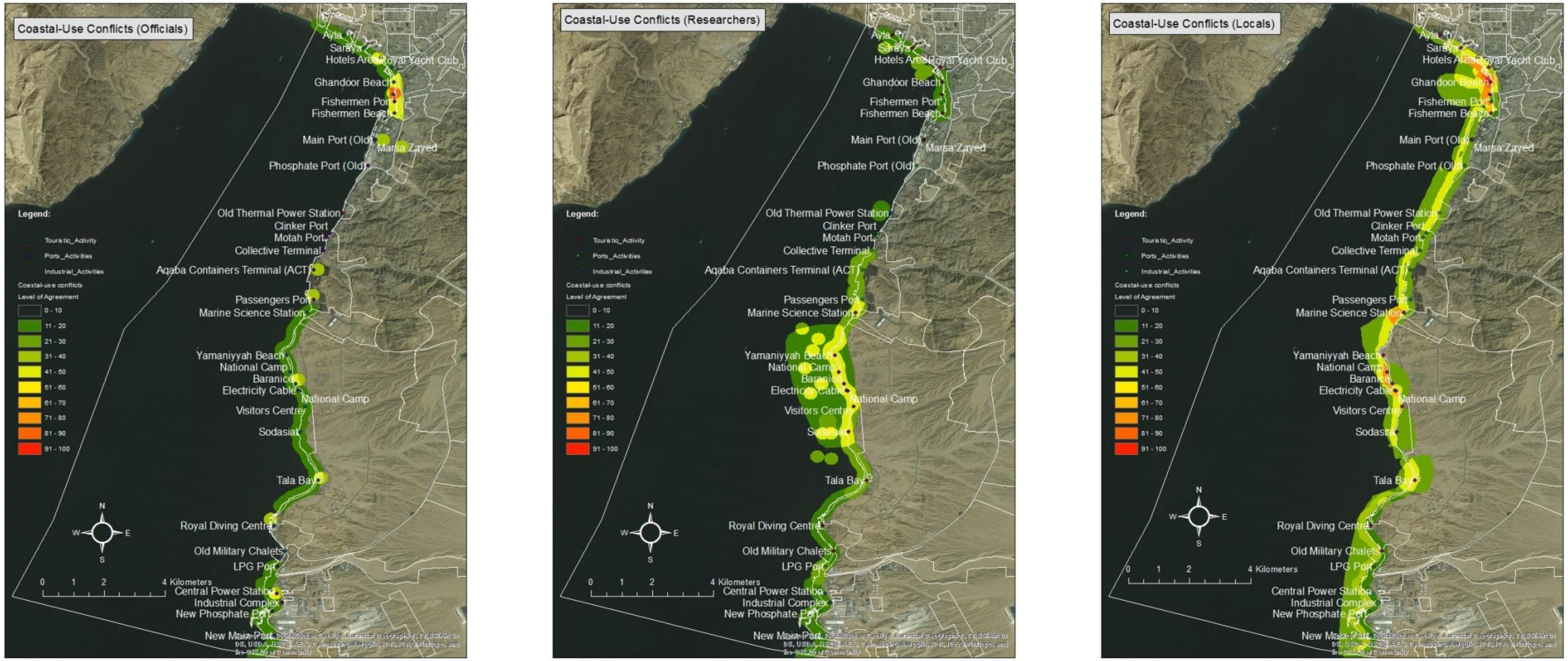


Figure 7.1: Coastal-use conflicts locations generated during PGIS meetings. Shading shows percentage of consensus among respondents mapping the area.



(a) (b) (c)

Figure 7.2: Spatial knowledge on the locations of coastal-use conflicts according to different stakeholders' views: a) officials, b) researchers, and c) locals. Shading shows percentage of consensus among respondents mapping the area.

7.3. Nature of Coastal-Use Conflicts Between Coastal Resource Users in Aqaba

Figure 7.3 shows the developed sub-themes based on the interpersonal conflicts definition provided by Vaske *et al*. (2007) and the main elements for the conflict provided by Brown *et al*. (2017b) as emerged following the thematic analysis procedure described by Braun and Clarke (2006). Codes emerged were sorted into three sub-themes to reflect 1) geographical area, 2) ICZM stakeholders and coastal resource users with incompatible interests, and 3) negative consequence, which reflect the nature of the conflict. Conflicts were categorized in following five broad types based on its nature (following the described thematic analysis earlier): Security issues: 3 conflicts; coastal space: 5 conflicts; access to beach: 6 conflicts; Scope of work: 7 conflicts; and safety issues: 3 conflicts.

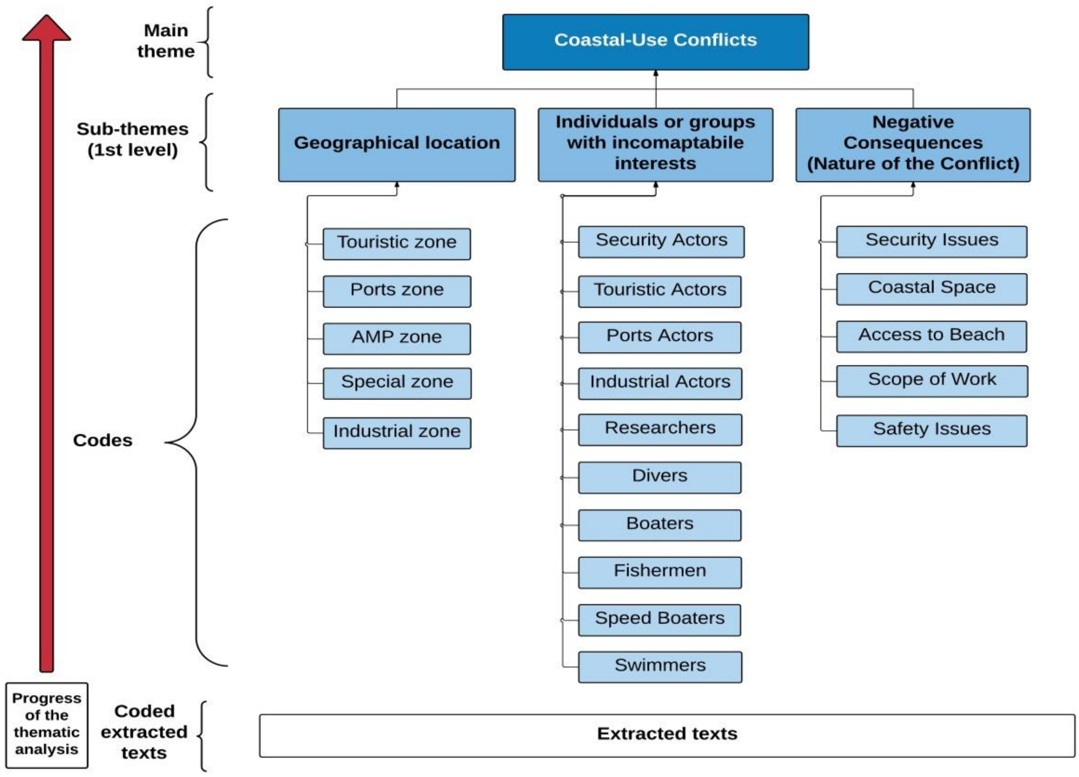


Figure 7.3: Emerged main theme "coastal-use conflicts" and its related sub-themes and codes, derived from the conducted thematic analysis from PGIS transcripts and maps.

The identified conflicts relate to different policy, security, economic, and social interests involving ten coastal actors: security agencies, economic sector representatives (land-based touristic, ports, and industrial activities), locals (divers, fishermen, boaters, speed boaters, and swimmers), and researchers. Figure 7.4 shows that stakeholders identified 20 conflicting relationships among actors (represented by the connecting lines), resulting in 24 distinctive conflicts (represented by the numbers on the connecting lines). This is because more than one type of conflict can occur between the two groups of actors. Thus, three types of conflicts occur between boaters and touristic actors, two between boaters and fishermen, two between fishermen and touristic actors, and two between touristic and port actors. Conflicts exist within the same group for the case of touristic actors. Figure 7.4 also shows that boating is the most conflicting activity, having 10 conflicts with 7 other groups of actors; followed by land-based touristic and fishing activities with 9 and 8 conflicts, respectively.

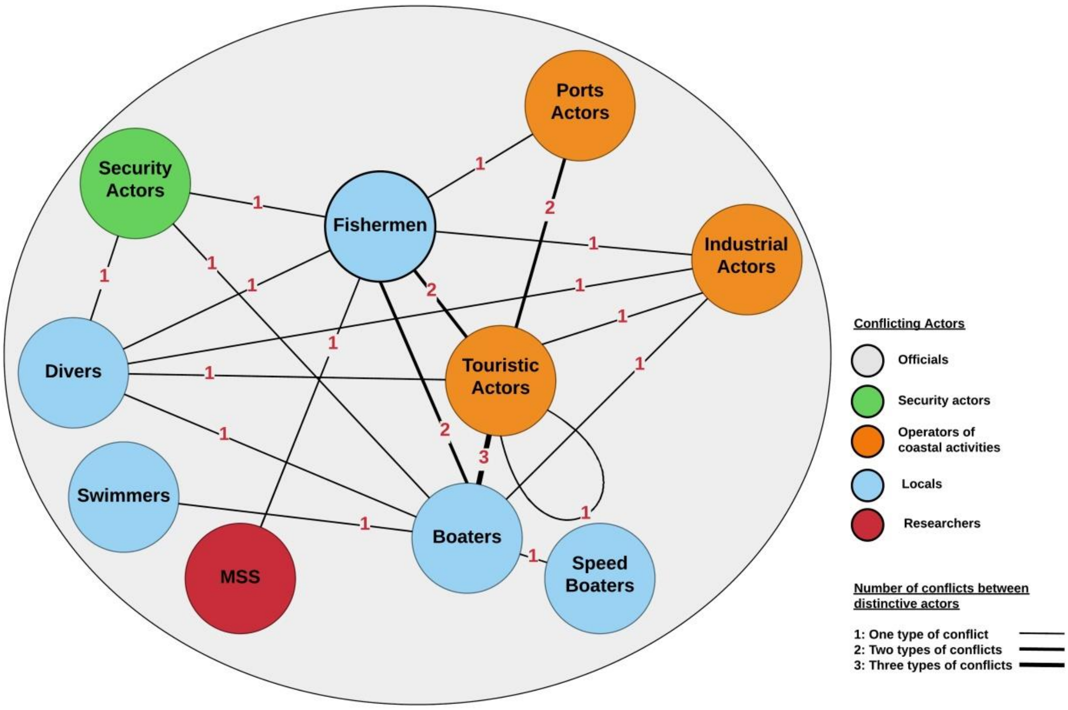
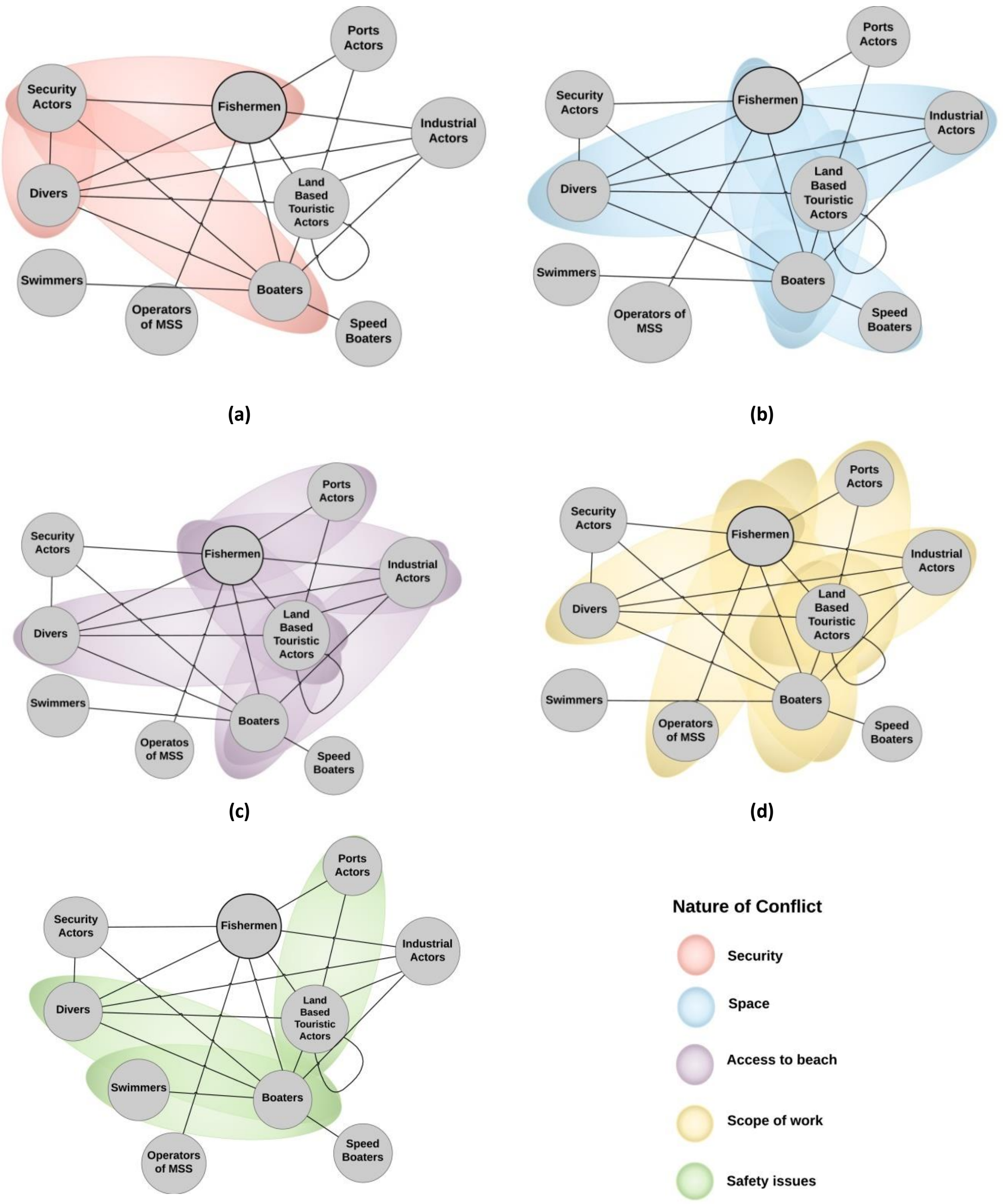


Figure 7.4: Conflicts as identified by stakeholders groups. Connecting lines reflect relationships between actors, and numbers reflect the number of conflicts between the distinctive actors.

