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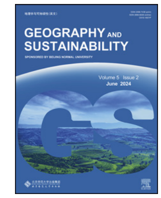

Review Article

Review of coastal land transformation: Factors, impacts, adaptation strategies, and future scopes

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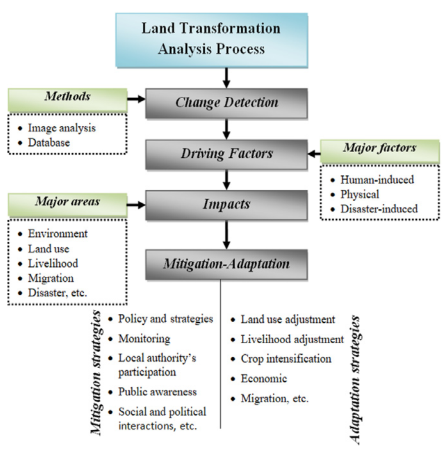
HIGHLIGHTS

- The land transformation process is presented systematically.
- The study suggests a framework for coastal land transformation.
- Population growth and urbanization are identified as the key driving factors.
- Lack of adaptation strategies is found in coastal land transformation research.
- Comprehensive systematic research in coastal land transformation is strongly suggested.

GRAPHICAL ABSTRACT



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ABSTRACT

Coastal land transformation has been identified as a topic of research in many countries around the world. Several studies have been conducted to determine the causes and impacts of land transformation. However, much less is understood about coupling change detection, factors, impacts, and adaptation strategies for coastal land transformation at a global scale. This review aims to present a systematic review of global coastal land transformation and its leading research areas. From 1,741 documents of Scopus and Web of Science, 60 studies have been selected using the PRISMA-2020 guideline. Results revealed that existing literature included four leading focus areas regarding coastal land transformation: change detection, driving factors, impacts, and adaptation measures. These focus areas were further analyzed, and it was found that more than 80% of studies used Landsat imagery to detect land transformation. Population growth and urbanization were among the major driving factors identified. This review further identified that about 37% of studies included impact analysis. These studies identified impacts on ecosystems, land surface temperature, migration, water quality, and occupational effects as significant impacts. However, only four studies included adaptation strategies. This review explored the scope of comprehensive research in coastal land transformation, addressing change detection, factor and impact analysis, and mitigation-adaptation strategies. The research also proposes a conceptual framework for comprehensive coastal land transformation analysis. The framework can provide potential decision-making guidance for future studies in coastal land transformation.

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1. Introduction

Land transformation is a change in land use and land cover that may involve a shift from one form to another or an intensification or modification of an existing one (Kaliraj et al., 2017; Siddik et al., 2018). It may be the key component of global change (Hooke et al., 2012) and has already altered about 60% of the global landscape (Ma et al., 2019; Xystrakis et al., 2017). Land transformation is the result of the interrelationship of quick population expansion, urbanization, industrialization, tourism, succession, cultural morality, property transfer, educational development, social and political conflict, war, and the direct or indirect effects of climate-induced natural hazards, including cyclones, storm surges, floods, sea level rise, water logging, etc. (Akhtar et al., 2018; Hasnat et al., 2018; Hooke et al., 2012; Kaliraj et al., 2017; Pham et al., 2021; Siddik et al., 2017, 2018, 2023).

Since the beginning of recorded history, and perhaps substantially towards future centuries, the global land transformation has undergone chronological and geographical changes (Idowu et al., 2020). The entire land area of Earth is about 510.072 million km^2, including 148.94 million km^2 (29.2%) of land surface and 361.132 million km^2 (70.8%) of water surface (World Bank, 2022). However, only a small part of the land surface remains in its primary form (Bhatta, 2010). The coastal area comprises about 620 thousand kilometers worldwide (NASA, n.d.). Both high economic growth and large population densities are vital characteristics of such places. More than 40% of the world's population lives within 100 km of the coast (Gopalakrishnan et al., 2019).

