

INTEGRATION OF LOCAL KNOWLEDGE IN THE DEVELOPMENT OF ENVIRONMENTAL SENSITIVITY MAPS

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<https://doi.org/10.47800/PVJ.2022.10-09>

Summary

The environmental sensitivity maps would be envisaged as an elaborated scheme exchanging knowledge among numerous stakeholders at decision-making and execution levels. Local knowledge, scientific knowledge and public knowledge are required to associate toward the development of environmental sensitivity maps, particularly the identification of shoreline types and its sensitivity; compiling biology, human-use resource information; ranking, prioritising sensitive sites and resources at risk. Especially, the value of local knowledge has been recognised over time and the need for its effective integration into research and development has grown significantly. One of the options to enhance the role of this knowledge should be participatory tools emphasising researchers-facilitation to obtain indigenous perceptions as well as increase environmental sensitivity maps adoption in the planning, regulatory community in islands and coastal areas.

Key words: Environmental sensitivity maps (ES maps), local knowledge (LK), public knowledge (PK), scientific knowledge (SK).

1. Introduction

Environmental sensitivity maps for coastal provinces and islands, where there have been petroleum activities, are among the well-known research achievements of Petrovietnam in the period of 2010 - 2020. In order to produce such kinds of maps, internationally recognised methodology has been applied. With the growing recognition of knowledge systems in the last decade, this paper aims to examine the integration of three types of knowledge - local knowledge, public knowledge, scientific knowledge - in the methodology of mapping environmental sensitivity. The focus will be on local knowledge to find out (i) to what extent it has been used; (ii) whether it contributes to improving research results and (iii) what are the solutions to make it be fully and comprehensively used.

2. Theoretical framework

2.1. The concept of three types of knowledge and their role in collaborative research

Knowledge management is a formal approach to acquire, create, codify, store, share and use contextualised

information, expertise, and other intellectual assets to fulfil objectives. Knowledge management is considered to promote policy-making through advancing informed debate and decision-making by accessing intelligence and insights from stakeholders [1]. Among different dimensions of knowledge and the dynamism of knowledge management, the basic concept of environmental research is incorporating local knowledge, scientific knowledge, and public knowledge to complement the consciousness of ecological functions and processes.

Local knowledge (LK) is a collection of facts related to the entire system of concepts and beliefs that people hold about the world around them. This includes the way people observe and measure their surroundings, how they solve problems and validate new information. Local knowledge is developed and adapted continuously to a gradually changing environment. It is passed down from generation to generation and closely interwoven with people's cultural values [2].

Scientific knowledge (SK) is produced through official methods by universities, researchers, or other institutions that satisfy demanding epistemic standards. Consequently, it is highly reliable, robust and well established [3].



Date of receipt: 28/4/2022. Date of review and editing: 28/4 - 26/7/2022.

Date of approval: 5/10/2022.

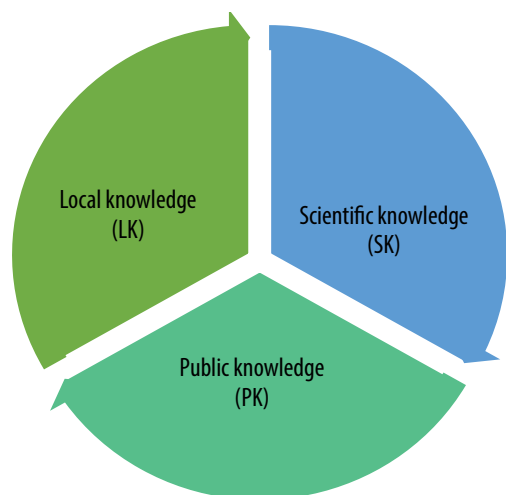


Figure 1. Three types of knowledge.