Figure 7.5 illustrates how groups of actors' relationship vary with the nature of the conflict and with issues over space, access to the beach and scope of work, involving a higher number of actors. Using this classification of conflicts and the actors involved, Table 7.1 provides an overview of respondents that mentioned them. Researchers and locals raised mainly concerns about conflicts between touristic actors and fishermen on issues related to space and access to the beach. Researchers also highlighted the conflicts occurring within touristic actors. Officials showed a lower level of awareness about conflicts. Detailed information about the nature of the identified conflicts is described in the following sections.



(e)

Figure 7.5: Nature of the identified coastal-use conflicts as perceived by the PGIS respondents, shades reflect the conflicting actors, while the colour reflect the nature of the conflict: (a) security conflicts, (b) space conflicts, (c) access to beach conflicts, (d) scope of work conflicts, and (e) safety conflicts.

Table 7.1: Level of awareness about the coastal-use conflicts based on the number of respondents (figures in table) and percentage of respondents (colours in table) who mentioned and mapped this impact.

Conflict		Number/ Percentages* of Respondents who Mentioned				Number/ Percentages* of Respondents who Mapped			
Nature of the conflict	Conflicting actors	Officials (10)	Researchers (7)	Locals (24)	All (41)	Officials (10)	Researchers (7)	Locals (24)	All (41)
Security issues	Fishermen and security agents	0	0	11	11	0	0	6	6
	Divers and security agents	0	0	5	5	0	0	1	1
	Boaters and security agents	0	0	7	7	0	0	7	7
Space	Fishermen and land-based touristic actors	1	5	17	23	1	5	6	12
	Fishermen and boaters	0	3	13	16	0	3	8	11
	Divers and industrial actors	0	1	2	3	0	1	0	1
	Boaters and land-based touristic actors	0	4	7	11	0	4	7	11
	Boaters and speed boaters	1	0	0	1	0	0	0	0
Access to beach	Fishermen and land-based touristic actors	1	5	17	23	1	5	6	12
	Fishermen and port actors	2	2	14	18	0	0	6	6
	Fishermen and industrial actors	0	1	9	10	0	0	0	0
	Divers and land-based touristic actors	1	4	3	8	0	4	0	4
	Boaters and land-based touristic actors	1	4	7	12	0	4	7	11
	Boaters and industrial actors	0	0	7	7	0	0	7	7
Scope of work	Fishermen and Marine Science Station	0	2	10	12	0	1	5	6
	Fishermen and divers	0	4	9	13	0	4	4	8
	Fishermen and boaters	0	3	13	16	0	3	8	11
	Boaters and land-based touristic actors	0	4	7	11	0	4	7	11
	Land-based touristic and ports actors	3	2	1	6	2	2	1	5
	Land-based touristic actors	4	6	2	12	2	5	2	9
	land-based touristic and industrial actors	2	2	0	4	0	2	0	2
Safety issues	Divers and boaters	1	3	2	6	1	3	0	4
	Boaters and swimmers	1	1	7	9	1	1	0	2
	Land-based touristic and port actors	3	2	1	6	2	2	1	5

Respondents mentioned/ mapped %
0 - 10% or NA
11 - 20%
21 - 30%
31 - 40%
41 - 50%
51 -60%
61 - 70%
71 - 80%
81 - 90%
91 - 100%

7.4. Description for the Coastal-Use Conflicts Between Coastal Resource Users based on its nature

7.4.1. Security Conflicts

Security conflicts occur mainly between agents of security entities and locals (fishermen, divers, and boaters).

7.4.1.1. Security issues conflicts between fishermen and agents of security entities

Conflicts between the fishermen and security agents occur as part of the process of getting a fishing license approved. This is perceived by fishermen as a very complicated process (PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38). The application needs to be submitted to and approved by four security agencies before the license is issued by AMP. The overall process may take more than one year, yet the issued fishing license is valid for a maximum of two years only. Fishermen are aware that the process to obtain a license for boating activities is much easier (by filling an application to two security agencies), even though boaters' licenses include the right to undertake fishing trips, and it is valid for 5 years. Responsible security agencies can differentiate between fishing and other boats based on their colour; red is for fishing and white for other boats (See Appendix 11), in this context a fisherman said: "*I changed the colour of my boat from red to white, so I can take people in fishing trips*" (PR34).

Conflicts between those two groups also occur while fishing in prohibited fishing sites. This conflict emerged because some sites are closed to fishing due to security reasons. For example, fishermen are not allowed to reach the special zone, even though they believe this area has high levels of fish stock (PR34, PR35, PR36, PR37, and PR38). Nine fishermen stated that there are prohibited fishing areas near Ayla project because of its location on the Jordanian borders with Palestine and the Royal Palace. Fishermen have also to keep a distance of 1.5 km from the territorial water for security reasons (PR26–PR29). Conflicts between fishermen and security agencies also occur at the ports, where fishermen illegally catch small fish species hiding under the berths. Security agents can destroy fishermen' fishing gear if they are caught and can arrest offending fishermen. However, (as mentioned in Chapter Four), fishermen are willing to take this risk because they perceived that this is the only way for them to continue their work (PR26, PR27, PR28, and PR29). In addition, the special zone used to accommodate the old fishermen's port years ago, but now it is closed to fishing for security reasons, and the zone is currently occupied by land-based touristic activities for military entities, in addition to other military activities.

In addition, the specific times of the day where fishing can be undertaken trigger the conflicts between fishermen and security agents. Fishing is not allowed after sunset, and no fishing trip can start before 6.00 a.m. for security reasons. Fishermen must register in the port's security office when they start and finish their trips, otherwise, they may get arrested. Five fishermen complained that they could get higher catches if they could start earlier, even if this means finishing before the sunset (PR34, PR35, PR36, PR37, and PR38).

7.4.1.2. Security issues conflicts between divers and agents of security entities

All the interviewed divers stated that they have a conflict with the security agencies because access to dive sites located along the special zone is not allowed due to security reasons (PR21, PR22, PR23, PR24, and PR25).

7.4.1.3. Security issues conflicts between boaters and agents of security entities

All boaters interviewed mapped a conflict related to their restricted access to Ayla and Royal Palace in the touristic zone, and the entire special zone because of security reasons (PR30, PR31, PR32, PR33, PR39, PR40, and PR41).

7.4.2. Space issues conflicts

This section discusses conflicts related to space issues, resulting from either expansion of land-based activities (e.g. touristic and industrial) that limit the work of locals (fishermen, divers, and boaters); or competition over space between different local groups working in the same areas (e.g. fishermen and boaters).

7.4.2.1. Space issues conflicts between fishermen and land-based touristic actors

Conflicts between the fishermen and touristic actors relate to (i) Closure of the fishermen's port. Fishermen mentioned that the fishermen's port will be closed once the construction of Marsa Zayed project starts (PR26, PR27, PR28, and PR29), (ii) Forcing the fishermen to leave their residential areas. Fishermen stated that the owner of Marsa Zayed touristic project (described in Chapter Four) bought large areas to the east of the port. One of those areas is called "Al-Shallaleh," where most of the fishermen used to live, but they were forced to leave it after this project (PR26, PR27, PR28, and PR29).

7.4.2.2. Space issues conflicts between fishermen and boaters

Boaters use the fishermen's port, and this has led to competition over space between these actors. Boaters land overnight in this port because it has a security office and is perceived to be a safer place compared with the glass boats landing sites along the public beaches within AMP (where robberies have occurred). Moreover, four fishermen and four boaters stated that the wind is very strong along AMP public beaches and the possibility of boats colliding is high (PR26, PR27, PR28, PR29, PR30, PR31, PR32, PR33). Fishermen stated that boaters' boats are bigger which may cause damage to fishing boats (PR34, PR35, PR36, PR37, and PR38). While four of the interviewed boaters stated that fuel and batteries were stolen from their boats at the fishermen's port (PR30, PR31, PR32, and PR33). Boaters complained that priority is given by the security office for fishermen to land close to the shore leaving the farther space for boaters to land in, which in turn, requires them to swim to reach their boats (PR30, PR31, PR32, and PR33) (See Appendix Nine).

7.4.2.3. Space issues conflicts between divers and industrial actors

Local divers (PR23, PR24, and PR25) perceive diving sites located in the industrial zone are being damaged due to the expansion of industrial activities, as an example, they mentioned the "Saudi Borders" dive site. (Chapter Four, Section 4.3.1).

7.4.2.4. Space issues conflicts between boaters and operators of land-based touristic activities

Boaters acknowledge that the expansion of Marsa Zayed mega touristic project may make the Ghandoor beach unavailable. This would represent a big challenge for their work because Ghandoor beach is a key location for their landing, and un/loading activities (PR39, PR40, and PR41).

7.4.2.5. Space issues conflicts between boaters and speed boaters

The manager of the AMP stated that there is a conflict between glass bottom boats and speed boats activities, specifically along Ghandoor beach because both groups of boaters land in the same sites and therefore compete over space (PR7).

7.4.3. Access to beach conflicts

Conflicts related to access to beach occur as a result of the expansion of land-based activities that limit the access of fishermen, divers, and boaters to the beach.

7.4.3.1. Access to beach conflicts between fishermen and land-based touristic actors

Fishermen are forced to keep distances from the shore along AMP where they used to fish before the expansion of land-based touristic activities. Four fishermen (PR26, PR27, PR28, PR29) stated that during winter, fishermen are not allowed to work within AMP borders, and required to keep a distance of 350 m from the shore or fish in areas with a minimum depth of 150 m (see Chapter Four, Section 4.6) (PR1, PR6, PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38). In summer (May to October) fishermen can fish in AMP areas but with a minimum depth of 15 m, provided that they use nets with opening size that allows small fish to escape. Moreover, fishermen used to collect small fish species which they need to catch larger fish species (as described in Chapter Four) specifically along two areas within AMP shore, currently occupied by Berenice and Tala Bay. However, when these activities started their operations, fishing was totally prohibited (PR1, PR6, PR26, PR27, PR28, and PR29). Fishermen stated that there are high levels of stock in the AMP for both small and large fish species because they used to fish in this area before the establishment of AMP, and so, they perceive the prohibition of fishing along the park coastline during winter and the conditional fishing during summer as unfair (PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38).

7.4.3.2. Access to beach conflicts between fishermen and port actors

Fishermen have to keep a 150 m distance from the berths of all the ports, the main port, the old phosphate port, passengers' port, and containers' port. Fishermen admitted that they might fish illegally in these areas, as they perceive that this is necessary in order to bring food to their families (PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38). A researcher (PR4) assured that fishermen could get arrested if they work near the ports but they still keep doing it.

7.4.3.3. Access to beach conflicts between fishermen and industrial actors

Fishing is prohibited in the industrial zone. Fishermen argued that they were willing to stop fishing in all the accessible areas along the coast if they were allowed to work in the industrial zone (PR34, PR35, PR36, PR37, and PR38).

7.4.3.4. Access to beach conflicts between divers and land-based touristic actors

Divers rarely dive in the deep sea because most of the diving centres do not have any diving boats, and shore diving (dive from the beach) is the only alternative (as described in Chapter Four). However, the expansion of land-based touristic activities is making many diving sites inaccessible from the beach (PR7, PR23, PR24, and PR25). Diving sites along the coast where most of the land-based touristic activities take place are only open to their residents (i.e., tourists), excluding other potential divers (local residents). This is the case for example of the "Garden eel" dive site, opposite to Tala Bay (PR23, PR25). In the case of Berenice, ASEZA agreed with the owners to keep the "black wreck" dive site located opposite to Berenice open for all divers (tourists and locals); however, local divers can only get access by following a bureaucratic procedure regulated by Berenice operators (PR23, PR25).

7.4.3.5. Access to beach conflicts between boaters and land-based touristic actors

Boaters are not allowed to land along the coast where land-based touristic activities take place. This is mainly the hotels' area within the touristic zone, and Berenice and Tala Bay within AMP zone. They mentioned that there are only two jetties for landing, the first is near the visitors' centre and the second is near Assodasiat; however, these jetties are not enough to accommodate the current number of boats (PR30, PR31, PR32, PR33, PR39, PR40, and PR41). On this issue, an official stated that hotels complain about glass boats landing opposite to their areas, with boaters loading and unloading clients without any prior arrangements with the hotels. This official (PR8) believes that ASEZA has tried to place buoy for boats' landing as an alternative solution for jetties, but his perception was that ASEZA has failed to properly organize boating activities.