The massive population density causes aberrant coastal development. This significant proportion of the population is responsible for the frequent and rapid transformation of both public and private lands. These changes will continue because of the continuous increasing trends of the global population and associated factors, including urban area development, industrial concentration, tourism, etc. (Hawash et al., 2021; Liang et al., 2022; Tuan, 2022; Wardhani et al., 2022). The extent of urbanization and the repercussions it brings are more widespread in coastal areas, and this has an effect on both the availability and the level of quality of environmentally friendly natural resources (Devi and Nair, 2021). Land transformation is also considered the result of the construction of roads and bridges and the establishment of wetlands (Siddik and Rahman, 2022). Although it continues to take place for the improvement of societal life and well-being, it has an impact on a variety of other spheres that are intimately connected to human existence, such as the economy, food stock, livelihood, water quality, and climate change (Gani et al., 2023; Hanks et al., 2021; Hasnat et al., 2018; Idowu et al., 2020; Regasa et al., 2021; Siddik and Zaman, 2021).

The coastal land transformation has been identified as a topic of research in many countries around the world. First and foremost, numerous studies have emphasized the spatio-temporal change of coastal land use. However, this change was detected using several methods, for example, remote sensing (Datta and Deb, 2012; Tran et al., 2015; Yagoub and Kolan, 2006), GIS and remote sensing (Hawash et al., 2021; Kaliraj et al., 2017; Reis, 2008; Weng, 2002), and CORINE methodology (Kuleli and Bayazıt, 2022; Sönmez et al., 2009; Yılmaz, 2010). Other researchers (Rahman et al., 2017a, 2017b; Rahman and Esha, 2022; Rahman and Ferdous, 2021) focused on land use prediction. Moreover, few other researchers have focused on the driving forces or impacts of coastal land transformation. Devi and Nair (2021), for instance, investigated the connection between urbanization and coastal land transformation. Similar to this, Li et al. (2010) investigated the connection between industrial development and coastal land transformation. Some researchers focused on disaster-induced coastal land transformation (Hartanto and Rachmawati, 2017; Siddik et al., 2018; Tran et al., 2019). Additionally, Camacho-Valdez et al. (2014), Kankam et al. (2022), and Xu et al. (2022) assessed the effects of land transformation on coastal ecosystems. Similarly, the impact of coastal land use change on ecotourism (Wardhani et al., 2022), water quality (Chen et al., 2020), surface temperature (Chanu et al., 2021), agriculture (Hasnat et al., 2018), landslide risk (Reichenbach et al., 2014), and flooding risk (Hussein et al., 2020) were also explored.

From the preceding discussion, it is evident that many studies have been conducted to ascertain the factors that lead to and the effects of land transformation in coastal areas. However, to the authors' knowledge, no attempt has been made to conduct a critical review on coastal land transformation. The review aims to present a systematic critical review of global coastal land transformation and its leading research areas. Such a review is crucial for understanding the current state of knowledge and potential research directions on coastal land transformation. The objectives are to identify factors and associated impacts of land transformation in coastal areas, explore the strategies that have been followed to adapt to the impacts of land transformation in the coastal world, and identify the opportunities for further research in the fields of coastal land transformation.

This research will consider the following questions:

(1) What are the driving factors and impacts of land transformation in coastal areas worldwide?
(2) Which strategies have been followed to adapt to the effects of coastal land transformation?
(3) What are the most significant research gaps on coastal land transformation in the existing literature?

2. Materials and methods

2.1. Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 principles were followed for the current meta-analysis and systematic review (Page et al., 2021). The Scopus and Web of Science databases have been used to perform this systematic review. These databases have been acknowledged as being the most popular and reputable platforms for carrying out systematic reviews and meta-analyses of scientific productions that have been subjected to peer review (Singh et al., 2021). When searching for relevant literature, the Boolean operators "OR" and "AND" were used in various combinations. The main keywords used in this review are (a) land transformation/land use and land cover change/land use change and (b) coastal region/coastal/coast (Fig. 1).