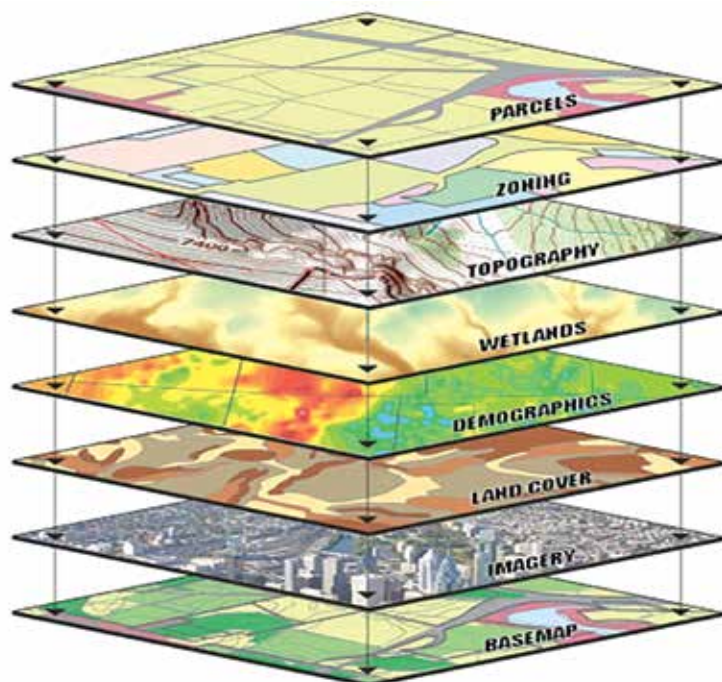


Figure 2. Map layers.

Public knowledge (PK) is generally captured from publications, newspapers, reports from national/local governments, laws, etc. [4]. Through the combination of various stakeholder’s knowledge, we will be able to have a thorough understanding of the situation in each context.

2.2. The methodology for developing environmental sensitivity maps

Mapping the sensitivity of the environment to accidental oil pollution is developed by the oil and gas industry to deliver acceptable health, safety, and environmental performance. The environmental sensitivity maps are the maps of numerous categories of environment, resources potentially exposed to oil spills, enabling the identification of the most sensitive sites, thus providing a basis for the definition of priorities for protection and clean-up, and information to plan the best-suited response strategy [5].

Environmental sensitivity maps enclose baseline maps and tactical, strategic, operational sensitivity maps. Baseline maps comprise a set of information to locate the diversified features such as: coastline and bathymetric depth contours, rivers, lakes; towns, villages, administrative borders, roads, railways, and central infrastructure. Tactical, strategic and operational sensitivity maps contain the shoreline facet, its general environmental sensitivity to oil spill; the

Table 1. Methodology for developing environmental sensitivity maps [6]

Identification of shoreline types and its sensitivity	<ul style="list-style-type: none"> • Aerial surveys: using fixed, high-wing aircrafts, helicopters or existing topographic maps, nautical charts, aerial photos, satellite images, GIS data. • Ground verification: an example of each habitat should be visited and photographed on the ground.
Compiling biology and human-use resource information	<ul style="list-style-type: none"> • Scientists, resource managers,... provide expert knowledge and have responsibilities for data compilation and creating two final products: <ul style="list-style-type: none"> - Environmental sensitivity index (ESI) maps that are bound together in a hard-copy atlas. - Digital data on CDROM that can be viewed using ArcInfo, ArcView, ESI viewer, or in portable document format (PDFs).
Ranking, prioritising sensitive sites and resources at risk	<ul style="list-style-type: none"> • Establishing a team comprised of GIS specialists, marine geologists, coastal zone environmental professionals, coastal and environmental economists, etc. • Ranking the sensitivity information via mathematical modelling, using multiple indices; aggregating the sensitivity information into one index; and using a map-based approach to simplify and rank the sensitivity information.

