Moving from an integrated coastal management approach to a transdisciplinary coastal management approach: a review of case study in Indonesia

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Abstract. Coastal areas, small islands, and oceans play a vital role in the Earth's support systems, harboring rich biodiversity. However, human activities, both direct and indirect, pose significant threats to these ecosystems. In rural regions, traditional coastal area management practices like sasi, awig-awig, sea commanders, and establishing prohibited areas are often utilized. As communities evolve and activities intensify, management strategies have shifted from community-based approaches to sectoral management, which has proven ineffective in ensuring resource sustainability.The concept of Integrated Coastal Management (ICM) emerged in the early '90s as a collaborative approach involving various sectors, disciplines, and communities. Unfortunately, initial attempts at ICM encountered challenges and failed to adequately sustain resources and ecosystems. In response, a transdisciplinary approach to natural resource management has gained traction, focusing on holistic and sustainable solutions.This paper aims to review Indonesia's experiences in coastal and small island management, drawing insights from existing literature. It highlights the need for transdisciplinary research to address complex coastal challenges effectively. By integrating diverse perspectives and knowledge domains, transdisciplinary approaches can enhance the sustainable management of coastal areas and support ecosystem resilience.

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1 Introduction

Sectoral management proved inadequate for maintaining resource sustainability. In the early '90s, an alternative collaborative approach, Integrated Coastal Management (ICM), was introduced to achieve sustainability, and widely implemented globally [1]. ICM replaced the ineffective sectoral approach, aiming to address complex issues in coastal and ocean management through the integration and harmonization of laws, policies, and stakeholder cooperation [2]. Despite involving various sectors, experts, and communities, ICM faced challenges, including overlapping laws, insufficient community participation, and conflicts of interest in land use. In recent years, a transdisciplinary approach to natural resource management has been developed to ensure their sustainability.

Human activities in managing natural resources need to be equipped with knowledge about the health of ecosystems. This knowledge becomes the basis and is an inseparable unity between human relations and nature, the relationship between human activity and natural processes that have an impact on environmental problems, pollution, and environmental/ecosystem health [3]. At the same time, various human activities, such as fishing (overfishing, ghost net), transportation (pollution), settlement and regional infrastructure (land conversion, reclamation), oil and gas mining, forestry, tourism, and agriculture (pesticides) have shown several indicators of problems in marine resource management that have a direct or indirect negative impact on this ecosystem [4]. Apart from that, global problems such as climate change, rising sea levels, and global warming also threaten the biological resources of coastal areas and small islands which are dynamic. Human health and well-being, as well as ecosystem health, are integral and cannot be separated. Coastal areas, small islands, and oceans are one of the earth's buffer systems, in which 70% of the earth's surface is covered by water. Indonesia as an archipelagic country has high biodiversity, which is very important in supporting human life [5].

In several areas of Indonesia that have not developed rapidly, management is carried out with a local wisdom approach, including *Sasi*[1] in Maluku and in Saparua; *Awig-awig*[2] in Bali, Nusa Tenggara, Lombok Timur [6][7]; Management of Coastal Waters of Tanjung Barari Village in Biak; The Way Muli FAD (Fish Aggregation Device) system in Lampung; Management of Lake Sentarum in East Kalimantan; Coral Reef Management in Jemluk Bali; Panglima Laot and Management of Singkil Swamp in Nangroe Aceh Darussalam; *Lubuk Larangan*[3] in Jambi, West Sumatra [7]; *Eha and Mane'e*[4] in North Sulawesi [8]; *Petik Laut*[5] in Banyuwangi [9] and many other examples of local wisdom. However, the development of coastal areas has become more complex, witnessing a shift from local community management to sectoral management. This sectoral management, often government-based, centralizes authority, impacting resource management. Economic development influences management shifts, causing problems such as overlapping regulations, insufficient community participation, and conflicts over coastal resource usage [10].

[1] A traditional fisheries management system that originated in Indonesia, particularly in the Maluku Islands

[2] A term used in the context of traditional governance and customary law in Indonesia particularly in Bali and other regions of Nusa Tenggara

[3] A local wisdom approach to sustainable fisheries management, often rooted in the traditional knowledge and practices of the local communities from Jambi

[4] The local wisdom and traditional knowledge of coastal communities in North Sulawesi for sustainable fishing.

[5] The traditional practice of seaweed cultivation in coastal areas.