2.2. Data eligibility criteria

This review set several inclusion criteria, including: (i) publication year between 2000 and 2022, (ii) original research article about land transformation in the coastal region, and (iii) final or finished production considering the English language. This review, on the other hand, took into account a number of criteria for excluding studies. These criteria included: (i) duplicate papers; (ii) publications that were not the result of original research; (iii) languages other than English; (iv) global or regional focus; (v) not focused on land transformation or focus other than land transformation issue; (vi) partial land transformation focus, for example, focused on forest cover change or urbanization; and (vii) partial coastal area focus, for example, used coastal area as a part of the whole study area (e.g., coastal and inland area). These inclusion and exclusion criteria were used to find out the relevant records to carry out this systematic review with a concentration on land transformation in the coastal region.

2.3. Literature search results

This review considered the PRISMA-2020 guideline, where there are three main stages of desired literature inclusion: identification, screening, and inclusion (Fig. 2). In the first stage (identification), we identified a total of 1,741 records from two widely used databases, i.e., Scopus (n = 1,039) and Web of Science (n = 702). After that, we performed a duplicate check and removed a total of 234 records. The second

a) Scopus

TITLE-ABS-KEY (("Land Transformation" OR "Land Use and Land Cover Change" OR "Land Use Change" OR "LULC") AND ("Coastal Region" OR "Coastal" OR "Coast")) AND (EXCLUDE (SUBJAREA, "ENGI") OR EXCLUDE (SUBJAREA, "COMP") OR EXCLUDE (SUBJAREA, "ENER") OR EXCLUDE (SUBJAREA, "BIOC") OR EXCLUDE (SUBJAREA, "MATH") OR EXCLUDE (SUBJAREA, "AGRI") OR EXCLUDE (SUBJAREA, "PHYS") OR EXCLUDE (SUBJAREA, "BUSI") OR EXCLUDE (SUBJAREA, "ECON") OR EXCLUDE (SUBJAREA, "MEDI") OR EXCLUDE (SUBJAREA, "MATE") OR EXCLUDE (SUBJAREA, "CHEM") OR EXCLUDE (SUBJAREA, "CENG") OR EXCLUDE (SUBJAREA, "PHAR") OR EXCLUDE (SUBJAREA, "IMMU") OR EXCLUDE (SUBJAREA, "NEUR") OR EXCLUDE (SUBJAREA, "HEAL") OR EXCLUDE (SUBJAREA, "PSYC") OR EXCLUDE (SUBJAREA, "VETE")) AND (EXCLUDE (PUBYEAR, 1999) OR EXCLUDE (PUBYEAR, 1998) OR EXCLUDE (PUBYEAR, 1997) OR EXCLUDE (PUBYEAR, 1996) OR EXCLUDE (PUBYEAR, 1995) OR EXCLUDE (PUBYEAR, 1994) OR EXCLUDE (PUBYEAR, 1993) OR EXCLUDE (PUBYEAR, 1992) OR EXCLUDE (PUBYEAR, 1991) OR EXCLUDE (PUBYEAR, 1990) OR EXCLUDE (PUBYEAR, 1989) OR EXCLUDE (PUBYEAR, 1988) OR EXCLUDE (PUBYEAR, 1987) OR EXCLUDE (PUBYEAR, 1986) OR EXCLUDE (PUBYEAR, 1984) OR EXCLUDE (PUBYEAR, 1981) OR EXCLUDE (PUBYEAR, 1980) OR EXCLUDE (PUBYEAR, 1979) OR EXCLUDE (PUBYEAR, 1978) OR EXCLUDE (PUBYEAR, 1976)) AND (EXCLUDE (DOCTYPE, "cp") OR EXCLUDE (DOCTYPE, "ch") OR EXCLUDE (DOCTYPE, "re") OR EXCLUDE (DOCTYPE, "bk") OR EXCLUDE (DOCTYPE, "cr") OR EXCLUDE (DOCTYPE, "no") OR EXCLUDE (DOCTYPE, "ed") OR EXCLUDE (DOCTYPE, "er") OR EXCLUDE (DOCTYPE, "le")) AND (EXCLUDE (LANGUAGE, "Chinese") OR EXCLUDE (LANGUAGE, "Spanish") OR EXCLUDE (LANGUAGE, "French") OR EXCLUDE (LANGUAGE, "Persian") OR EXCLUDE (LANGUAGE, "Portuguese") OR EXCLUDE (LANGUAGE, "Croatian") OR EXCLUDE (LANGUAGE, "German") OR EXCLUDE (LANGUAGE, "Italian") OR EXCLUDE (LANGUAGE, "Slovenian")) AND (EXCLUDE (SRCTYPE, "p") OR EXCLUDE (SRCTYPE, "b") OR EXCLUDE (SRCTYPE, "k") OR EXCLUDE (SRCTYPE, "d")) AND (EXCLUDE (PUBSTAGE, "aip"))