7.4.3.6. Access to beach conflicts between boaters and industrial actors

All boaters interviewed mapped a conflict related to their restricted access to the industrial zone (PR30, PR31, PR32, PR33, PR39, PR40, and PR41).

7.4.4. Scope of work conflicts

Scope of work issues occur when ICZM actors with different type of job work in the same location.

7.4.4.1. Scope of work conflicts between fishermen and Marine Science Station (MSS)

A researcher from MSS stated that it is illegal to fish opposite the MSS since it is a Marine Protected Area (MPA) (PR4). Fishermen (PR26, PR27, PR28, PR29, PR34, PR35, PR36, PR37, and PR38) mentioned however that this regulation is harmful to them because they believe fish stock abundance is high in this area. A local respondent reported that verbal altercations often occur between MSS staff and fishermen (PR17).

7.4.4.2. Scope of work conflicts between fishermen and divers

Fishermen catch fish near the diving sites within the park, specifically in summer because during this period fishing is legally allowed (conditional fishing). They stated in the interviews that some divers destroy or remove their cages (PR26 – PR29), either to free the fish or because they are concerned that fishing traps may damage the corals (PR4). Fishermen mentioned:

> *"We make sure to place cages on the sand, not to protect the corals, but because we do not want to destroy our cages by placing them on the corals, and because it is dark near the corals, we will not be able to take out the caught fish, the cage is expensive 40 – 50 JD (approximately 40 – 50 pounds) and divers can easily destroy them" (PR26 – PR29, PR34 – PR38).*

7.4.4.3. Scope of work conflicts between fishermen and boaters

Boaters can take tourists on fishing trips without the need of a fishing license (PR26, PR27, PR28, and PR29, PR39, PR40, and PR41). However, fishermen are not allowed to do this (PR26, PR27, PR28, and PR29). Fishermen acknowledged that in the past, they illegally used boaters' boats to run fishing trips for tourists, but they stopped doing this due to an increase in the level of monitoring and enforcement (PR26, PR27, PR28, and PR29). One of the interviewed fishermen (PR34) complained: "*I took people in fishing trip in the deep sea and someone complained officially, why is it allowed for the boaters but not allowed for the fishermen?*". A local respondent (PR17) believed that fishing trips arranged by boaters reflect a clear conflict, and also mentioned that boaters do not have enough fishing experience. Moreover, four fishermen mentioned that boaters can land at many sites along the coastline while fishermen can only land in the fishing port. These benefit boaters because it gives them the opportunity to catch small fish species near the shore easily which they use to catch large fish species (as mentioned in Chapter Four) (PR26, PR27, PR28, and PR29).

7.4.4.4. Scope of work conflicts between boaters and land-based touristic actors

Large touristic boat companies have contracts with hotels, the Royal Yacht Club, and Tala Bay, leading to conflict with the work of the small glass bottom boats. Large boats can thus pick up customers directly from the hotels, while small boats cannot (See Appendix 11). This issue was raised by 7 local boaters (PR30 – PR33 and PR39 – PR41). In addition, ASEZA installed a new jetty for these large boats near the Ghandoor public beach in the touristic zone. Local boaters complain because those boats attract more tourists as they accommodate a high number of visitors, and therefore are cheaper (PR30 – PR33).

7.4.4.5. Scope of work conflicts between land-based touristic and ports actors

Respondents (PR13, PR14, and PR15) were also aware that the reserved area within the AMP (located between the ports and the industrial zones) may be negatively impacted by ship traffic (Chapter Six), and also reduce the aesthetic value of the park (See Appendix 1).

7.4.4.6. Scope of work conflicts between actors of land-based touristic activities

Respondents explained that land-based touristic activities within AMP zone are in conflict with the intended legal use of AMP. An official planner in ASEZA (PR8) stated that the most sensitive area along the coast is the ecotourism area within AMP, and therefore, ASEZA' should not approve any (touristic) project which may conflict with the environmental conservation aspects, and the compatibility of existing touristic projects with the environmental criteria should be re-assessed. In his opinion, ASEZA has not managed to balance ecotourism and environmental protection. He gave an example by saying:

> *"When Tala Bay was constructed, the Environmental Impact Assessment (EIA) included a condition of having public access to the beach within the Tala Bay area, and the whole investment was supposed to be "Low density",*

> *and its use to be compatible with the marine resources, but for example Tala Bay is inaccessible for public and offers the jet ski which is illegal"* (See Appendix 1).

Another official reported on the incompatibility of the tourism resorts as intensive touristic activities being operated in a reserved AMP zone (PR9). A researcher (PR5) added: "*any project within the park represents a conflict of interest because the park is a reserved area*". Respondents gave two examples for tourism projects operating in the marine reserved zone (AMP): Tala Bay (PR5), and Berenice (PR14, PR15, and PR18).

7.4.4.7. Scope of work conflicts between actors of land-based touristic activities and industrial activities

Tala Bay, a land-based touristic activity within AMP, is in conflict with the work of the nearby southern industrial activities because of the potential negative impact which may include the loss of aesthetic value of the AMP area, as well as health and safety risks posed by the water and air pollution associated with industrial activities (PR5, PR14, and PR15).

7.4.5. Safety issues conflicts

There are safety related conflicts between divers and boaters, boaters and swimmers, and between land-based touristic and port actors.

7.4.5.1. Safety conflicts between divers and boaters

This conflict occurs at specific abundant coral areas, such as the "Japanese garden" dive site (PR23) (Chapter Four, Figure 4.3). An official stated that divers are concerned about their own safety due to the presence of boats moving above them (PR7). Nevertheless, a diver acknowledges the legitimacy of both users (divers and boaters) by saying: "*Both of us are doing the same business, they show people the corals from the top while we show people the corals from the bottom*" (PR24).

7.4.5.2. Safety issues conflicts between boaters and swimmers

Safety of swimmers was discussed by 3 officials, 1 researcher, and 4 local boaters. Boaters highlighted the safety issues for swimmers in the Ghandoor public beach, where there are also boating activities (PR39 – PR41). Three boaters stated that swimming zones were not properly marked (e.g. no zoning or buoys), which put swimmers at risk by swimming outside the designated swimming zone. This issue was not identified at the public beach within AMP where swimming zones were more clearly identified.

7.4.5.3. Safety issues conflicts between land-based touristic and port actors

There are conflicts related to the safety of the touristic boats. This is because there are two types of marine-use activities in the touristic zone: the boating trips (such as boating operated by the hotels), and ships heading to the port which anchor there (Chapter Four, section 3). Three officials expected this issue to escalate after "Marsa Zayed" project starts its operations, as the intensive cruise ship activities coupled with the location of the project on the northern borders of the port zone will add to the crowding caused by ships anchorage and boating trips operated through hotels (PR8, PR14, and PR15). Therefore, the risk associated with the safety of the operators of those activities (as well as the tourists) may increase especially with the absence of a sea-use plan for Aqaba (Chapter Two, Section 2.5.2.)

7.5. Identifying Priority Areas Based on the Coastal-Use Conflicts

Intense conflict areas were identified consistently with previous Chapters, based on information related to the highest response rate for mentioning and mapping the conflicts; and the highest spatial consensus for conflict areas. The relevance of the conflicts involving fisheries activities is evident when prioritizing conflicting issues across group actors attending to stakeholder awareness (response rate) (Figure 7.6). These fisheries-related conflicts occur at the touristic, the AMP zones, the port and the industrial zones; and involved port actors, touristic actors, and boaters. Fishing, therefore, can be characterized as the widest spread conflicting activity in the coast of Aqaba.

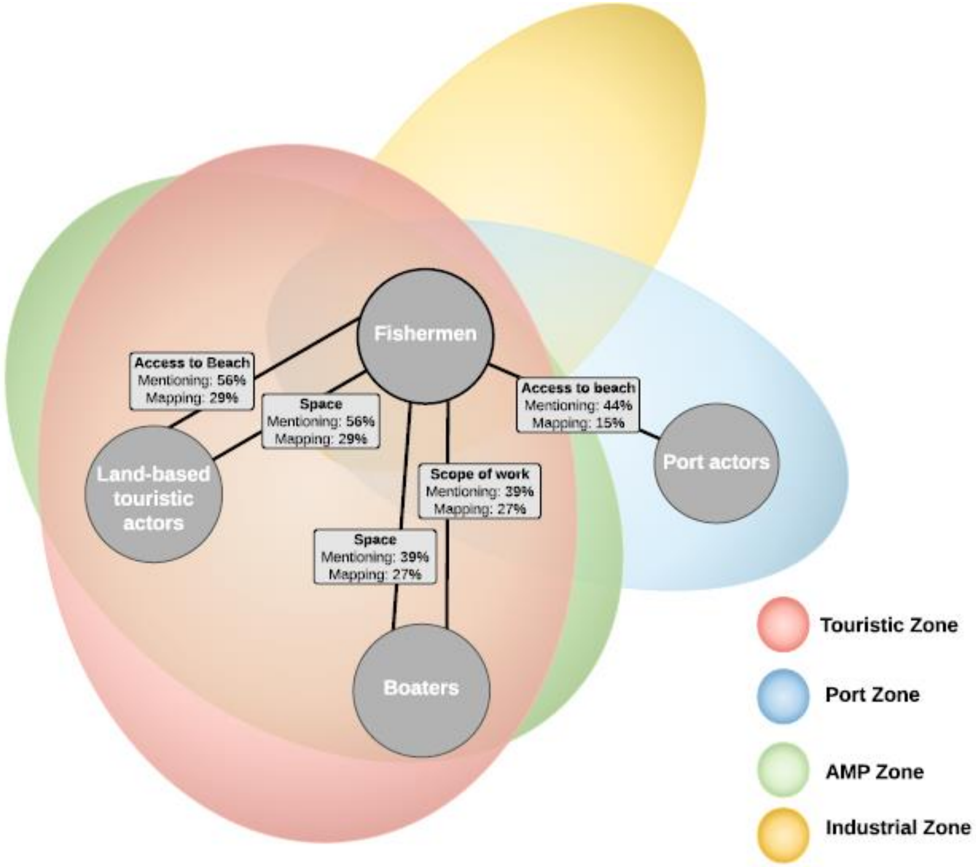


Figure 7.6: Priority conflicts between the ICZM actors based on the response rate for mapping and responding, and their scope of work zones, resulting from the PGIS interviews.

In order to prioritize conflicting areas attending to spatial consensus, Figure 7.7 simplifies the spatial distribution of conflicts captured in Figure 7.1, but with the level of consensus among stakeholders categorized as very high (81-100), high (61-80), medium (41-60), low (21-40) and very low (1-20). Results show that Ghandoor beach, within the touristic zone, is the area with the highest level of consensus on the occurrence of conflicts among its users. About half of the respondents agree on conflicts on the hotels' area, RYC, and fishermen's port (in the touristic zone), and the area between MSS and the visitors' centre, in addition to Tala Bay (in the AMP zone).

The results of combining the results of actors confronting highest conflicts, and the areas with the highest consensus where those conflicts occur suggest the following:

1- The first priority area is Ghandoor public beach where focus should be on conflict resolution between fishermen, boaters and the land-based touristic actors.
2- The second priority areas are hotels' area, RYC, and fishermen's port, involving the same conflicting users (fishermen, boaters, and land-based touristic actors).

3- The third priority areas are the public beaches along AMP, with a focus on the conflict between boating and land-based touristic actors.

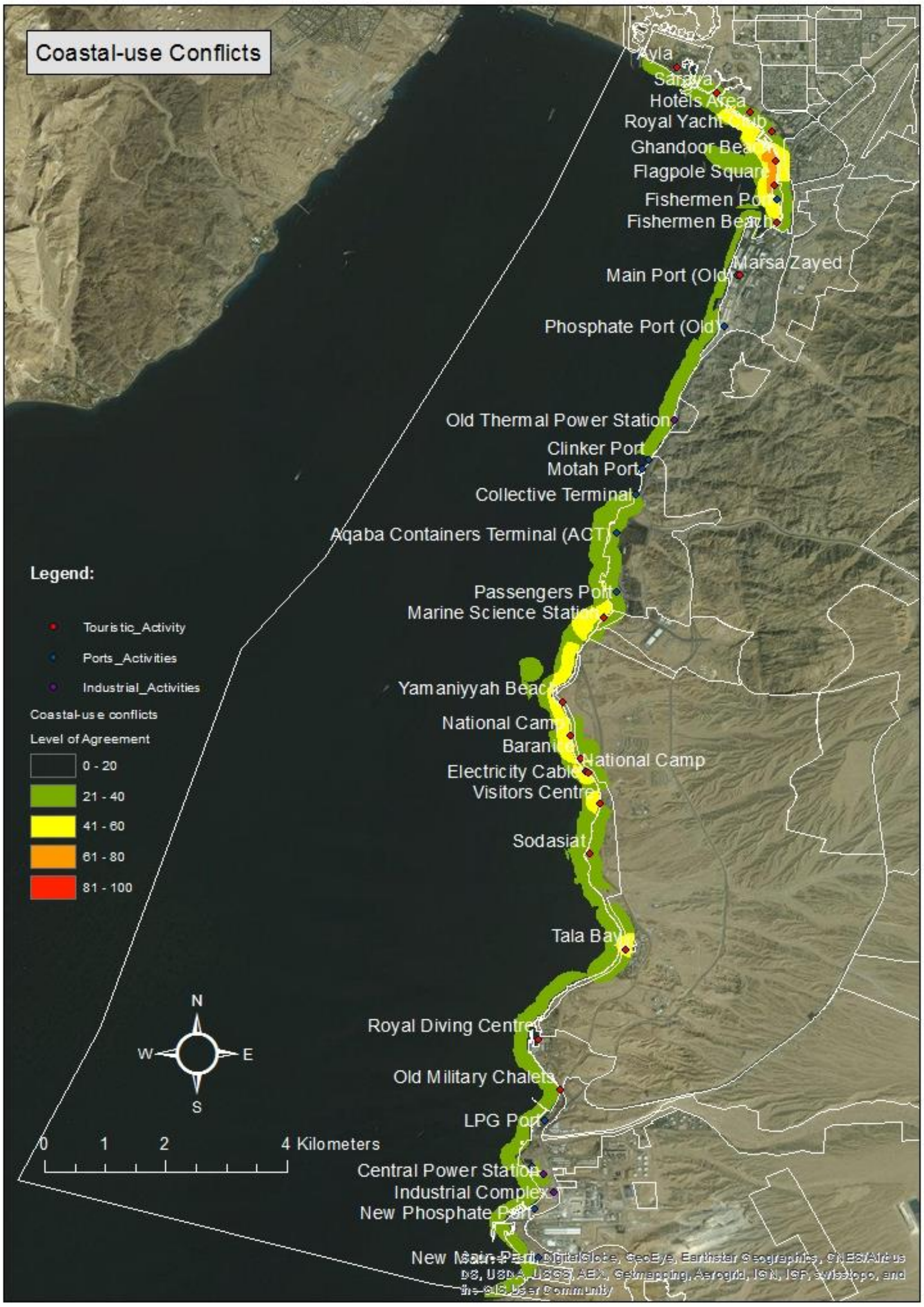


Figure 7.7: Priority areas attributed to the spatial distribution of coastal-use conflicts as a result of consensus among all stakeholders