Centralized management leads to ineffective rules, as they are not internalized in society, incurring substantial transaction costs for implementation and supervision, resulting in weak law enforcement [11]. Business permits granted by the central government may not consider regional and local interests, leading to problems like unclear legislation, overlapping policies, and conflicts of interest between regions. Despite efforts, sectoral management proves unsustainable in the long run [12]. The paper aims to review transdisciplinary coastal management, drawing insights from Indonesia's coastal and small island management experience and existing literature. It also outlines opportunities for cross-disciplinary research supporting sustainable management in this area.

2 Method

Collecting data in research through searching published scientific references regarding local wisdom, the concept of ICM, and coastal management with a transdisciplinary approach [13]. The main scope of the study focuses on evaluating the management of coastal and small islands based on local wisdom, the journey of implementing ICM in Indonesia, and the concepts of thought and practice of using a transdisciplinary approach in the management of coastal and small islands. The study in this research includes an assessment of the effectiveness of local wisdom; the implementation of the ICM program and the successful impact on the sustainability of natural resources and coastal ecosystems and human welfare; and concepts of thinking and practice of using a transdisciplinary approach in coastal and small island management.

This writing was conducted through meta-analysis using tools with Excel for database collection. Data and information based on the results of research studies were obtained from existing literature, namely scientific articles, papers, research reports, reports from related government agencies, and other research results published both online and offline [14]. In addition, this study is also enriched by the author's experience in coastal and small island management. This study uses global articles on management which are analyzed bibliometrically through http://connectedpapers.com to choose popular scientific articles. Sources of scientific articles are obtained from Google Scholar (http://scholar.google.com), Scopus (http://scopus.com), Science Direct (http://sciencedirect.com), and the database of Indonesian scientific literature “Sinta” (http://sinta.dikti.go.id).

3 Results and discussion

3.1 Description of coastal zone management in Indonesia

The management of coastal, small islands in Indonesia generally starts from local wisdom. Along with social and economic developments, there has been a shift in management in related sectors. Then in its development in 1985, the concept of ICM was developed. This paper reviews the journey of coastal and small island management in Indonesia, starting from local wisdom to ICM approach.

3.1.1. Community-based management

Coastal management in Indonesia originates from the local wisdom concept known as Hak Ulayat Laut (HUL), translated as sea tenure. This term, introduced by marine expert Laundsgaarde, denotes a system of mutual rights and obligations related to sea area ownership. Sea tenure involves multiple individuals or social groups utilizing and regulating the exploitation of the sea, preventing over-exploitation [15]. Indigenous peoples in

Indonesia have traditionally safeguarded the coast and enriched biodiversity, maintaining local wisdom and resource management. These rules, passed down through generations as customary law, are integral to coastal communities. The values of local wisdom and customary law that exist in various regions in Indonesia are considered to be quite effective in coastal management and the preservation of marine ecosystems from various destructive activities, including customary regulations and local wisdom (Table 1).

Local wisdom is quite effective in preserving natural resources in areas that are not yet open to the outside world and developing with increasingly complex activities because the community recognizes and obeys these regulations. The community is very wise in utilizing natural resources because they realize that their lives are very dependent on and united with natural resources. So that they obey the customary rules governing the use of these resources, because of a sense of shared ownership. As long as the area is not opened to the public with multi-stakeholders and complex activities, this local wisdom will be able to become a tool for sustainable natural resource management.

Table 1. Some local wisdom in Indonesia is related to coastal management and preservation of marine ecosystem resources [16].

Name of Local Wisdom	Region	Description of Local Wisdom
Panglima Laot	Province of Nanggroe Aceh Darussalam	Panglima Laot is a customary law that is used to maintain order in fishing and protect the lives of fishing communities living around the coast
Lebak Lebung Tradition	South Sumatra	Lebak lebung is a system for determining the management rights of public waters in the form of swamps, rivers which are places for growing fish
Sashi Customary Law	Maluku	Sashi is a customary law about the prohibition of entering, taking, or doing something in a coastal area that has been designated to be protected for a certain period.
Awig-awig Tradition	West Lombok, NTB	Awig-awig is a rule made based on community agreement for order and security in social life. Since ancient times, the people of West Lombok have known the rules relating to the utilization of coastal and fishery resources

Regrettably, local wisdom loses its effectiveness in developed areas with an influx of external immigrants, leading to increased complexity in problems. Typically, local wisdom is limited to application within local communities, leaving various emerging activities beyond the scope of customary law. In modernized regions, management responsibilities shift to the government through relevant sectors. During this transition, natural resources transition into open-access areas controlled by the government through licensing and permits for resource utilization.