b) Web of Science

((“Land Transformation” OR “Land Use and Land Cover Change” OR “Land Use Change” Or “LULC”) AND (“Coastal Region” OR “Coastal” OR “Coast”))

Fig. 1. Search string including a) Scopus, and (b) Web of Science platforms.

stage (screening) included three main sections: records screened, reports sought for retrieval, and reports assessed for eligibility. After checking the title and abstract, 1,117 records were excluded out of 1,507 records during the records screening. The main reasons for exclusion were the wrong publication year, review paper, global or regional focus, general focus on land use and land cover, and partial focus on coastal areas. Seven records were not retrieved in the second section out of 390 screened records. For eligibility checking, we had 383 papers in the third section of the second stage of the PRISMA guideline. These records were selected for full-text review. After reviewing 383 full texts, 323 records were excluded following the exclusion criteria described in the data eligibility criteria section. Finally, 60 papers were selected for this systematic review in the included stage.

3. Results

3.1. Spatial and temporal distribution of the earlier literature

Fig. 3 shows the number of scientific publications by year and country. This review identified 17 relevant production years out of a total of 23 screened years (2000–2022). The publication years 2000, 2001, 2003, 2007, 2011, and 2016 were not considered because there was no relevant scientific production throughout those years. This study found an almost increasing trend in production during the study period. There were three publications in the first production year of 2002, which finally increased to ten in the year 2022, with an average output of 3.5 per year and an average annual growth of 6.20%.

This study covered 60 scientific studies that were conducted in 23 different countries. Forty-three of the studies were carried out in eleven Asian countries, six in four African countries, four in four European countries, two in two North American countries, and five in two South American countries. The overall average of the studies was determined to be 2.6, while the average of the studies conducted in Asian countries was 4.6. Among the Asian countries, the highest numbers of studies were found in Turkey, with a total of 12. China follows with nine, while Bangladesh and India both have five studies each. Conversely, only one study was carried out in some other countries, including Algeria, Bahrain, Brazil, Chile, Egypt, Greece, Indonesia, Italy, Poland, Saudi Arabia, Spain, and Thailand. Meanwhile, Ghana, Iran, Mexico, Nigeria, the UAE, the USA, and Vietnam have represented multiple studies.

3.2. Leading focus areas of the studies

The supplementary Table S1 shows the study-wise leading focus areas with details. This review identified four leading focus areas incorporated into the selected 60 scientific studies conducted in the different countries of Asia, Africa, Europe, North America, and South America. It was discovered that the primary emphasis of all studies was the identification of coastal land transformation, which may be referred to as change detection (detail description in Section 3.3). In addition, 26