7.6. Discussion

ICZM requires coordination with various actors and dealing with complex social processes (Duavin *et al*., 2004). If not done properly, conflicts in the implementation phase can hinder the entire ICZM program (Breen and Hynes, 2014; EC, 2007), compromising efficient coastal management (Tuda *et al*., 2014). The coastal zone is a typical system for multi-user conflicts. This zone attracts a variety of coastal activities, and when such activities overlap, there will be competing interests that result in conflicts among users (Brody *et al*., 2006). This situation may be intensified by the growing population of coastal cities (e.g. UNEP/MAP, 2012). As previously reported in this thesis, Aqaba accommodates various coastal activities (Chapter Four), competing over limited resources (Chapter Five), which results in various coastal-use conflicts. This Chapter showed that many conflicts are associated with the diversity of uses of the limited coastal space. Conflicts over access to beach seem to be exacerbated by the policy adopted by ASEZA for encouraging touristic investments which further limits local public access to the beach and diving sites. This suggests that in the case of Aqaba, ICZM failure may occur as a result of conflicting goals of different actors (Breen and Hynes 2014), rather than weak coordination among them. Conflicting goals are also evident in the coastal zone legislation with designated areas for conservation, touristic, ports, and industrial activities, limiting access to the natural resources available at those locations for local coastal users such as fishermen and divers. Findings of this Chapter provide evidence of a poorly managed social participation in regulatory decision-making, and a lack of participatory approach as key ICZM challenges, consistently with (Soriani *et al*., 2015; Tuda *et al*., 2014), and the findings of Chapter Two.

When the developed coastal zone legislations and policies are sectoral, many conflicts may emerge in the implementation phase (EC, 2007). This is certainly a risk at Aqaba, where conflicting goals seems to exist also among officials working on different entities or even within the same entity, as they compete on the responsibility to manage the coast (PR17, PR19). An official from the planning directorate (PR8) stated:

> "*When saying urban planning, it includes the political, economic, and tourism dimensions, which are reflected by the concept of ICZM and it should be the responsibility of the planning directorate. Coast management*

> *should not be limited only to environmental issues which are mainly guided by the EIA under the control of the environment directorate*".

The findings of this thematic analysis show that there are twenty-four distinctive user-user conflicts, mainly between different groups of actors. This contrasts with Tuda *et al*. (2014), which found more evidence of conflicts between same resource users (e.g. fishermen using different fishing gears). The results show evidence mainly of interpersonal conflicts (Brown *et al*., 2017b; Karimi and Brown, 2017; Vaske *et al*., 2007) with elements of the conflict associated to 1) groups with incompatible interests and 2) incompatible geographical location (Brown *et al*., 2017b). Thus, show that the identified conflicts in Aqaba are related to security issues, coastal space, access to the beach, the scope of work, and safety issues. Some of those conflicts basically stem from the physical presence (face to face encounter) (Miller, 2015). For example, the landing of fishermen and boaters' boats (physical presence of two groups) in the fishermen's port triggers the space conflict. Other identified conflicts stem from the behaviour of individuals and/or groups or indirect encounter through actions that can cause the conflict (Miller, 2015). This is the case, for example, when divers damage the fishermen's gears to free the caught fish triggering a scope of work conflict. Evidence was also found for conflicts which stem from both, physical presence and behaviours that cause the conflict. For example, boaters arranging for fishing trips causing the conflict due to physical presence with the fishermen and selling the fish in the market causing conflict due to competing behaviours without direct encounter.

The findings of this Chapter also show that 95% of respondents mentioned coastal-use conflicts and 73% of them mapped them during the interviews, i.e., the highest response rate compared to all the previously mentioned and mapped themes in the thesis. Possible explanations for these high rates are 1) the high level of awareness among respondents, 2) richness of local knowledge as it relates to their daily work, or 3) the seriousness of coastal-use conflicts along Aqaba coastline which make it obvious to the respondents. The findings also show that the most conflicting actors are fishermen with touristic actors on issues related to space and access to beach issues, followed by fishermen with ports actors on space issues, then, the fishermen with boaters on space and scope of work issues. Moreover, some of the identified conflicts are currently occurring /or occurred in the past, while others are expected to happen in the future. Fishermen, for example, provided an example for the first case when they were forced to leave their residential area due to the construction of some components of the mega touristic project (Marsa Zayed). Boaters were concerned about conflict potential in the future if Ghandoor beach is closed after starting the construction of other components of Marsa Zayed.

Tuda *et al*. (2014) classified conflicting actors into primary and secondary; primary is '*the competing user groups whose activities contributed directly to use conflicts'* (p. 61), and secondary is '*the government agencies responsible for regulating the coastal uses*' (p. 61). In this research, all the identified conflicting actors are primary (even the security entities) because they are competing over uses; while the officials (ASEZA employees) are secondary conflicting actors. ASEZA is the responsible authority for managing, regulating and developing ASEZ (Aqaba Special Economic Zone) under ASEZA law no (32) for the year 2000 (as discussed in Chapter Two). Officials are involved in all the identified conflicts between the coastal resource users because ASEZA is the responsible entity for:

1- Enhancing economic development within the zone, Article 3 in ASEZA law (2000) stipulates '*the aim of the establishment of the zone is to enhance economic capability in the Kingdome by attracting different economic activities and investments'* (p. 1);
2- Licensing coastal activities, with reference to Article 10-B2, ASEZA is responsible for '*Issuing permits and certificates and any other authorizations which pertain to conducting economic activities in the zone according to the provisions of this law and the regulations issued pursuant thereto'* (ASEZA, 2000, p. 4). This is done through the "Permitting and Building Directorate" in the "Infrastructure and Services Affairs Commission" (as described in Chapter Two). This is consistent with Tuda *et al*. (2014) who clarified that government agencies are the responsible entities for issuing licenses without proper consultations which in turn, leads to conflicts;
3- Determining the bases for zoning and building in the zone (ASEZA law, Article 10.3), through the "Planning and Studies Directorate" in the "Infrastructure and Services Affairs Commission". For example, a master plan was prepared in 2013 to identify the nature of uses along the coastline;
4- Protecting the coastal and marine environment (ASEZA law, Article 10.5) through the "Commission of Environmental Affairs"; and
5- Regulating and monitoring the activities of the registered enterprises, with reference to Article 15 – M1 from ASEZA law.

Finally, the Chapter shows that the most conflicting area is Ghandoor public beach based on the highest spatial consensus. This is followed by hotels' area, RYC, and the fishermen's port, then, the public beaches along AMP. From the seaward, all of those areas are open to the public; they are also open to the landward side, except the RYC and the hotels' area. Conflicts in fisheries occurs along four zones (touristic, ports, AMP, and industrial zones), and therefore can be considered as the widest spread conflicting activity along the Aqaba coastline; followed by the conflicts facing both, boating and land-based touristic activities which occur along the touristic zone and AMP zone. Consequently, the priority actors for coastal conflicts resolution are fishermen, boaters, and operators of land-based touristic activities.

7.7. Conclusion

This Chapter contributes to the scarce literature on evaluating conflicts as recognised by social groups using participatory mapping (Brown *et al*., 2017a) as a step toward ICZM planning diagnosis. To the author's knowledge, this is one of the few attempts to map coastal-use conflicts among coastal actors (Moore *et al*., 2017). Results showed that coastal-use conflicts between ten ICZM actors relate to security, competition for space, access to beach, scope of work, and safety. This work informs management on addressing conflicts resolution, which can enhance the social and economic status along Aqaba coast, and in turn impact positively the sustainable goals of the ICZM (Brody *et al*., 2006). Fishermen, boaters, and operators of the land-based touristic activities are priority stakeholder groups due to the high coastal-use conflicts in which they are involved both in the touristic zone and AMP zone. Moreover, Ghandoor public beach is a priority area to address the coastal-use conflicts and therefore a key location for any upcoming ICZM programs.

8. Chapter Eight: Conclusion

8.1. Introduction

Integrated coastal zone management (ICZM) is a multidisciplinary management approach designed to resolve environmental, social, and economic issues along the coast, it deals with both human and natural resources along both the land and the marine sides. ICZM has evolved as a response to the accelerating pressure on the coastal zones worldwide, especially related to the expansion of coastal activities such as tourism, ports, industries, and fisheries (e.g. Malone *et al*., 2014; EC, 2002).

ICZM has been described as a long-term management process, implemented in cycles (ICZM cycle); each cycle consists of five phases (Farhan and Lim, 2010; Pickaver *et al.*, 2004; GESAMP, 1996). The success of an ICZM process is highly dependent on its first stage "Issue Identification and Assessment" through collecting, processing, analysing, and prioritizing required information for both, terrestrial and marine environment within the coastal zone to form what can be called a coastal profile (Areizaga *et al*., 2012; Koutrakis *et al*., 2011; González-Riancho *et al*., 2009; Christie *et al*., 2006; ATKINS, 2004; Tortell., 2004; Olsen *et al*., 1999; GEF/UNDP/IMO, 1996; World Bank, 1996; GESAMP, 1996; Robadue, 1995; UNSD, 1992). This coastal profile also implies assessing all the coastal pressures, short and long-term impacts on the coastal resources in order to identify priority areas which require special management attention (González-Riancho *et al*., 2009; UNEP/MAP/PAP, 2008; Christie *et al*., 2006; Tortell, 2004; GEF/UNDP/IMO, 1996; GESAMP, 1996). The purpose of the coastal profile is to aid decision-makers in defining and taking into consideration success factors that enables moving to the next stage of ICZM that includes preparing the required ICZM strategies (Areizaga *et al*., 2012; González-Riancho *et al*., 2009).

Knowledge and public participation are essential elements for developing the coastal profile and the required ICZM strategies (e.g. Areizaga *et al*., 2012; Koutrakis *et al*., 2011; Cicin *et al*., 2000; EC, 2002). Knowledge facilitates assessing the progress of the ICZM implementation, while public participation, through involving the local stakeholders from the early stage of the ICZM, stems from the crucial knowledge they have on the state of the coast, the importance of gaining their support, facilitating an equitable and transparent ICZM decision-making process, and enhancing the legitimacy and salience of the proposed scenario for the ICZM implementation (e.g. Volkery *et al*., 2008; Anuchiracheeva *et al*., 2003; EC, 2002; Cicin-Sain and Knecht, 1998; Dahl, 1997).

However, these two factors are generally either neglected or weak (e.g. Breen and Hynes, 2014; Maccarrone *et al*., 2014; Areizaga *et al*., 2012; Rochette and Billé, 2012; Duvat, 2011; Pak and Majd, 2011; Storbjörk and Hedrén, 2011; Ballinger *et al*., 2010; Chaniotis and Stead, 2007; Dauvin *et al*., 2004). Adopting a participatory approach is recommended because it enables filling potential knowledge gaps by acquiring this knowledge from coastal users and enhancing their role in the decision-making process (e.g. Soriani *et al*., 2015; Emami and Ghorbani, 2013; King, 2003). Thus, under a participatory approach, conflicts of interest can be resolved, coordination can be enhanced, and trust is built among different actors, thus enhancing the usage of the local knowledge (Volkery *et al*., 2008; Anuchiracheeva *et al*., 2003).

This thesis has evaluated the usefulness of a participatory mapping approach to develop a coastal profile using ICZM implementation in Aqaba as a case study. The acquired local knowledge, including spatial knowledge was shown in this work to yield rich and unique information on Aqaba's coastal profile of coastal activities, natural resources, environmental pressures and impacts, and user-based conflicts. This thesis demonstrated therefore that the PGIS approach is a flexible tool that can provide an alternative when there is difficulty in acquiring official reports and/ or limited scientific knowledge, particularly in relation to spatial knowledge. The present study makes several noteworthy contributions to the ability of using the PGIS approach to fill the gaps in data-poor areas like Aqaba, in relation to the required knowledge for initiating an ICZM cycle.