3.1.2. Sectoral management

Coastal and marine management in Indonesia poses a significant challenge due to its global importance. Indonesia's coastal areas are recognized as vital hubs of biodiversity, hosting diverse marine and coastal species. One of the reasons is that Indonesia's coastal areas are very important for the world and are recognized as centers of diversity of natural resources for marine and coastal biota, including coral reefs, reef fish, mollusks, and mangroves [17][18]. The shift from local community to sectoral management accompanies the development of coastal areas. Being an archipelagic country, Indonesia's geographical composition is predominantly coastal and marine. Authority over these areas, as outlined in Law No. 32 of 2004 on Regional Government, leads to differences in regional perceptions

and coordination challenges, exacerbated by Indonesia's government system that often fosters sectoral management.

Sectoral management, while successful in sidelining local wisdom, lacks robust supervision and coordination. Entrepreneurs, holding permits to exploit resources, often exploit them extensively before permit expiration. Concern for resource sustainability is minimal, as these entrepreneurs are not entirely dependent on these areas and resources. The economic concept of maximizing profit before competitors intervene prevails. Weak supervision by the relevant government sector issuing permits contributes to this area becoming open access, intensifying resource exploitation.

The inadequacy of sectoral management is evident in its failure to ensure natural resource sustainability. The complexity of coastal activities, involving multiple sectors with conflicting interests, renders sectoral management irrelevant. Diverse spatial utilization becomes a serious issue that, when not managed integratively, leads to conflicts. Sectoral management results in varied policymakers and fragmented operational schemes within the same geographic space, each with different agendas. This situation hinders collaborative problem-solving.

3.1.3. Management with an integrated approach

Coastal and marine management in Indonesia originated in response to the 21st Global Agenda, as outlined in Indonesia's 1996 Agenda 21. The principles of Integrated Coastal Management (ICM) were subsequently formalized through legal rules. Law No. 27 of 2007 regarding the Management of Coastal Areas and Small Islands serves as a key reference for establishing legal instruments to implement integrated marine resource management across policies, regulations, and institutions [19].

ICM was internationally recognized in 1992 and has since been widely adopted by nearly all coastal countries worldwide [17]. The concept of integrated management has been present in maritime policy dialogues, both nationally and internationally, for at least 40 years. The 1982 Law of the Sea Convention preamble emphasized the importance of treating oceans and their resources as a unified whole. However, the development of regulatory instruments for integrated management has been a recent and challenging endeavor. Despite its conceptual simplicity, translating these goals into practical measures, policy instruments, and regulations proves complex, especially in the context of contested resources, evolving industries, varying scales of action, and societal complexities. Territorial issues in coastal management are increasingly difficult to resolve. Integrated coastal management is defined as an ongoing decision-making process aimed at the sustainable use, development, and protection of coastal land and sea areas and their resources [20].

ICM, as a policy process, encompasses key phases, including planning, development, implementation, monitoring and evaluation, and adaptation (**Fig.** 1). It serves as an umbrella term for various processes, tools, and related concepts like Ecosystem-Based Management (EBM), Marine Protected Areas (MPA), Marine Spatial Planning (MSP), and Integrated Coastal Zone Management (ICZM). Despite the recognition of governance structures (e.g., policies, institutional arrangements) in ICM analyses, [21] emphasizes their relevance while acknowledging that they do not guarantee the long-term sustainability of the initiative or its contribution to the desired social-ecological outcome [22].