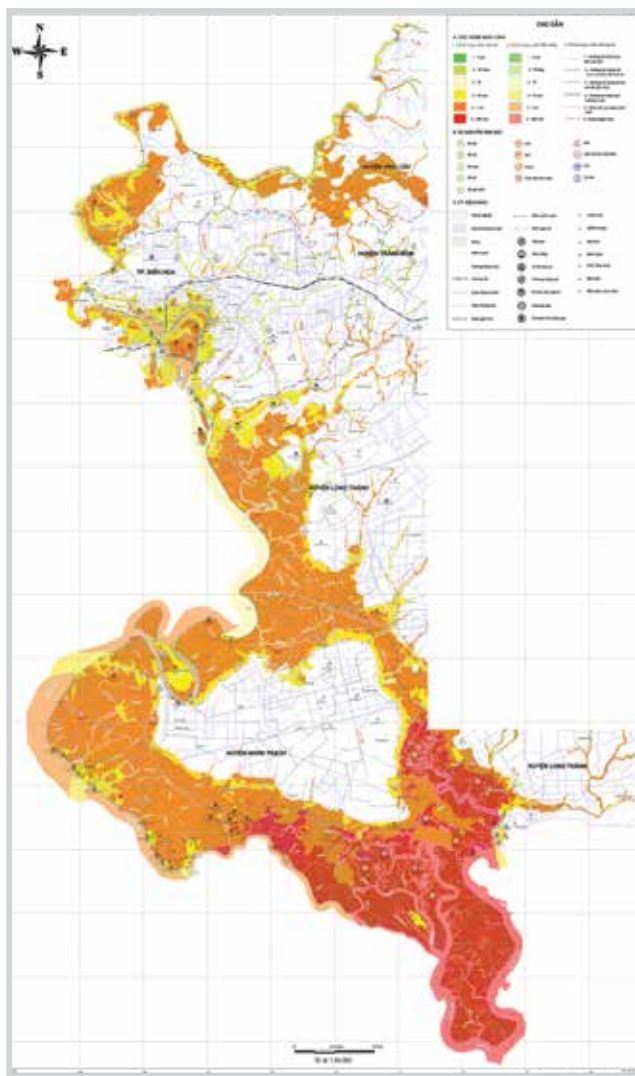


Figure 3. Environmental sensitivity map for Dong Nai province in 2011 [7].

sensitive ecosystems, habitats, species, natural resources; the sensitive socio-economic factors; and the logistical and operational oil spill response features.

The methodology for developing environmental sensitivity maps is described in Table 1.

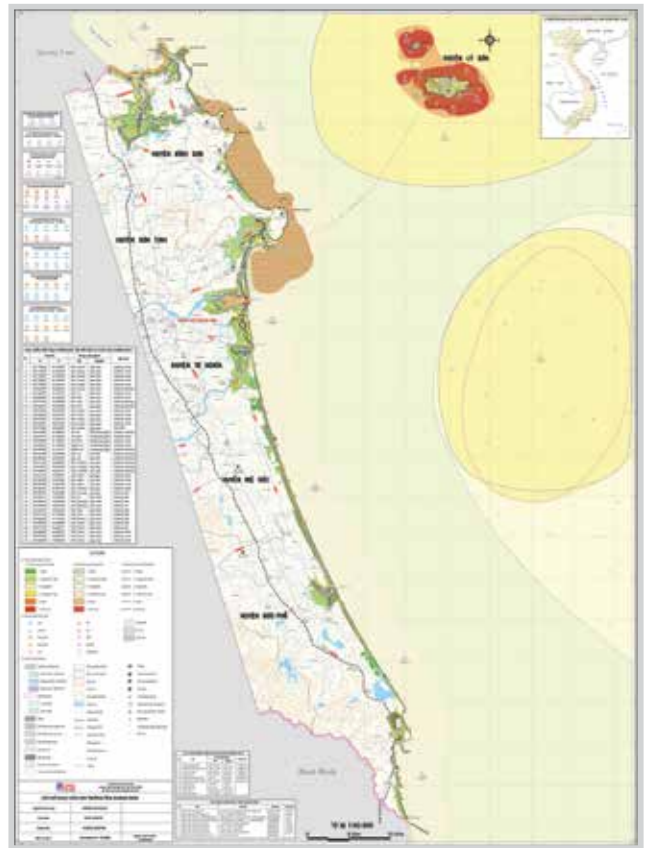


Figure 4. Environmental sensitivity map for Quang Nam province in 2012 [8].