The thesis has important implications to the provision of systematized information about the Aqaba coastal zone, addressing a lack of updated and georeferenced information about the current status of the coast. It presents novel maps that describe the current status of the Aqaba coastline. Such maps differ from traditional maps (in cases where they exist) by including the social and cultural understanding (Corbett and Rambaldi, 2009) of the Aqaba coastal zone relying on the respondents' integrated local knowledge.

Separate spatial records were developed in this thesis for coastal activities, resources, pressures and impacts and coastal use conflicts. No previous studies have investigated the direct damage to coastal resources from the expansion of coastal activities, such as the ports relocation or the new mega touristic projects. Moreover, no studies, to the author's knowledge, exit on the impacts from intensive diving activities on the diving sites in the AMP or even on the current status of the diving sites in the special and the industrial zones. This is the first study that investigates pressures and impacts along the entire coastline, even including the special zone. To the best of the author's knowledge, no recent studies explore the environmental status (including pressures and impacts) either in the special zone or the industrial zone, especially while taking into consideration the following two facts. First, the recent major changes associated for example with the construction of the new chalets (in the special zone) and ports relocations (in the industrial zone). Second, the fact that the special zone does not fall under the jurisdiction of ASEZA, therefore, it is not allowed to monitor (e.g. through the NMP) the coastline in this zone. This work showed that officials and researchers map potential user-based conflicts almost similarly, while the locals perceive the existence of conflicts more broadly along the entire coastline. However, the three groups agreed on the priority of conflicts along the touristic and AMP zone, and specifically, along Ghandoor beach.

The thesis ensured that the agendas for the stakeholders, specifically, locals are presented in the costal profile maps, which was highlighted as one of the main challenges in the participatory mapping (Corbett and Rambaldi, 2009). Thus, the thesis adds to the identification of the uniqueness of the local knowledge when developing a coastal profile in ICZM implementation. Therefore, providing a step toward the growing reversal for the top-down management approaches in the developing countries (Goodchild, 2007), such as the case in Jordan.

PGIS was used as a way to store and manage spatial data (local data), comparing the perception of different stakeholder groups. Thus, this research contributes to the limited study (e.g. Brown et al., 2017b) that used participants group as a factor in the mapping process and contrasted between the spatial knowledge acquired from different groups, which in turn, helped in understanding the issues along the coast from different perspectives. In particular, Chapter Seven contributes to the limited research on the spatial identification of coastal conflicts by comparing the inputs from different groups as a key aspect (Brown *et al*., 2017b). Finally, this research provides a step in mapping coastal-use conflicts on the marine environment, where little research has been conducted so far (Moore *et al*., 2017).

8.2. Summary of key findings

Coastal profiles

The need for the use of a participatory approach in the Aqaba's ICZM implementation is highly motivated by the stocktaking carried-out in Chapter Two, which involved defining the main sectors, and the stakeholder institutions, their roles, regulatory framework governing their work and identifying their concerns. The output of this analysis showed, that even though ASEZA has adopted some of the recommended ICZM tools (EIAs, environmental audits, environmental monitoring and inspection, the establishment of AMP, fishing and boating permitting process, controlled land deposition procedure, and a zoning system), there was a consensus among ICZM stakeholders that there are still, key challenges with regard to coastal management: weak enforcement, low level of awareness, conflicts of interest, non-integrated decisions and practices. Primarily, in the case of Aqaba, respondents highlighted the absence of a coastal profile and GIS maps to describe the current situation along the coast. Thus, consistently with the literature, this work showed the stakeholders' concerns on lack of knowledge related to the coastal systems (e.g. corals and fish resources), the natural and anthropogenic pressures on them, and their spatial distribution (e.g. Reis *et al*., 2014; Pak and Majd, 2011; González-Riancho *et al*., 2009). Chapter Two also showed a weak engagement of the local community in the ICZM decision-making process, as their role have been limited to a "consultation" role (as in Soriani *et al*., 2015; Volkery *et al*., 2008; King, 2003; Hare *et al*., 2002). The remaining findings of the thesis relate to the use of PGIS as a tool to overcome these identified challenges.

This thesis presented the spatial-referenced coastal profile for Aqaba's land-based activities (touristic, ports, and industrial) and marine-based activities (diving, boating, and fishing) in Chapter Four, main coastal resources (corals, fish, seagrass, and sandy bottoms) in Chapter Five, the anthropogenic pressures and their consequent negative impacts on the coastal zone in Chapter Six, and conflicts among coastal users in Chapter Seven. The profile describes each activity, resource, pressure, impact and conflict based on officials, researchers and locals' accumulated experiences and thoughts to reflect their local knowledge. The profile also encompasses the maps created during the PGIS meetings to show the distribution of these factors along five zones: touristic, port, AMP, special, and industrial.

The touristic zone was found to accommodate land-based touristic activities, boating, and fishing; port zone is mainly for port activities and to a lesser extent, diving activities; AMP zone hosts land-based touristic, diving, boating, and to a lesser extent fishing activities; the special zone is for touristic and port activities; and finally, the industrial zone includes a mix of industrial and port activities.

Corals are the predominant coastal resource, their spatial distribution shows a gradual increase in the abundance while heading southward, reaching the highest abundance along AMP zone. Coral reefs were found to be lacking in the touristic zone. Fish is more abundant along the touristic and port zones, and northern parts of AMP zone. Seagrass occur mainly along the touristic and AMP zones, and to a lesser extent in the ports zone. And finally, sandy bottoms, the fourth recognized key natural resource, was highly mapped in areas within the touristic zone. The knowledge gathered in this thesis shows that specific resources co-exist in the same areas, such as the occurrence of sandy bottoms and /or seagrass between the fringing reef. Local knowledge on natural resources captured in this thesis is highly consistent with the findings of existing scientific knowledge (e.g. Khalaf *et al*., 2012; Al-Rousan *et al*., 2011; Al-Rousan *et al*., 2005; Schwarz and Hellblom, 2002).

This thesis allowed the officials, who issue the approvals for the economic investments in the coastal landscape, researchers, who monitor the state of the coast, and locals, who spend their day in the sea, to discuss and map their concerns, which are reflected in the pressures and impacts coastal profile. Multiple negative environmental impacts were found, either on the state of the coast (water, air, and solid waste pollution) or the coastal resources/ ecosystems (e.g. degradation of the coral ecosystem), which are mainly from anthropogenic sources of pressure. Intensive land-based touristic activities were the predominant coastal pressure causing coastal degradation at coral reefs and seagrass environments, mainly along the touristic and AMP zones. For example, at Berenice and Tala Bay, touristic resorts in the operation phase, located within AMP, corals and seagrass have been already impacted. Current construction activities in Ayla and Saraya were shown to have already impacted the seagrass ecosystems, which in turn, have negatively impacted fish abundance. This decline in seagrass distribution and diversity, associated to human development activities, is not unique to Aqaba (e.g. Al-Rousan *et al*., 2011; Orth *et al*., 2006). Moreover, fish stock is expected to decline once the Marsa Zayed project starts its construction phase, in an area (currently occupied by the old main port) with high fish stock as shown in the coastal profile of natural resources (Chapter Four). Water and air pollution was found also to be a key impact resulting from various coastal pressures, especially caused by the old phosphate port.

The coastal profile of Chapter Seven uncovers information on areas with high conflicts, and where rights and responsibilities are cloudy. Following recent literature (e.g. Brown *et al*., 2017b), it also illustrated the use of PGIS as a diagnostic tool to identify coastal user-user conflicts, which was showed to provide a suitable way to reflect the three elements of the conflicts; conflicting actors, the geographical location, and the consequences. Twenty-four distinctive coastal-use conflicts were identified related to security, space, access to the beach, scope of work, and safety. Conflicts of interest in the use of space are dominant in the Aqaba coast. Actors facing the highest conflicts are fishermen with touristic actors on use of space and access to the beach issues, fishermen with port actors, also on space issues, and fishermen with boaters on space and scope of work issues.

Priority areas

Priority areas for ICZM management were identified in this thesis emerging form the coastal profiles. Mapping priority areas informs public decision-making, due to the limited public funds and resources allows "funnel-shaped" processes in policy development and shows the power of the spatial images language (Cartoon, 2002). Following, Brown *et al*. (2012), priority areas were recognized by relying on information related to the response rate and spatial agreement that reflect the actors' perceptions and concerns. The thesis also illustrated how the location of priority areas can differ depending on the management objectives to overcome coastal impacts in Aqaba. For example, the priority area to minimize coastal pollution is the old phosphate port, while to minimize ecosystems degradation, the priority area is that occupied by the new military chalets. If the management objective is to minimise the overall coastal impacts in natural resource abundant areas, the area occupied by the old phosphate port emerges as the first priority area. Finally, the priority areas for resolving coastal-use conflicts showed that the major priority area is Ghandoor public beach with a focus on fishermen, boaters, and operators of the land-based touristic activities. Prioritization in management should also be given to the hotels' area, RYC, and fishermens' port, with the same conflicting users. Note that in all of these areas, conflicts of different nature co-exist (security, space, access to the beach, the scope of work, and safety issues).

Comparing stakeholder groups perceptions

In this thesis, PGIS was used to contrast the perceptions of the main ICZM actors in Aqaba (officials, researchers, and locals) with the purpose, as shown by Carver *et al.* (2001) and Close and Hall (2006), to produce more efficient knowledge and to better orient decision-makers. Spatial consensus reached 100% among the same group for some studied themes. However, spatial consensus was consistently lower when integrating the spatial knowledge for the three groups. This, highlights the complexity of integrating the knowledge and perceptions of various players at the coastal zone, but at the same time, assures the importance of strengthening the role of non-officials' participation to enhance the state of the coast and the level of ICZM implementation.

Moreover, comparing the acquired knowledge from the semi-structured interviews (Chapter Two) and the PGIS (Chapters Four, Five, Six, and Seven), it can be noticed that the latter provided richer and more detailed information. An example is the acquired knowledge on corals status presented in Chapter Two (which can be seen as preliminary information), compared with the coastal profile of this natural resource in Chapter Five. In addition, when identifying coastal activities in Aqaba, the outcomes of the PGIS provide information of marine based activities (fishing, diving, boating), which were ignored in the stocktaking carried out through semi-structured interviews in Chapter Two, where the knowledge from the locals was not collected. Similarly, the PGIS approach enabled capturing more pressures and impacts and provided key information of coastal-user conflicts. Interestingly, in some cases, the same respondents participated in the two fieldworks, yet the amount of knowledge these respondents gave was much fuller in the PGIS fieldwork. This provides evidence that the PGIS approach is an efficient way to acquire information, especially in knowledge poor situations.

Enhancing the role of locals in decision-making

The spatial knowledge collected from locals is useful for the decision-makers, as it can help in identifying their concerns and increasing the level of locals' satisfaction (Huck *et al*., 2014). The conducted PGIS exercise, which acquired local knowledge, is expected to contributes to the social acceptability (Brown *et al*., 2004), and the legitimacy and salience of management decisions (e.g. Volkery *et al*., 2008; Anuchiracheeva *et al*., 2003).

Volkery and others (2008) argue that well-developed storylines are needed to facilitate constructive discussions among decision-makers for future management. The mapping process in this thesis, provided a step in this direction, whereby locals were encouraged to share their storylines, and discuss their knowledge and concerns. In addition, the use of multiple research modes that consist of the GIS together with the mapping process, allows us to better reflect for different aspects of the traditional knowledge (Young and Gilmore, 2017). Fishermen share historical stories about their ancestors, their fishing daily life, and their long fishing trips, which are now illegal because of the current political situation in the region. Boaters expressed their insecurities when they were telling their concerns about the proposed mega project in the port zone (Marsa Zayed). They expressed the injustice they feel they are exposed to, when they will be forced to no longer work along Ghandoor public beach in the touristic zone. They were clear that their voice is not being considered by the decision-makers. Fishermen also complained about the challenges they face and the high number of conflicts they have to deal with along the entire coastline. They also complained that decision-makers do not take their views into account when expanding land-based activities. Similarly, divers expressed concerns about the increasing pressures on the current diving sites and complained about closing many attractive diving sites as a result of expanding touristic and port activities. This illustrates, using Volkery *et al.*,'s (2008) terminology, that locals complained as being merely considered as agents, who either receive the developed knowledge (information) or give comments and some information (consultation role). As Arnstein terminology puts it (cited in Carver 2001), locals complained that they were just given the "public right to know" and the "public right to object".

In the context of this research, ASEZA conducts the National Monitoring Program, whereby the marine environment is being monitored along specific sites on the coastline (Chapter Two). Brown *et al*. (2004) highlight that analysis for conservation planning is usually developed based on the scientific sampling methods and in only few occasions relies on the local knowledge, ignoring thus that humans interact with their environment very strongly through their perceptions. In this research, local respondents, specifically divers, boaters, and fishermen show their reliance on the spatial knowledge based on the nature of their work, which gives added value for the acquired spatial local knowledge from the PGIS interviews that is updated and covers the entire coastline. Following Cinderby (2010), PGIS meetings with the locals were carried out along the beach, so, participants felt relaxed and confident in the mapping process. In fact, they provided sensitive local knowledge. For example, fishermen mapped the areas where they fish, regardless if it is legally permitted or illegal. This complements the work on illegal natural resource harvesting (e.g. de Lara and Corral, 2017; De Freitas and Tagliani, 2009; Hall and Close, 2007; Anuchiracheeva *et al*., 2003).However, in contrast to Anuchiracheeva *et al*., 2003 which also targeted fishermen's local knowledge using PGIS, in this thesis, the author did not have to analyse the spatial data to identify the illegal fishing sites; because the fishermen participating in the PGIS felt comfortable to talk about their illegal practices. They were open about what they are doing because the illegal practices were felt as needed in order to be able to work and maintain their families (e.g. to have food on the table at the end of the day).