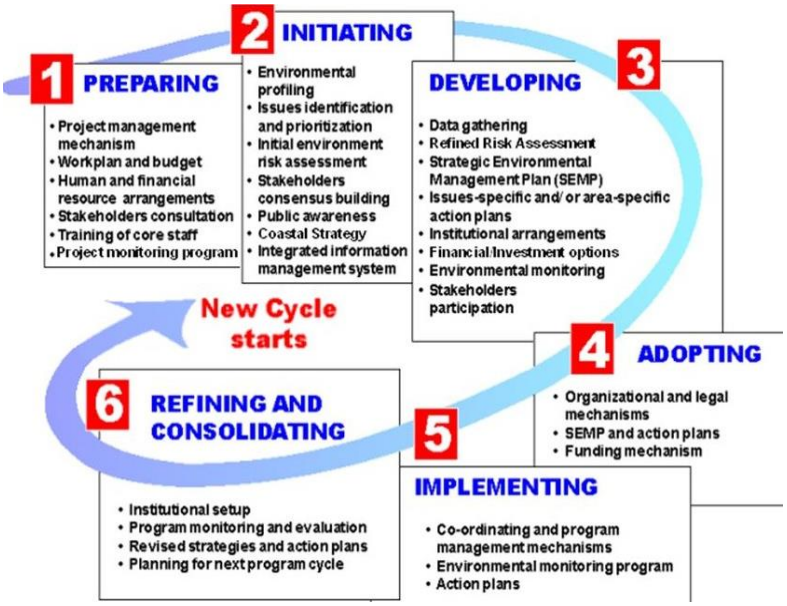

Fig. 1. ICM Development Cycle and Implementation (Source: taken from PEMSEA, 2007)

To ensure the success of ICM initiatives, adaptability in overarching governance is often crucial. This may involve the creation of new formal structures and innovative mechanisms that enhance both horizontal and vertical linkages. Attention is needed to build momentum for an integrated approach, including within various government branches and through active participation from state and non-state actors. Clear expectations about the role of ICM and the mechanisms to achieve it should be established, incorporating structures that facilitate collaboration and coordination.

3.2 Roadmap for integrated management of coastal areas in Indonesia

The management of coastal areas by the government in Indonesia began in 1985. This management is part of several ICM initiation programs both at the Asia Pacific level which have been implemented in several countries with coastal areas. Coastal Resources Management (CRM) sub-projects in Brunei Darussalam, Indonesia, Malaysia, the Philippines, Thailand, and Singapore through USAID funding in 1985-1992. The GEF/UNP/IMO Project program was attended by 11 countries from 1993-1999. PEMSEA Program (Partnership in Environmental Management for The Seas of East in 1999—2008.

Table 2. Coastal Zone Management Activities

Project Name/Period	Source of funds/executing agency	Goals/Targets	Achievements	Output
Indonesia's Marine Environment: A summary of policies, actions, and issues/1988	Government and CIDA /Bapenas, KLH, CIDA	Examining marine policies, activities, and issues for the initial basis for the development of marine programs in Indonesia	Accommodation of problems and management of coastal and marine resources in national development policies (REPELITA VI:	Document: Indonesia's Marine Environment: A summary of policies, actions, and issues

Project Name/Period	Source of funds/executing agency	Goals/Targets	Achievements	Output
			Marine Sub-sector in 1993/19940)	
M, REP/ 1993-1998	ADB/dirjen Bangda	Evaluation of Indonesia's marine resources	Identified and documented Indonesia's marine resources	Establishment of a marine data and information center (with skilled human resources and adequate facilities) at the regional level to become a pilot project
Proyek Mitra Pesisir/ Coastal Resources Management Project (CRMP)/ 1997-2003 (Tahap 1)	USAID/ CRC-IPB	Decentralize and strengthen the institutional management of Indonesia's coastal resources	Realization of a measurable ICM activity	The formulation of coastal strategic plans using a bottom-up approach in three provinces and ten coastal provinces.
Proyek Mitra Pesisir/ Coastal Resources Management Project (CRMP)/2003-2005 (Tahap 2)	USAID / IRG (International Resources Group)	Partnership development with stakeholders	ICM development is not based on project consultants but rather on partnerships	The establishment of partnerships in the development of the ICM program.
MCRMP/ 2002-2007	ADB/DKP	Improving and increasing sustainable management of natural resources for the benefit of environmental protection and socio-economic development within the framework of government decentralization in fifteen provinces.	Provide access to spatial data and other planning information, improve legal and regulatory frameworks for management and enforcement, and implement small-scale resource management investments for improving socio-economic conditions and ecosystems in coastal habitats.	Determination of the concept of institutionalization of ICZPM, basic maps of coastal and marine areas, and establishing law enforcement mechanisms.

ICM initiatives in the Asia Pacific have been implemented in various coastal countries. From 1985 to 1992, CRM sub-projects were conducted in Brunei Darussalam, Indonesia, Malaysia, the Philippines, Thailand, and Singapore, funded by USAID. The GEF/UNP/IMO Project involved 11 countries from 1993 to 1999. The PEMSEA Program (Partnership in Environmental Management for the Seas of East) was carried out from 1999 to 2008.