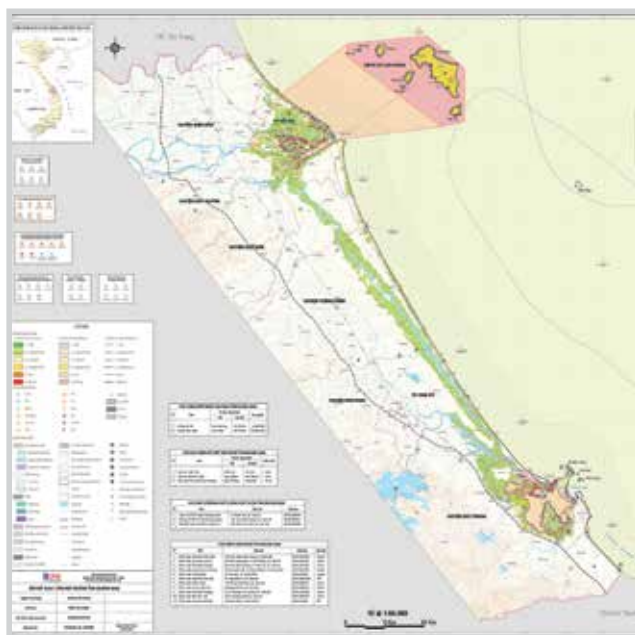


Figure 5. Environmental sensitivity map for Quang Ngai province, 2013 [9].



Figure 6. Environmental sensitivity map for Thai Binh province in 2013 [10].

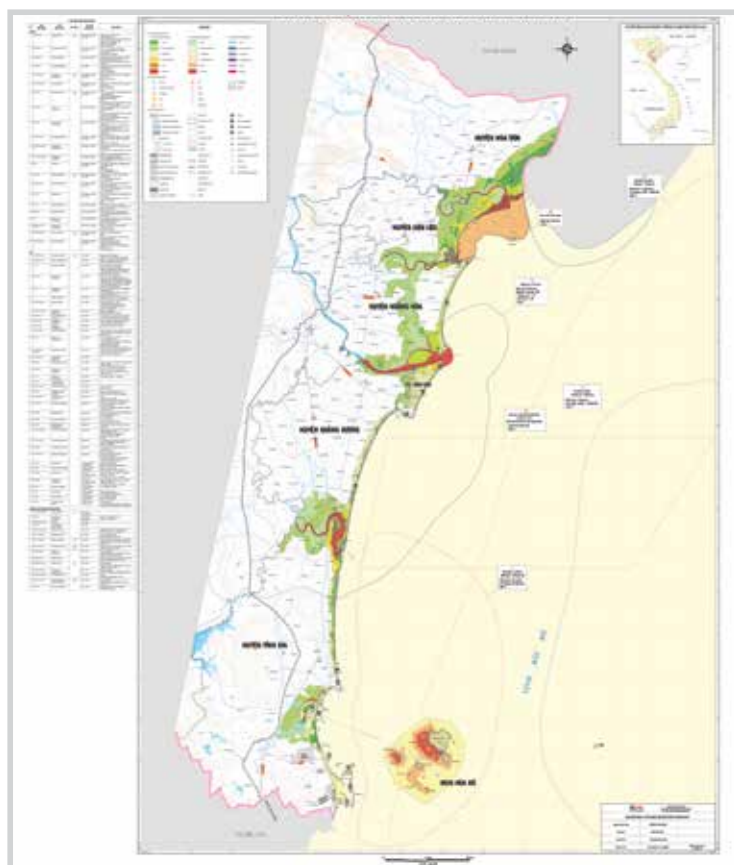


Figure 7. Environmental sensitivity map for Thanh Hoa province in 2015 [11].