Uniqueness of the acquired knowledge

This research enabled acquiring unique knowledge, specifically from the coastal resource users (locals group), which can be considered culturally sensitive (Rambaldi *et al*., 2006). The gained local knowledge from divers, boaters, and fishermen showed to be crucial in describing and spatially identifying the coastal profiles. For example, officials identified only one coastal resource (corals), locals managed to describe and spatially identify a broader range of coastal resources (e.g. corals, fish, and seagrass), similar to those identified by researchers. This is because the scope of work for the locals relies directly on knowing those resources and its location, compiling and interpreting what they sense in their daily work (Goodchild 2007; Dahl, 1997). Moreover, consistently with Goodchild (2007) and Brown and Kytta (2014), acquiring unique knowledge in the PGIS meetings was facilitated by the respondents' ability to recall transactional experiences.

Diving to explore the unique corals in Aqaba coast is the main attraction for many tourists; and divers are thus, the main users of the corals, who were shown in this research to be able to enrich scientific information with the fine and unique details (as shown in Chapters Five and Six). This thesis has documented for the first time, the corals' status, abundance, depths and location, as well as their rapid changes, and anthropogenic threats, through capturing the knowledge of the divers.

Fishermen provide unique knowledge on the fish stock along the coast, and described the current status of fishing activities, by providing their accumulated and inherited knowledge in terms of fish abundance areas, fishing gear used, and fishing sites. This research output complements information that may result from the monitoring activities of fish stock through the NMP, which as Chapter Two indicates is based on indicator species only. In fact, there is a lack of documented knowledge about fish stock in Aqaba (Chapter Two). Fishermen mapped in detail the fish stock distribution and abundance for both large and small fish species along the coast (Chapter Four). Similarly, boaters described their routes in a detailed way. This information is unique because there are no official routes for the boating trips. Boaters utilized the provided maps during the PGIS interviews to show that they memorize all the features along the coast (Chapter Four). The significance of the local knowledge was shown thus, to be key for the profile of all the coastal natural resources in Aqaba.

It is worth mentioning that a third of the sample from the locals group was illiterate and nearly forty percent reached the secondary school-level only. However, locals were shown to provide valuable knowledge when it comes to aspects of their work and the variety of natural resources they deal with on a daily basis. The findings of this thesis provide evidence of the importance of not underestimating the usefulness of engaging local participants in coastal management despite their potentially low level of education.

Response rate and spatial consensus

Involving different stakeholders groups in the mapping process and reaching a consensus is complex (e.g. Brown *et al*., 2016; Brown and Kytta 2014; Corbett and Rambaldi, 2009; Alcorn, 2000). The findings from this thesis reveal that there are three factors that play a major role in the response rate and spatial consensus for mapping features: the importance of the theme, type of participants, and the nature of the mapped theme.

In relation to the importance of the theme to respondents, note that different groups usually focus on specific issues that reflect their interest, identity, importance, and agenda during mapping processes (Brown *et al*., 2016; Brown, 2012b; Corbett and Rambaldi, 2009; Alcorn, 2000). Brown and others (2012) suggest that there seems to be a link between frequency of mapping and importance of the theme in the minds of participants. This thesis confirms this link between the importance of the theme and the response rate and/or the spatial consensus. The findings showed that there is a high spatial consensus for identifying and mapping specific themes, such as land-based coastal activities, resources, and coastal-use conflicts. For example, there is a high response rate for corals, which indicates a high level of awareness, acknowledgment, and importance of this resource for those that participated in the development of the coastal profile. This acknowledgment agrees with the literature, because Aqaba fringing reefs are considered as a part of the northernmost reefs in the Northern Hemisphere and the most diverse one in this Hemisphere, reflecting their high environmental significance (Kotb *et al*., 2015). Moreover, the coastal profile of corals highlights these ecosystems for their economic importance as well, with coastal users like divers and boaters relying on the presence of corals in their work (UNSD, 1992). Interestingly, the rate of response was also high when identifying and discussing use-based conflicts. Following Brown *et al.* (2012), this may reflect their high level of awareness, and the richness of the local knowledge, as they relate to their daily work, and the importance of resolving such conflicts seems to make them obvious.

Note however, that even when there is a high response rate and/ or spatial consensus among participants, this does not necessarily means that they are mapping the same feature within the same location for the same reason. In fact, mapping specific issues occur by different groups for different reasons in many cases (Alcorn, 2000). In the findings, the mapping rate for port and industrial activities by officials and researchers was high, with officials perceiving these as of high economic potential (Chapter Four), while researchers were concerned about the negative impacts on the coastal resources (Chapter Six).

The second factor playing a role in a high response rate/spatial consensus is the type of the stakeholder group (individual or multiple). In this research, agreement among locals reached 100% while mapping marine activities and 82% while mapping fish in specific sites. In this process, locals for example, associated fish stock abundant areas with the suitable habitats that accommodate fish (corals and seagrass) which is consistent with the literature (e.g. Khalaf *et al*., 2012; Khalaf and Kochzius, 2002a). In addition, high levels of consensus even when integrating the perceptions of the three groups were found when mapping land-based activities (touristic, ports, and industrial) and coastal resources in specific locations. Local knowledge was found to be comparable with that acquired from researchers and/or officials, giving legitimacy for the produced maps (Alcorn, 2000). Nevertheless, the overall spatial consensus is lower than that for each group separately, which could be explained, as discussed above, that each group mapped in relation to their interest, identity, importance, and agenda (Brown *et al*., 2016; Brown, 2012b; Corbett and Rambaldi, 2009). For example, fish was highlighted and mapped with a high agreement among locals, but was neglected by officials and researchers, confirming the ICZM challenges found in Chapter Two, weak communication and lack of adequate studies about fish status in Aqaba, i.e., lack of knowledge.

The nature of the theme also plays a role in the response rate/ spatial consensus. Thus, the overall spatial consensus for identifying the pressures and impacts was found to be lower compared with the one achieved for the coastal profiles on activities (Chapter Four) or coastal resources (Chapter Five). This means that respondents have less disagreement about features (activities and resources) compared to status (coastal pressures and impacts). This may be because (*i*) Pressures and impacts can be assessed based on their significance with varying levels between low to high. Some respondents indicated that pollutants in specific locations are within acceptable limits and they did not map them, while others seem to find those sites as polluted because it includes pollutants regardless of their degree. (*ii*) They can be permanent or temporary. Some respondents may not be mapping pressures and impacts when they are temporary, while others may consider them regardless of this factor. (*iii*) Seasonal variations may also play a role in mapping coastal pressures and impacts, such as solid waste pollution (in summer), or eutrophication (early spring). (*iv*) Finally, water, air, and solid waste pollution are unconfined and their spatial distribution can be affected by natural factors, such as the wind direction, currents and waves, and seawater temperature.

Differences between response rate for mentioning and mapping

PGIS usage also shows that the response rate for mapping was either lower or similar to the response rate for mentioning, this could reflect that some respondents are not familiar with the mapping process, even with using simple techniques. It also shows that acknowledging a specific theme (e.g. corals) does not necessarily mean having the spatial knowledge about it.

8.3. Limitations of the study

The conducted PGIS meetings using the hard copy maps for this research required intensive time during the meetings and through the manual digitizing process for all the hard copy maps as also acknowledged in the literature (e.g. Brown *et al*., 2012; Alcorn, 2000). An alternative way to overcome this limitation is using web-based mapping (Huck *et al*., 2014), with examples including web-based spraycan PPGIS and Volunteered Geographic Information (VGI) (Huck *et al*., 2014; Huck *et al*., 2013; Evans and Waters, 2007; Goodchild, 2007; Carver *et al*., 2009; Waters and Evans, 2003; Carver *et al*., 2001; Kingston *et al*., 2000). However, the ability to use web-based applications in this study was limited by the fact that most of the stakeholders in this thesis, in particular, the local fishermen, boaters and divers, were not digitally competent, did not have access to the internet, and did not have the language skills required for such applications. Therefore, the use of hard copy PGIS mapping was selected over the web-based mapping for locals. Even though, other respondents (researchers, officials) had the ability to use the web-based applications, the use of hard copy mapping was also chosen for these groups to allow for a better homogeneity and comparability between different stakeholder groups' responses, and reducing the impact of that the digital divide (Corbett and Rambaldi, 2009) may impose in the participation of the locals.

Another limitation encountered this research is the validation for the produced PGIS maps. Validating the PGIS maps using the Google Earth is possible; however, there is no way to inform the users about the quality of the data layers (Goodchild, 2007). In addition, Aqaba is facing accelerating changes over a short period of time; therefore, comparing the Google Earth maps with the PGIS maps are not applicable as the Google Earth does not provide information on the date the images were obtained (Goodchild, 2007).

The GPS could also be used to validate the produced maps in this thesis. However, some respondents were not familiar with GPS, leading to the digital divide issue (Corbett and Rambaldi, 2009). Nevertheless, GPS could also have been used for validation after finishing the meetings; but, this process was expected to require huge time, and the researcher opted to rely on the available literature to compare with the findings of this research. As in Brown *et al*. (2017b), note that validation was not applicable for the produced maps on coastal-use conflicts, which were mapped in Aqaba for the first time to the researcher's knowledge.

Another limitation encountered in this research is the map scale. Thornton *et al*. (2011) highlighted that there is no one scale to be recommended and the researcher made a trade-off as explained in Chapter Three to use the most appropriate scale for this case study.

It is worth mentioning also that the concept of the ICZM requires partnership along all levels (regional, national, and local) (e.g. UNEP/MAP/PAP, 2008; EC, 1999). However, the PGIS respondents identified coastal threats at the local level only, although the Gulf of Aqaba is narrow, and this means that threats on the Jordanian side can affect and be affected by the other side of the gulf (e.g. the Egyptian coastline). The lack of identification for regional issues in this thesis could reflect 1) the low level of awareness among the PGIS respondents in regard to such issues, especially given that nearly half of them have limited education levels; 2) respondents are more concerned with the local issues that they face during their daily work.

PGIS was shown to offer a usable approach to present information to decision-makers. The challenge of making the proper balance between delivering realities and details acquired from the locals with the precision and the scale of the GIS (Abbot *et al*., 1998) was overcome by reviewing PGIS recordings and transcripts several times, a careful implementation of the thematic analysis using different sets of themes, and an analysis of the findings in the views of the literature. Nevertheless, the existing limited research in coastal management in Aqaba also limits this comparison of the thesis outcomes with the literature.

8.4. Recommendations for Future Research

Further research could include a larger sample with a wider range of stakeholders, addressing thus, issues of validation for the identified potential conflicts, as advised in Brown *et al*., (2017b) and enhancing the effectiveness of the PGIS methodology (Brown *et al*., 2012). Moreover, in line with the purposive sampling used for the PGIS methodology, (targeting specific groups with particular scope of work), future work, could include stakeholders working in the land-based touristic, ports, and industrial activities in order to acquire their perceptions in relation to specific themes, such as the coastal-use conflicts.

Future research may aim to reach higher spatial consensus on mapping coastal pressures and impacts that could meet any potential policy target (Alcorn, 2000) by using more specific questions during the PGIS meetings, classifying them based on their significance (low to high), time duration (permanent or temporal), and the seasonal variability. This could have decreased the level of uncertainties among respondents in deciding whether to map existing pressures and impacts and increase the spatial consensus. Moreover, as the concept of ICZM requires partnership along the local, national, and regional levels, future work on a coastal profile that tackles regional impacts may require the design of questions for the PGIS meetings that include the regional issues in a more clear manner. Note also that this thesis does not explicitly addresses the uncertainty that may characterise local knowledge. Nevertheless, some priority areas (particularly the old phosphate port and the Ghandoor beach) emerged based on the consensus of all the stakeholders, and could be used in initiating the Aqaba ICZM program. Future work addressing local uncertainties can be more efficient if this focuses on the validation of low or medium priority areas (Teran *et al*., 2006).

Conflict resolution is also an interesting area of future research. Passive management through zoning different locations for incompatible users can be an effective strategy for the interpersonal conflicts (Miller, 2015; Vaske *et al*., 2007). However, by zoning, one conflicting group will be migrated to another location which could also encounter opposition; therefore another less strict alternative is to engage both conflicting groups to find a suitable coordinated solution (Breen and Hynes, 2014). Addressing conflicting goals of different actors may be solved through a better knowledge of conflicts that contribute to enhance coordinated responses.

Finally, in line with the growing interest in the literature of integrating the local knowledge (traditional knowledge) and the scientific knowledge for the management of environmental resources (McBride, 2016), further work can be done in this integration still lacking in Jordan, specifically in Aqaba, where the voice of the locals in decision-making is not being considered, except in particular cases during scoping sessions within the EIA process (as shown in Chapter Two). This research used the PGIS methodology as a novel approach to fill the current information gaps for developing the coastal profile and to enhance the role of locals, as a first step in this direction. The future integration of the LK with the SK will contribute to adopted policy-makings decisions to be more legitimate, salience, and credible. Similarities and differences could be assessed between these knowledges as well as the produced maps from the two data sets (LK and SK). This will allow questions such as where and why respondents have mis-perceptions to be understood, i.e., when their LK is in disagreement with the SK, and will help identifying the current threats, upgrading the current strategies, and increasing ecosystem resilience (Young and Gilmore, 2017).

Appendices

Appendix One: Photos for some sites along Aqaba coastline taken during the PGIS meetings.