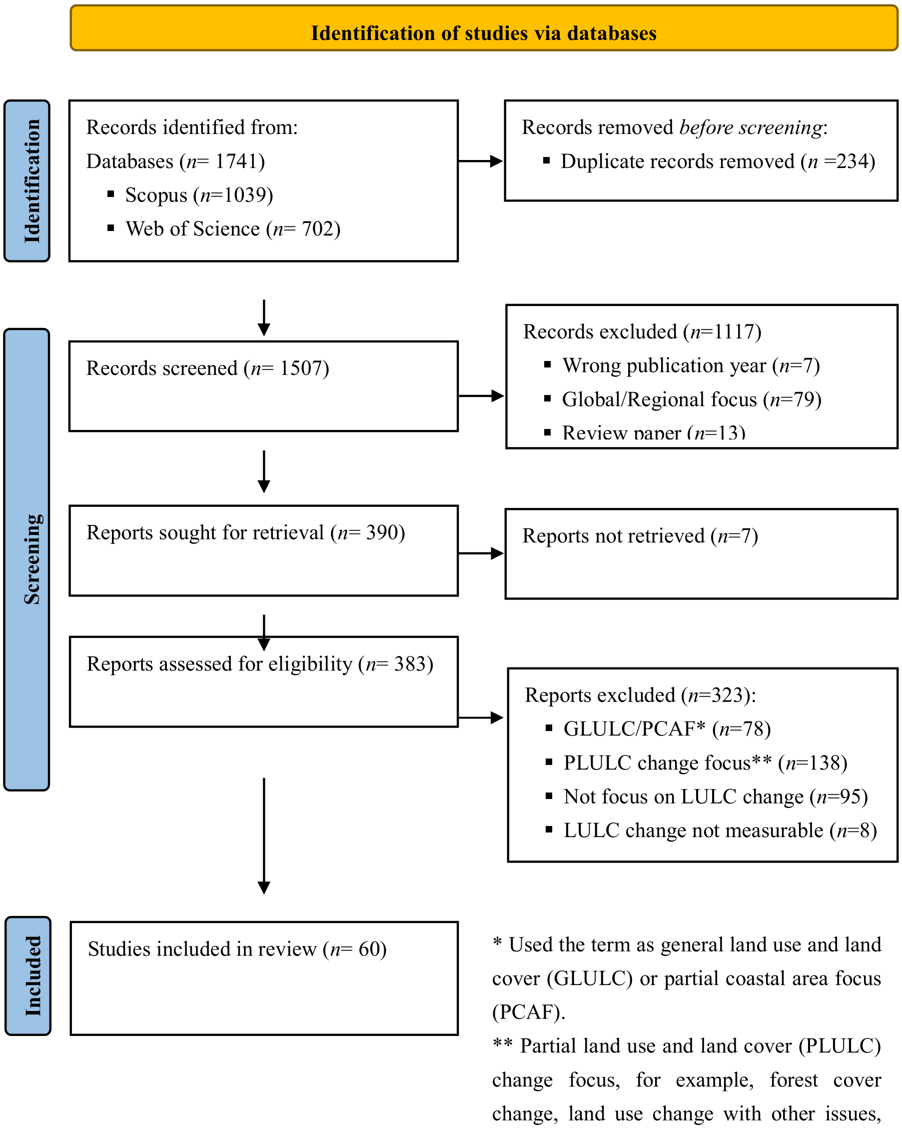

Fig. 2. Identification of relevant studies using the PRISMA guideline, including three stages i.e., (i) the identification stage indicates the total number of available records in the databases (here, Scopus and Web of Science), (ii) the screening stage includes records screening, retrieval, and assessment for eligibility, and (iii) the included stage includes selected records for performing the systematic review.

studies included factor analysis linked with changes in land use and land cover (detail description in Section 3.4), and 21 studies covered impact analysis associated with these changes (detail description in Section 3.5). Moreover, only four of the studies discussed adaptation measures to cope with the effects of coastal land transformation (detail description in Section 3.6).

3.3. *Identification of coastal land transformation*

Land transformation is the process of changing land use and cover. This can be accomplished by shifting to a new kind of land use or by intensifying or modifying an existing land use. In the selected studies, land transformation was computed by analyzing images from different satellites, including Landsat, SPOT, ASTER, GeoEye, IKONOS, QuickBird, Sentinel, ALOS, RapidEye, WorldView, and Resourcesat. Aerial photographs, OpenStreetMap, topographic maps, and several databases were also used. It has been identified that the Landsat satellite image is the most often used satellite image for assessing land transformation. Nearly 86.7% of the research included the use of Landsat satellite imagery, with 71.7% of the studies using Landsat satellite imagery exclusively and 15% combining images from other satellites (Table 1).