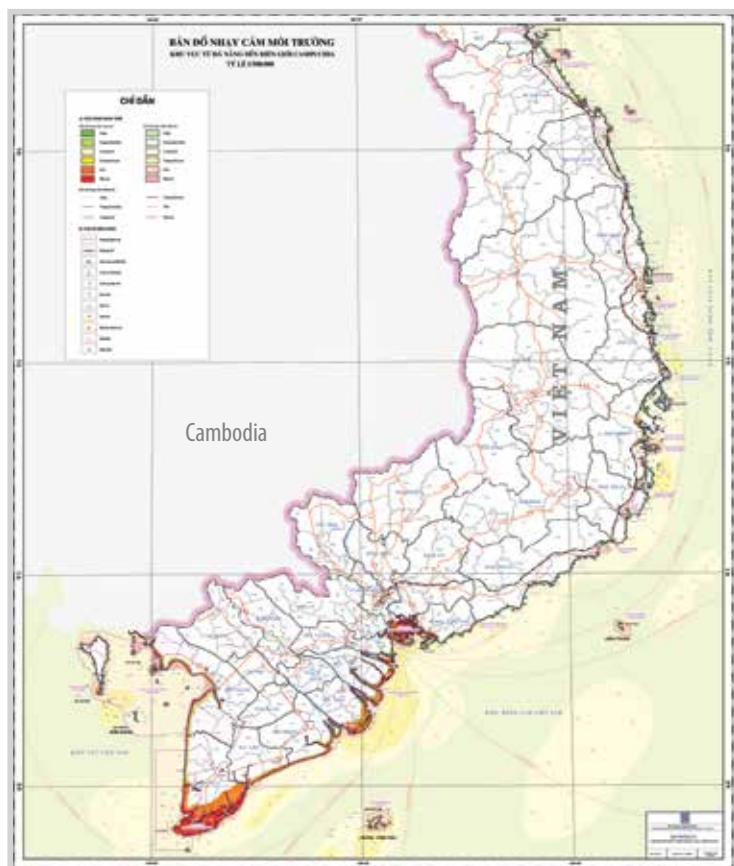


Figure 8. Environmental sensitivity map for central southern provinces in 2015 [12].

3. Analysis

Since 2010, there have been many projects carried out by the Vietnam Petroleum Institute (VPI - a subsidiary of Petrovietnam) constructing environmental sensitivity maps for coastal provinces and islands which have occurred petroleum activities as shown in the following figures.

The research outputs are environmental sensitivity maps and oil spill response contingency plans transferred to local provincial agencies during this time.

The knowledge system symphonised in these cases

First of all, VPI researchers worked with local governmental agencies such as the Department of Natural Resources & Environment, Department of Agriculture & Rural Development, Management Board of National Forests, Protected Areas to collect data on natural resources (forests, coral reefs, wetlands, mangroves, biodiversity, national parks, etc.), agriculture, aquaculture, tourism together with land-use maps, residential maps, etc. and regional master plans, environmental impacts assessment reports, details on capacity of provinces to respond to oil spills.

Besides, Geological Mapping Division was cooperated to digitise the baseline maps and update the shoreline conditions whereas the Department of National Remote Sensing was consulted for advanced analysis of satellite imagery using python; Ground verifications were also conducted to confirm grain-size classifications for sedimentary substrates [5].

On the other hand, socio-economic surveys were conducted to gather the information on non-living resources that may be directly injured by oiling; managed areas that may suffer economic damages, e.g., through interruption of use if oiled; and areas that may be valuable in the event of a spill for access or staging activities [5]. Those include:

- Worked with People's Committee to identify tourism, recreation areas, port, infrastructures; industrial activities (relying on

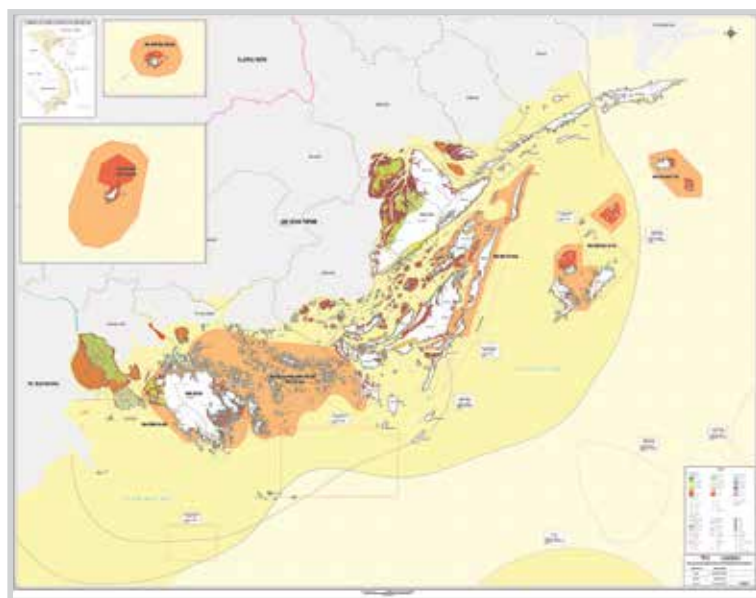


Figure 9. Environmental sensitivity map for islands in Quang Ninh province, Hai Phong city, Quang Tri province in 2018 [13].