(a) the construction activities in Saraya touristic project; (b) Royal Yacht Club's marina; (c) the fishermen's port; (d) view for the nearby Aqaba Containers' Terminal from Marine Science Station's beach; (e) landing site for the bottoms glass boats along a public beach in AMP; (f) sand barrier between the public beach and Tala Bay within AMP borders.

(a)

(b)

(c)

(d)

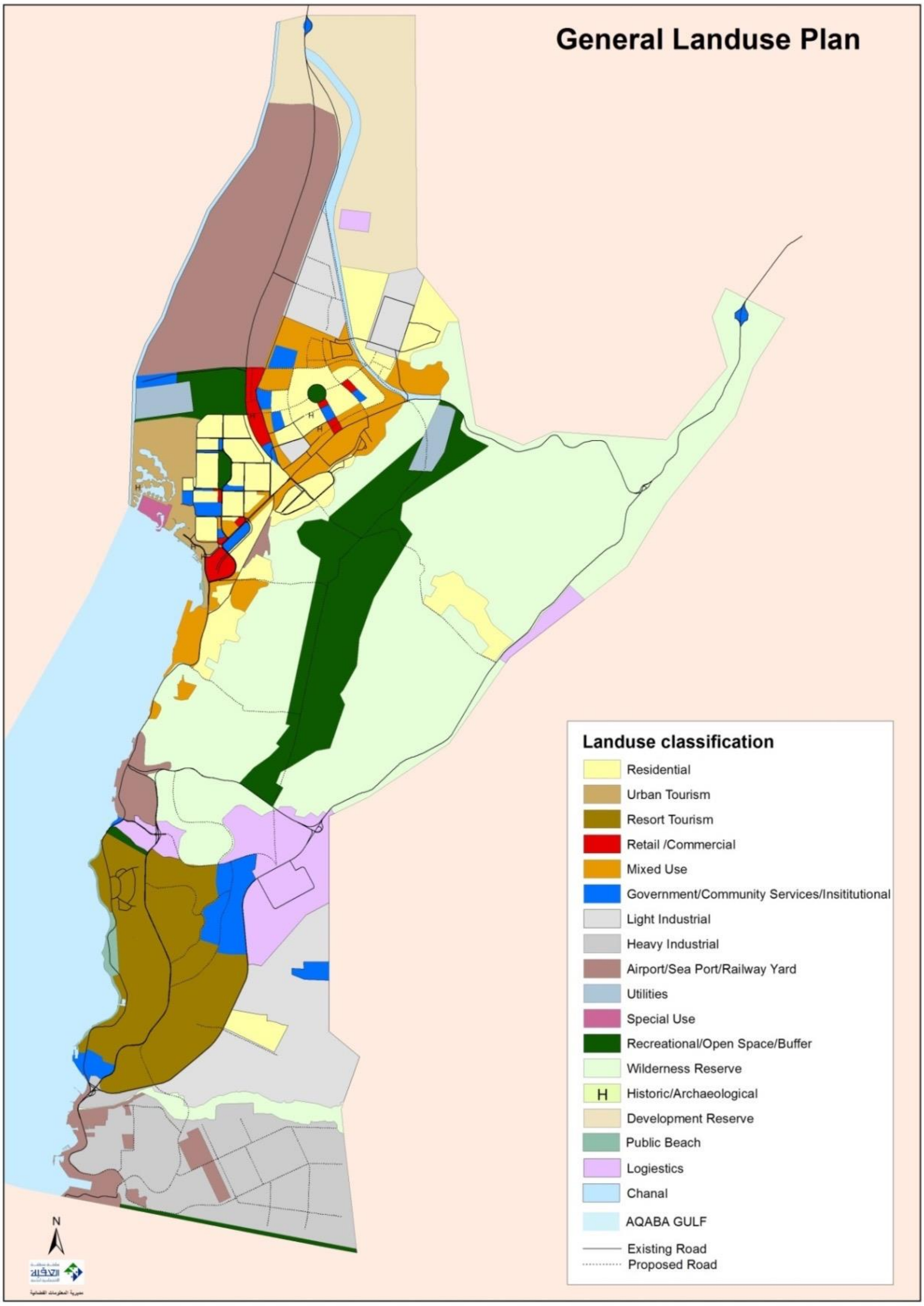
(e)

(f)

Appendix Two: Reference Environmental Legislations for ASEZA.

Level of Legislation	Legislation Title
Reference Environmental Legislations on the Local Level (ASEZ)	
Law	ASEZA Law No (32) for the Year 2000 and its amendments
Regulation	Regulation No. (21) For the Year 2001 "Regulation for the Protection of the Environment in the Aqaba Special Economic Zone"
	Regulation No. (11) For the Year 2001 "Regulation for the Development and Improvement of the Investment Climate for the Aqaba Special Economic Zone"
	Regulation No. (22) For the Year 2001 "Regulation for AMP" and its amendments.
Instruction	Instruction No (13) for the Year (2001) "Instructions for Environmental Inspection"
	Instructions No (37) for the Year (2002) "Instructions of Formulation of valuation committee for the environmental damages, defining its Tasks and Regulating its Meetings in ASEZA and its amendments
	Instructions No (48) for the Year 2002 "Instructions for Regulating the Dealing and the Usage of Plastic Bags in ASEZA"
	Instructions No (68) for the Year (2005) "Instructions for Management of used oils"
	Instructions No (80) for the Year (2005) "Instructions for Checking compressed Cylinders of AMP"
	Instructions No (82) for the Year (2005) "Instructions for Organizing Scientific Research in AMP"
	Instructions No (83) for the Year (2005) "Instructions for Regulating Entrance to AMP"
	Instructions No (84) for the Year (2005) "Regulating Boats work inside AMP"
	Instructions No (85) for the Year (2005) "Regulating Diving in the AMP"
	Instructions No (86) for the Year (2005) "Clean-up Under Sea by Diving in AMP"
	Instructions No (87) for the Year (2005) "Instructions for Collecting services fees in the AMP"
Standards	Ambient air quality
	Stack emissions
	Jordanian Standard for Water bathing beaches
Policy	Zero Discharge Policy
Reference Environmental Legislations on the National Level (Jordan)	
Law	Environmental Protection Law No. 52 for the Year 2006
Regulation	Regulations No. (24) Of 2005 "Management, Transportation and Handling of Harmful and Hazardous Substances Regulations"
	Regulations No. (25) Of 2005 "Soil Protection Regulations"
	Regulations No. (26) For 2005 "Protecting the Environment from Pollution in Emergency Situations Regulations"
	Regulations No. (27) For 2005 "Management of Solid Waste Regulations"
	Regulations No. (28) Of 2005 "Regulations for the Protection of the Air"
	Regulations No. (29) Of 2005 "Natural Reserves and National Parks Regulations"
	Regulations No. (37) Of 2005 "Environmental Impact Assessment Regulations"

Appendix Three: Aqaba Special Economic Zone (ASEZA) Master Plan 2013.



Appendix Four: Parameters for the National Monitoring Program (NMP) being applied in Aqaba.

Theme	Parameter of Interest
Physical properties	Tides: Tidal Records (cm), Global Mean Sea Level (MSL) (cm), Multi Annual Mean (MAM) (cm)
Physical properties	Meteorological Conditions: Wind Speed (ms^{-1}), Wind Direction, Air Temperature (^oC), Relative Humidity (%)
Physical properties	Currents: Currents Direction, Currents Speed (cms^{-1})
Physical properties	Sea Water Temperature (^oC)
Physical properties	Conductivity (ms)
Physical properties	Dissolved Oxygen (mg/l)
Physical properties	Salinity (mg/l)
Chemical and Biological Properties	Nutrients: Ammonia (NH^{+4}), Nitrate (NO^{3}), Nitrite (NO^{-2}), Phosphate (PO_4^{-3}), Silicate (SiO_2) (µM)
Chemical and Biological Properties	pH
Chemical and Biological Properties	Alkalinity
Chemical and Biological Properties	Particulate Matter
Chemical and Biological Properties	Chlorophyll a (µM/l)
Chemical and Biological Properties	Hydrocarbons (mg/l)
Chemical and Biological Properties	Enterococcus (mpn)
Chemical and Biological Properties	Zooplankton biomass (mg/l)

Theme	Parameter of Interest
Sedimentation	Sedimentation Rate ($mg.cm^{-2}d^{-1}$)
Sedimentation	Physiochemical Characteristics of Coastal Bottom Sediments: Colour, odour, and redox potential
Sedimentation	Ignition Loss (g/kg)
Sedimentation	Hydrogen Sulphide (mg/kg)
Sedimentation	Grain Size Distribution (%)
Sedimentation	Calcium Carbonate ($CaCO_3$) (%)
Sedimentation	Total Phosphorous (TP) (g/kg)
Sedimentation	Heavy Metals: Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), and Zinc (Zn) (mg/kg)
Sedimentation	Total Nitrogen (TN) (g/kg)
Sedimentation	Organic Carbon (OC) (g/kg)

Theme	Parameter of Interest
Fish	Fish assemblage and community indices
Fish	Predominant Species
Fish	Relative Fish Abundance (RA) (per $250m^2$)
Fish	Frequency of Appearance (FA) (per $250m^2$)
Fish	Average Number of Species (S) (per $250m^2$)
Fish	Average Number of Individuals (N)
Fish	Shannon-Wiener Diversity Index (H`)
Fish	Average number of species (S) at different depths
Fish	Average number of individuals
Coral Cover and Benthic Communities	Hard Corals Cover (%)
Coral Cover and Benthic Communities	Soft Corals Cover (%)
Coral Cover and Benthic Communities	Sea Anemone (%)
Coral Cover and Benthic Communities	Sea Sponge (%)
Coral Cover and Benthic Communities	Ascidians (%)
Coral Cover and Benthic Communities	Clams (%)
Coral Cover and Benthic Communities	Algae
Coral Cover and Benthic Communities	Sea grass
Coral Cover and Benthic Communities	Sand
Coral Cover and Benthic Communities	Rock and Rubble
Coral Cover and Benthic Communities	Man Made Objects
Coral Cover and Benthic Communities	Recently Killed Corals

Appendix Five: Photos for the fishing gears in Aqaba taken during the PGIS meetings.

(a) engine used for the fishing boat; (b) fishing boat ready for a trip; (c) fishing in the shallow water; (d) floating material for the fishing; (e) and (f) traps as a common fishing gear in Aqaba.

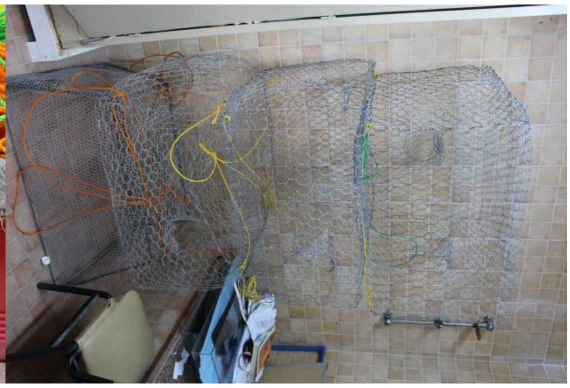
(a)

(b)

(c)

(d)

(e)



(f)

Appendix Six: PGIS Interviews Consent Form.

Jan, 2015

Environment Department

Heslington, York YO10 5DD

United Kingdom

Consent Form

My research project is seeking to identify best management practices for Integrated Coastal Zone Management (ICZM) in Aqaba, Jordan. The research is looking at the possibility of using participatory mapping to incorporate local knowledge from coastal resource users and fill the gaps that scientists may not have identified or considered.

I confirm that I had read the terms of research and have discussed any confidentiality issues or questions I may have had.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I understand that this is a research study and that my responses may be used in a postgraduate dissertation and / or in reports and publications arising from this research. I understand that I will not be identified in the study but my responses will be referred to anonymously (e.g. Respondent XX said "…").

I agree to take part in the above study (   )
Name:
Title:
Date:
Signature:

For further information about this project, please ask me or feel free to contact my dissertation supervisor

Wissam Yahia Al-Hayek
Telephone: 447920824207
Email: wyah501@york.ac.uk
Skype: Wissam hayek

Appendix Seven: Respondents Information filled by the respondents at the end of the PGIS interviews.

Conducting Participatory Geographic Information System (PGIS) for Integrated Coastal Zone Management (ICZM) in Aqaba, Jordan

Basic Information

Name	…………………………………………………………………………………………
Gender	…………………………………………………………………………………………
Age	…………………………………………………………………………………………
Level of education	…………………………………………………………………………………………

Field of work

Institution	…………………………………………………………………………………………
Department	…………………………………………………………………………………………
Job Title	…………………………………………………………………………………………
Years of experience	…………………………………………………………………………………………

Contact Information

Telephone	…………………………………………………………………………………………
Mobile	…………………………………………………………………………………………
Address	…………………………………………………………………………………………
Email address	…………………………………………………………………………………………
Skype	…………………………………………………………………………………………

Signature:
Date:

Appendix Eight: Participant's Information Sheet handed to respondents at the beginning of the PGIS Interviews.

Environment Department
Heslington, York YO10 5DD
United Kingdom

Participant Information Sheet

Dear …

My name is Wissam Yahia Al-Hayek and I am a PhD student from the University of York (UK). I am contacting you as a potential coastal resource user in Jordan.

My research project is seeking to identify best management practices for Integrated Coastal Zone Management (ICZM) in Aqaba, Jordan. The research is looking at the possibility of using participatory mapping to incorporate local knowledge from coastal resource users and fill the gaps that scientists may not have identified or considered.