ICM initiatives in Indonesia have been implemented in various regions with diverse programs. From 1992 to 1995, the MERP (Marine Resource Evaluation and Planning) was initiated by the Directorate General of Bangda, Ministry of Home Affairs. From 1996 to 2003, the Coastal Resource Management Project (CRMP) operated in the provinces of Lampung, North Sulawesi, and East Kalimantan. In 2007, there was a District ICM Declaration in Bali Province. From 2004 to 2007, ICM initiated PEMSEA demo sites in the provinces of Bali and West Java (Sukabumi). Also, from 2004 to 2007, the Marine and Coastal Resource Management (MCRM) DKP RI was established in 2007 (Table 2).

3.3 Problems of coastal zone management with the ICM approach in Indonesia

The implementation of the ICM program in Indonesia follows the coastal management program project cycle [23], consisting of six stages as depicted in **Fig. 1**. Executed from 1997 to 2002, it comprised four program topics: (1) Documentation (1997-1999) involving early implementation actions, provincial working groups, and a general monitoring framework. (2) Marine protected areas, environmentally friendly pond development, and management area profile preparation were covered in the second year (1999-2000). (3) The third year (2000-2001) focused on preparing management plans at three administrative scales and co-management. (4) The fourth year (2001-2002) involved the implementation process of the management plan, discussing efforts to institutionalize coastal management at each project location [24].

The implementation of ICM in Indonesia falls short of optimal results because the integrated management concept is only partially realized through a multi-disciplinary approach. Some problems observed include: (1) Regional commitment varies due to differing capabilities and perceptions within built systems. (2) Support from high-level decision-makers remains suboptimal and requires comprehensive attention. (3) Trained staff for future assignments often lack alignment with their abilities, hindering proper management program implementation. (4) Obstacles in system development and public policy arise from imbalances in specific sub-systems, making it challenging to achieve synchronization in program implementation. Each sector's interests create difficulties in implementing coordination functions.

The learning outcomes from applying ICM in Indonesia have yet to fully address the evolving complexity of coastal and small island management. While a transdisciplinary approach has started to emerge in land-based natural resource management, its implementation in coastal and ocean management in Indonesia is still limited. The potential of transdisciplinary methods to tackle the challenges posed by the intricate nature of coastal and ocean management, along with the necessary supporting components, will be further explored in the subsequent discussion [25].

3.4 Management with transdisciplinary approach

Transdisciplinarity integrates and transforms diverse knowledge from various perspectives to enhance understanding of complex issues for sustainable decision-making [26]. Unlike a scientific discipline, transdisciplinarity is an approach to augment knowledge by integrating and transforming diverse perspectives [27]. It involves studying complex problems by integrating and transforming various disciplines, making its application unique [28].

A transdisciplinary approach, based on perfect integration and collaboration, offers an alternative for sustainable management in coastal and marine areas. It involves studying and researching problems using perspectives from various disciplines, ensuring comprehensive problem-solving from discussion to conclusion. Unlike interdisciplinary, multidisciplinary, cross-disciplinary, and intradisciplinary approaches, which maintain segmented disciplines, the transdisciplinary approach emphasizes integration and transformation, facilitating knowledge transfer and interdisciplinary iteration [29].

The Transdisciplinary Coastal Management (TCM) approach is a concept and strategy proposed for the integrated management of complex coastal areas and small islands. With a multitude of activities and uses in these areas, conflicts may arise, including threats to vulnerable ecosystems (coral reefs, sea grass, and mangrove ecosystems), marine waste and pollution, ecotourism, the fishing industry, transportation services, fishing, research, coastal cultivation, ports and shipping, settlements, oceanographic dynamics, estuaries, and rivers. An example of research employing a transdisciplinary approach, as conducted by [28], focuses on sustainable mangrove management through cross-disciplinary integration and transformation.

Several case studies in Indonesia, such as the mangrove ecosystem management in Tongke-Tongke Province of South Sulawesi, the integrated management of coral reef ecosystems in Raja Ampat, and the proper utilization and management of several islands, have demonstrated the effectiveness of the transdisciplinary approach [30]. These studies, including research on adaptation and climate change [30], emphasize the success of Transdisciplinary Coastal Management (TCM) as an ecosystem-based management (EBM) that integrates science [31]. Unlike Integrated Coastal Management (ICM), TCM not only integrates various disciplines but also transforms, creating a new, merged approach illustrated in **Fig.** 2.