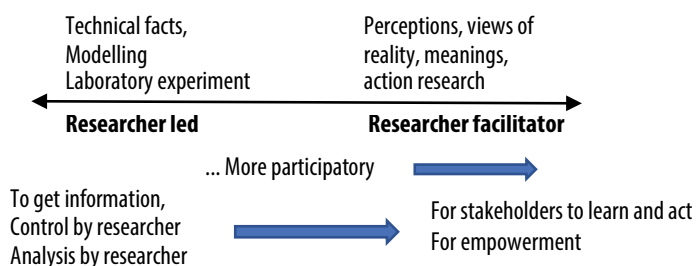


Figure 10. Behaviour and attitude [17].

maritime transport); infrastructures related to oil exploration, production, and transport activities; and cultural sites (archaeological, historical, religious, etc.).

- Interviews with local communities focusing on incomes, income sources; livelihoods, for example: aquaculture activities (farm species, methods/areas of cultivation, farming seasons, water intake location, annual production, number of household members involved), fishery activities (fishing areas/routes, distance from shore, fishing methods, fishing depth, fishing seasons, fishing species, number of fishermen, boat capacity); salt production activities, impacts of offshore oil and gas activities/oil spills, impacts of environmental incidents (typhoons, tsunami, etc.) (if any); In mapping socio-economic components, the concentration is to locate the activities and areas potentially suffering the most impacts.

The final step was employing the Raster Calculator of ArcGIS¹ to adjust the environmental sensitivity indexes. All layers were assigned class ranks that range from low to high, where the lowest represents

Table 2. Comparison between practices and theory under the spectrum of knowledge system

	The theory			Practices		
Stage 1: Identification of shoreline types and its sensitivity	Classification through existing topographic or thematic maps and studies; remote sensing data, local knowledge, etc. Ground trothing mission, socio-economic surveys to validate existing information and complete the information for the areas where no data is available.			Utilise the available data; Field surveys/Ground verification; Socio-economic surveys.		
	Public knowledge	Local knowledge	Scientific knowledge	Public knowledge	Local knowledge	Scientific knowledge
Stage 2: Compiling biology, human-use resource information	Biologists, resources managers compile biological and human-use (socio-economic) resources onto maps and data tables for data entry.			Done by scientists.		
	Public knowledge	Local knowledge	Scientific knowledge	Public knowledge	Local knowledge	Scientific knowledge
Stage 3: Ranking, prioritising sensitive sites and resources at risk ²	The relative ranking of sensitive assets desires broad stakeholder engagement to understand the demands and concerns of those affected by decisions, specifying a set of agreed criteria. Therefore, a steering group consisting of the potential users of the maps may also be set up to ensure the involvement of the key stakeholders [5]. Methods to rank the sensitivity information as shown in Table 1.			Consult more advice, opinions from the People’s Committee, local governmental agencies for ranking/AHP Raster Calculator of ArcGIS		
	Public knowledge	Local knowledge	Scientific knowledge	Public knowledge	Local knowledge	Scientific knowledge

¹ ArcGIS is a family of client software, server software, and online geographic information system (GIS) services developed and maintained by Esri, an international supplier of GIS software, web GIS and geodatabase management applications. The company is headquartered in Redlands, California, the USA.

² Ranking the sensitive ecosystems and natural resources in the context of oil industry, sensitive natural resources may depend on their recovery time after a spill. Existing classifications or lists can also be used to rank them: IUCN red list (conservation status and distribution information on endangered species), lists of rare, endangered and threatened species and habitats, etc. The likelihood of impact must be considered. The sensitivity ranking may include managed areas, e.g. low to medium sensitivity for local protection status, medium for national status and high for international status [5].

the least suitable condition (highest oil spill risk) and the highest - the most suitable condition (lowest oil spill risk) [14]. Analytic hierarchy process (AHP) was handled via quantifying criteria and alternative choices for relating those elements to the overall goal. AHP process represents an approach to quantifying criteria and options that traditionally are difficult to measure with numbers. Inputs can be obtained from actual measurements, such as price, weight etc., or from subjective opinions such as feelings of satisfaction and preference. The paired comparison matrix is established for the eigenvector as the priority. The AHP can be implemented in 3 consecutive steps: i) weight of the criteria vector, ii) matrix of option scores, iii) ranking of options. Having all stakeholders weigh in is important as various divisions will value criteria differently [15].