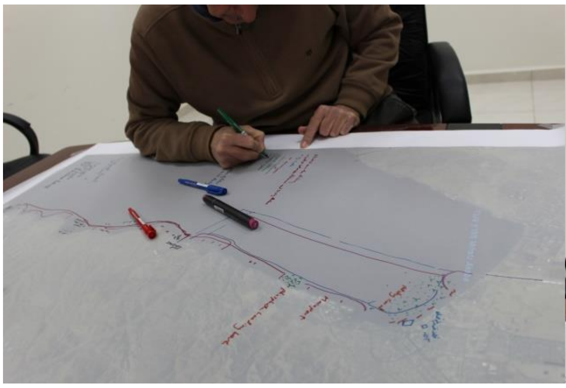
Participating would entail an interview at a time of your choosing. I have attached a sample copy of the questions we will cover and a consent form. Interviews will be recorded and transcribed on private devices to ensure confidentiality. After the interviews are transcribed, all information linking you and your comments will be deleted and it will not be possible to identify you.
We hope you will be interested in participating in our research or maybe able to give your views on this research.

Many thanks in advance for your consideration of this request. For further information about this project, please ask me or feel free to contact my dissertation supervisor

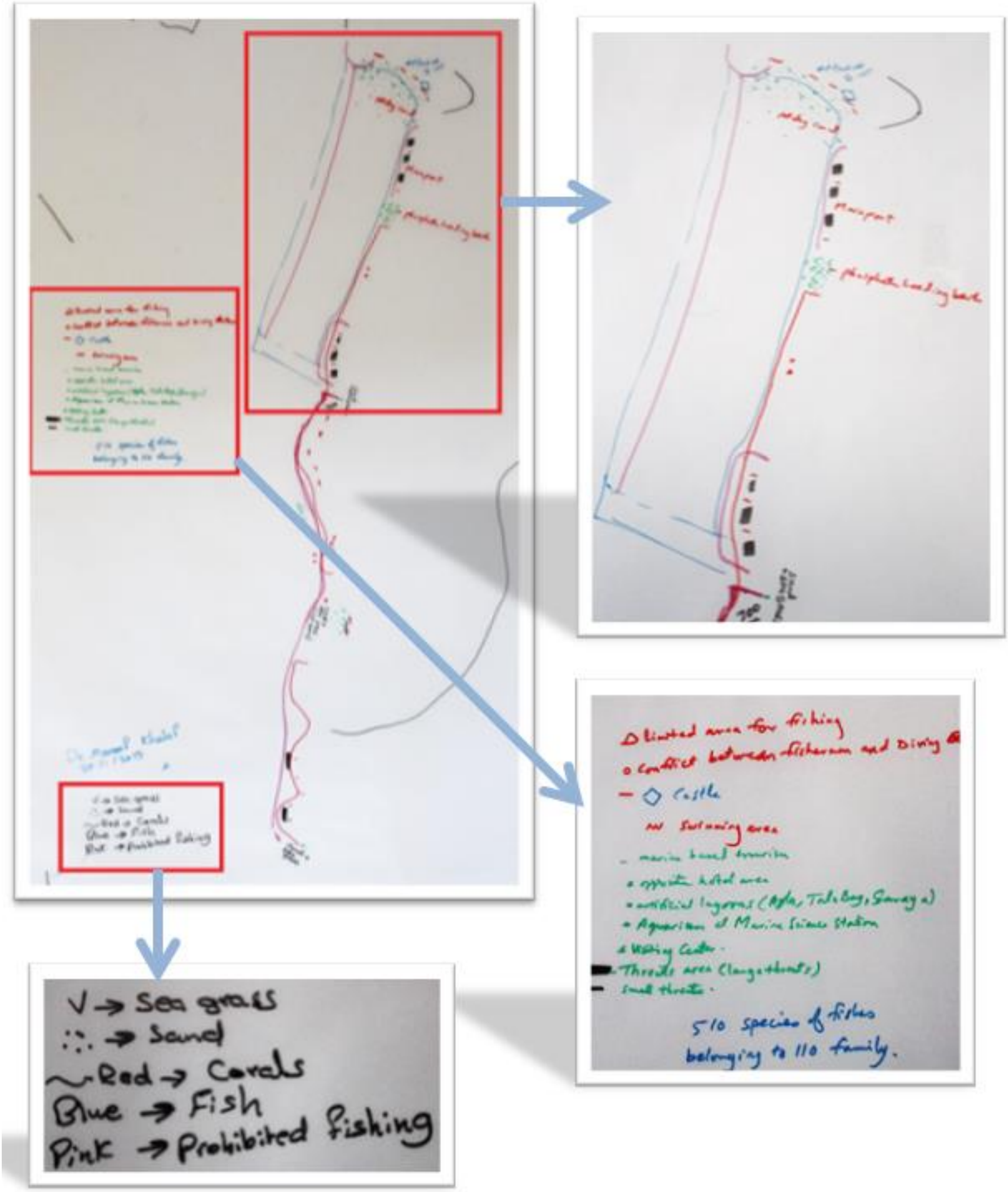
Wissam Yahia Al-Hayek
Telephone: 447920824207
Email: wyah501@york.ac.uk
Skype: Wissam hayek

Best wishes
Wissam Yahia Al-Hayek
PhD Student in Environmental Economics and Environmental Management

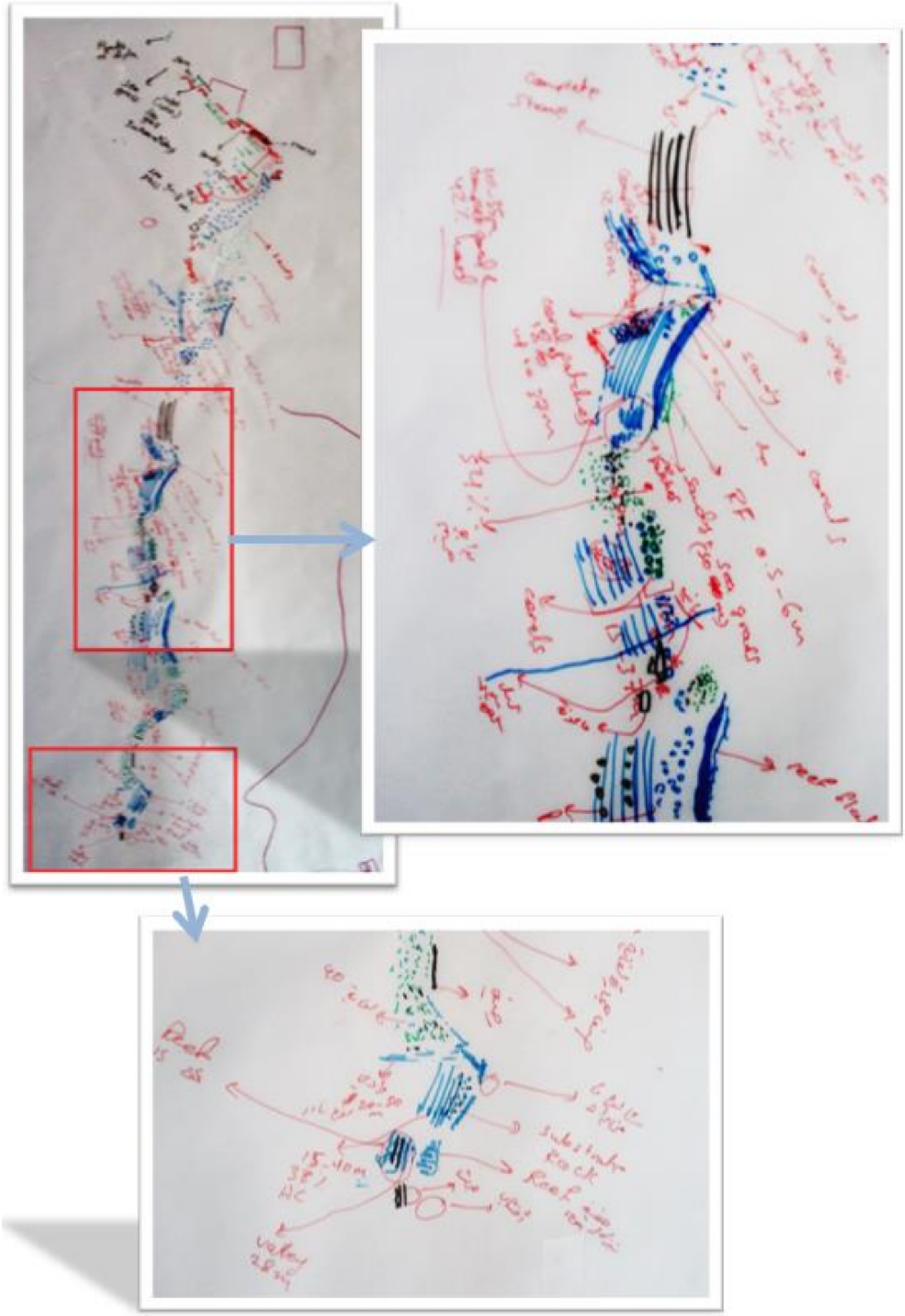
Appendix Nine: Photos taken during the PGIS interviews showing the mapping process for different respondents.



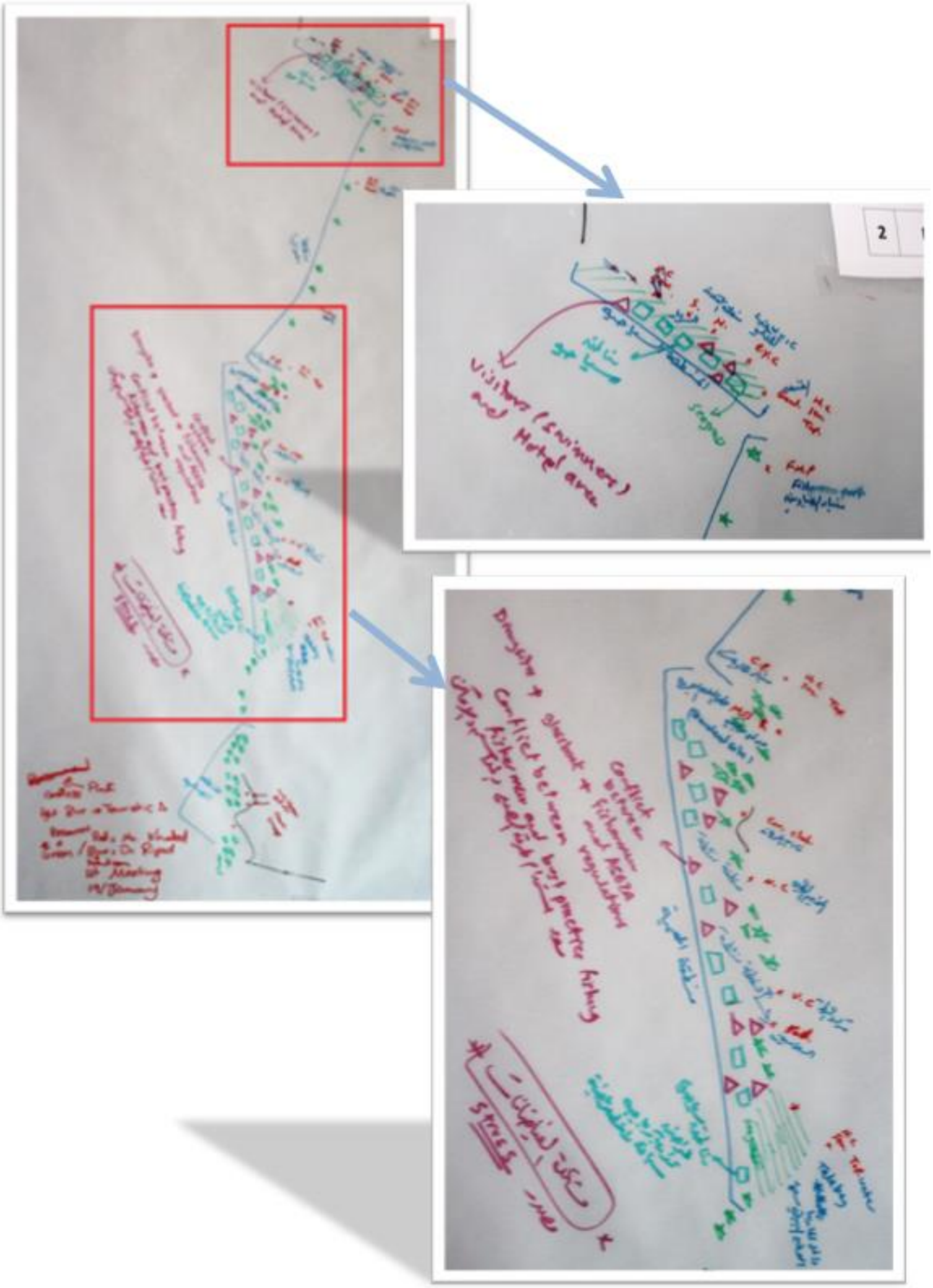
Appendix Ten: Sample photos for the PGIS hard copy maps prepared by different respondents.



Appendix Ten: continued.



Appendix Ten: continued.



Appendix Eleven: Photos for the different types for Boating activities in Aqaba taken during the PGIS meetings.

(a) glass bottom boats (white) and fishing boats (red); (b) large boats operated through the touristic companies, compared with the glass bottoms boats (white) and fishing boats (red); (c) speed boats landing in the RYC's marina; and (d) jet skis landing in the RYC's marina

(a)

(b)

(c)

(d)

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