Table 1
Data used in identifying coastal land transformation in the reviewed studies ($N = 60$).

Change detection method	Frequency
Landsat image	52 (86.7%)
Aerial photograph	6 (10.0%)
SPOT image	5 (8.3%)
Database	3 (5.0%)
ASTER image	2 (3.3%)
GeoEye image	2 (3.3%)
IKONOS image	2 (3.3%)
QuickBird image	2 (3.3%)
Sentinel image	2 (3.3%)
ALOS image	1 (1.7%)
OpenStreetMap	1 (1.7%)
RapidEye image	1 (1.7%)
Resourcesat image	1 (1.7%)
Topographic map	1 (1.7%)
WorldView image	1 (1.7%)

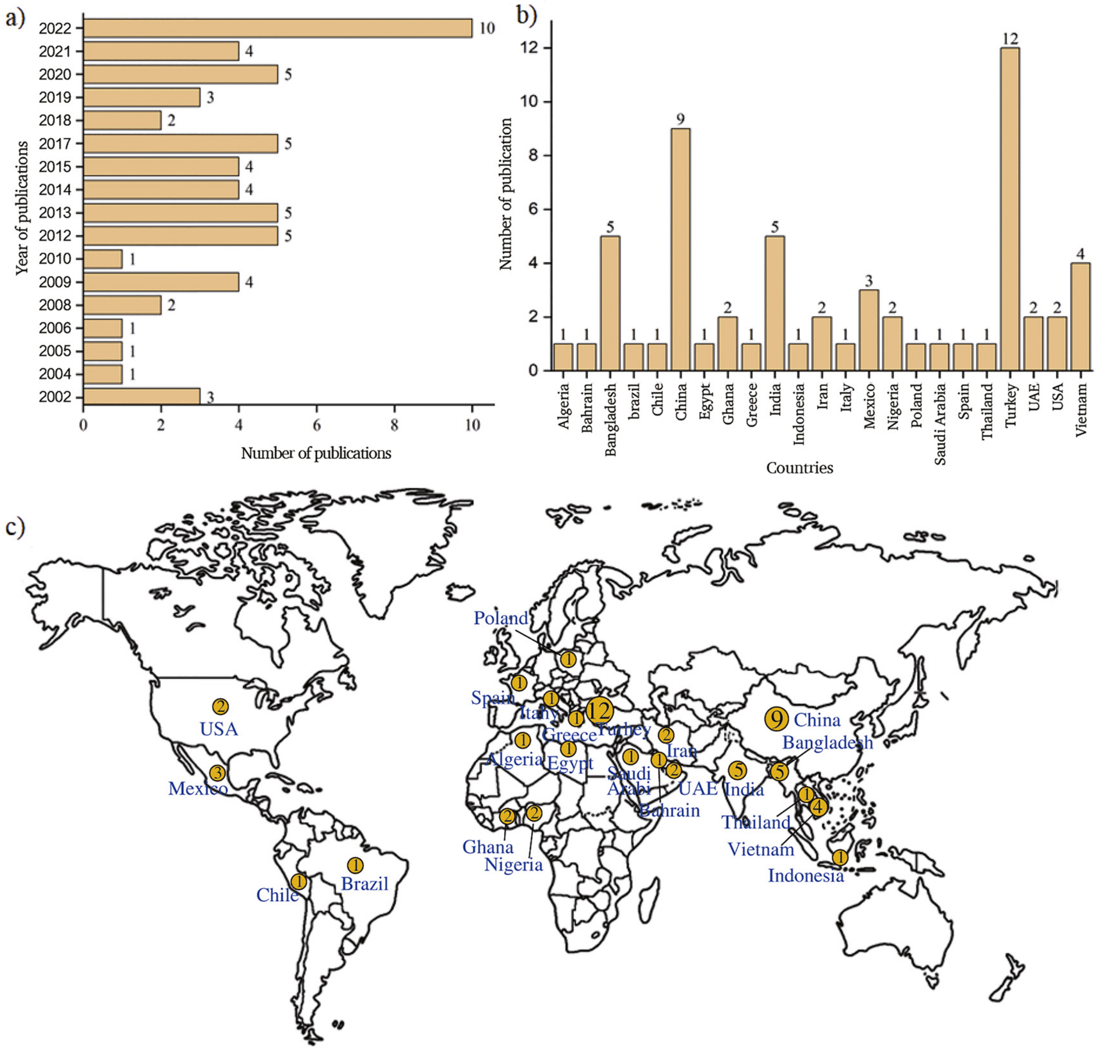

Fig. 3. Scientific publication of documents (a) the annual publication from 2002 to 2022; (b) and (c) present the number of publications by countries.

3.4. Driving factors of coastal land transformation

This review explored 41 different driving factors for coastal land transformation from the selected 60 studies. Fig. 4 shows a word map of the associated factors of coastal land transformation. It can be assumed that disasters, population, urbanization, topography, tourism, planning policies, construction, industrialization, migration, climate change, distance from the coastline, etc. were the main factors in coastal land transformation (details are presented in the supplementary Table S1).

Fig. 5 shows that nine driving forces have been found in five or more selected studies. These are population growth, urbanization, socioeconomic development, natural disasters, topography, tourism, planning policies, construction, and industrialization. Amongst them, population growth and urbanization were identified as the key driving factors of coastal land transformation in about 25% of the studies. In order to provide shelter to the additional population, people are constantly changing coastal farmlands, vegetation areas, saltpans, aquaculture areas, etc. and setting up their settlements (Cetin et al., 2008; Cinar, 2015; Kaliraj et al., 2017; Kankam et al., 2022; Kolios and Stylios, 2013; Kuleli and Bayazıt, 2022; Liang et