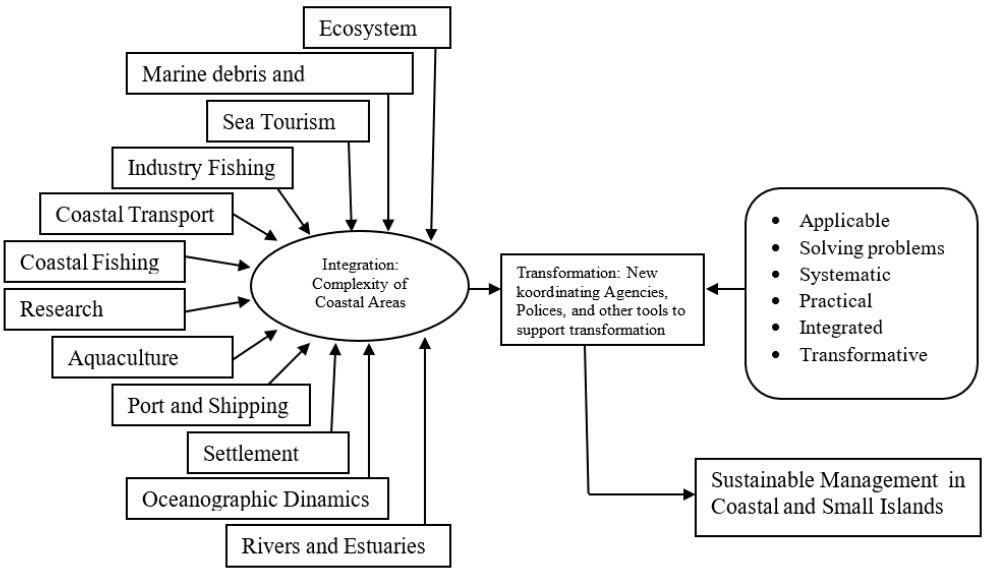

Fig. 2. Use of Transdisciplinary Approach in the Complexity of Coastal Areas

Stakeholder component, the results remain as separate disciplines without undergoing a transformation process. The Transdisciplinary Coastal Management (TCM) approach, on the other hand, not only integrates various disciplines but also emphasizes the transformation process. This transformative aspect allows for a more comprehensive and unified

understanding of the complex issues in coastal areas and small islands, leading to more effective and sustainable management practices.

In the Integrated Coastal Management (ICM) approach, stakeholders contribute their expertise in the planning phase, but there is a lack of transformation in its implementation. After the stakeholders return to their respective institutions, the plans remain within their disciplines, resulting in a lack of integrated perspective during implementation. Conflicts arise as each sector considers only the scientific input relevant to its interests. In contrast, the transdisciplinary approach views complex issues in coastal areas and small islands as a unified whole. It advocates for integrated solutions that are transformed into a unified package, even though practical implementation involves various sectors based on their roles and functions. This approach aims to address complex problems through a unified lens.

The study of coastal vulnerability and seawater inundation using a transdisciplinary approach has yielded indicators for predicting future events [29]. Adopting a transdisciplinary approach in management serves as a beneficial roadmap with several advantages: (1) Applicability, as it involves various fields of knowledge related to managing coastal areas; (2) Solutive, preventing conflicts and overutilization by accommodating all stakeholders' interests based on scientific analysis; (3) Systematic, decision-making based on multi-parameters from various sectors of interest; (4) Efficiency, achieving management principles more quickly through collaborative problem-solving; and (5) Practicality, addressing common problems collectively, creating knowledge, and reapplying it efficiently. Creating a transdisciplinary approach model can begin within the scientific community, fostering collaboration through effective data and communication standards in interdisciplinary networks [32].

4 Conclusion

The research conclusions are as follows: (1) The management roadmap for coastal areas and small islands in Indonesia, spanning traditional to integrated approaches, has been implemented for decades. However, it has not been optimal due to the failure to adopt a solutive management concept for addressing the complex and dynamic issues in coastal areas. (2) The transdisciplinary approach emerges as the most suitable concept for sustainable management in addressing the complexity of problems in coastal areas and small islands. This approach, implemented through perfect integration and transformation, involves collaboration among various stakeholders, unifying them as a whole.

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