4. Discussion

To conceive the gap in terms of utilising local knowledge between practices and the theory, an in-depth comparison is made as follows.

From the perspective of knowledge management, Stage 1 is a synthesis of scientific knowledge, public knowledge and local knowledge. In Stage 2, there are basically scientific knowledge, public knowledge as the centre is biologists, resources managers who compile and edit environmental sensitivity index (ESI) data. In Stage 3, the sole use of automated computer-aided methods is not advisable since the environmental sensitivity prioritisation should be done through consensus building with the main stakeholders of the contingency planning process. The prominent players are resource managers and governmental agencies, the importance of local communities is implicitly mobilised in this phase. In theory, the knowledge system has been harmonised in building up environmental sensitivity maps along with the presence of local knowledge in almost three stages. In practice, due to certain circumstances, local knowledge has only been engaged at the beginning, public knowledge has been lacked in the middle stage;

scientific knowledge seems to be dominant through the whole procedure.

Conventional approaches imply that development processes always drive for technology dissemination from places that are perceived to be more advanced. This practice has often led to overlooking the potential of local experiences and practices [16]. In the past, local knowledge was regarded as having little value for research method development. In fact, recognition of the existence and value of local knowledge, often collected over generations, in addition to the prerequisite for its adequate connection into research and development, have grown immensely in the last two decades. This rising interest can be attributed to: (i) the growing importance of local knowledge in defining research agenda; (ii) the realisation that local knowledge is a useful source which can be complementary to scientific knowledge and public knowledge [16].

Researchers lead refers to the fact that information is controlled, analysed by researchers (based on technical facts, modelling, laboratory experiments). Whereas Researchers facilitate implies for stakeholders to learn and act, for empowerment (owing to views of reality, meanings).

Despite the research agenda and various conditions, it is necessary to leverage local knowledge up to a basis with reference to researcher facilitation. Among the above cases, local knowledge is only the vital element of data input to structure environmental sensitivity maps, investigate shoreline types and its sensitivity. Participatory tools such as participatory landscape analysis (PaLA³) might be considered in scoping studies that can inform more detailed subsequent analysis of specific functions and issues. In relation to ranking, prioritising sensitive sites and resources at risk, AHP has played a primary part. However, a wider range of participants entailing the grassroots level is fundamental, not only the People's Committees but local governmental agencies also as they represent public knowledge in the knowledge system.

³Participatory Landscape Appraisal (PaLA) developed by World Agroforestry Center (ICRAF) is a diagnostic tool of the issues in a landscape, helps document a process of participatory appraisals of local concern - farmers as research partners. The technique is holding group discussions with unique tools to capture local knowledge at relevant temporal and spatial scales. At the district level, the participants are head of district people's committee, district cadastral officer, agriculture officer, meteorology and hydrology officers, head of communal people's committees, cadastral and agriculture officers of each commune. At communal level, the attendants are Head of communal people's committee, cadastral officers, agriculture officers, head of all villages. At the village level, people are selected based on criteria, for example: experiences in cultivation/fishery; being representatives for ages, genders, living standards of households. The village history, timeline for hotspots, seasonal calendar (specific months of cultivation, fishery) with major changes overtime related to the coastal lines, water resource and people's livelihoods are drawn by the inhabitants. Researchers then support them to outline the problem trees to find causes and describe their own management options. The village sketch is also depicted from the native angle. Thanks to that, researchers design transect-walk along hot spots using Global Positioning System - GPS, which assists to increase accuracy and facilitate imagination during spatial analysis [17].

5. Conclusion

Developing environmental sensitivity maps is the complex methodology assembling both digital data, socio-economic surveys, and mathematical models, etc. The knowledge conveyed and transmitted in these maps is a result of effective interactions with distinct social and ecological contexts, significantly contributing to the research outcomes. Among environmental sensitivity maps implemented by Petrovietnam, the involvement of local knowledge is remarked as one of the data sources at the starting point and indirectly portrayed throughout the rest of the course. In favour of attaining indigenous perceptions for objective assessment, evaluation for promoting efficient integration with other types of knowledge, participatory tools, analytic hierarchy process with broader stakeholder engagement accommodating local people might be the options. This mechanism at the same time increases environmental sensitivity maps adoption in the planning, regulatory community in islands and coastal areas.

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