al., 2022; Lin and Qiu, 2022; Mousazadeh et al., 2015; Pham et al., 2021; Rahman et al., 2017a; Rahman and Ferdous, 2021; Tran et al., 2015; Zhao et al., 2021; Zhu et al., 2012). It is evident that most urban people are engaged in secondary and tertiary economic activities. This process is considered a profound cause of irretrievably decreasing agricultural lands, water bodies, forest lands, saltpans, etc. (Avelar and Tokarczyk, 2014; Cetin et al., 2008; Cinar, 2015; Huang et al., 2009; Hussein et al., 2020; Kaliraj et al., 2017; Kolios and Stylios, 2013; Kuleli and Bayazıt, 2022; Kurt, 2013; Liang et al., 2022; Mousazadeh et al., 2015; Rahman and Esha, 2022; Sönmez et al., 2009; Zhao et al., 2021; Zhu et al., 2012). In addition, real estate development is found to be a contributing factor to coastal land transformation in India, which may convert cultivated land into urbanized areas (Kaliraj et al., 2017).

Economic or socio-economic development-related factors of coastal land transformation were included in about 13% of studies. Further, both natural disasters and topography (slope and elevation) were included in about 12% of the studies. Moreover, both tourism and planning policies were included in about 10% of studies, and construction and industrialization were included in 8% of studies.

3.5. Impacts of coastal land transformation

Out of 60 studies, 37% included impact analysis. A total of 13 main impact areas were identified from the studies, including agriculture and aquaculture, air temperature, carbon stock, dryness, ecosystem, flooding, landslides, land surface temperature (LST), migration, occupation, population, salinity intrusion, and water quality (Fig. 6). Land transformation frequently entails the degradation of natural ecosystems, which

Fig. 4. Word map of the driving factors of coastal land transformation included in the reviewed studies and prepared with the help of word clouds (https://www.wordclouds.com/).

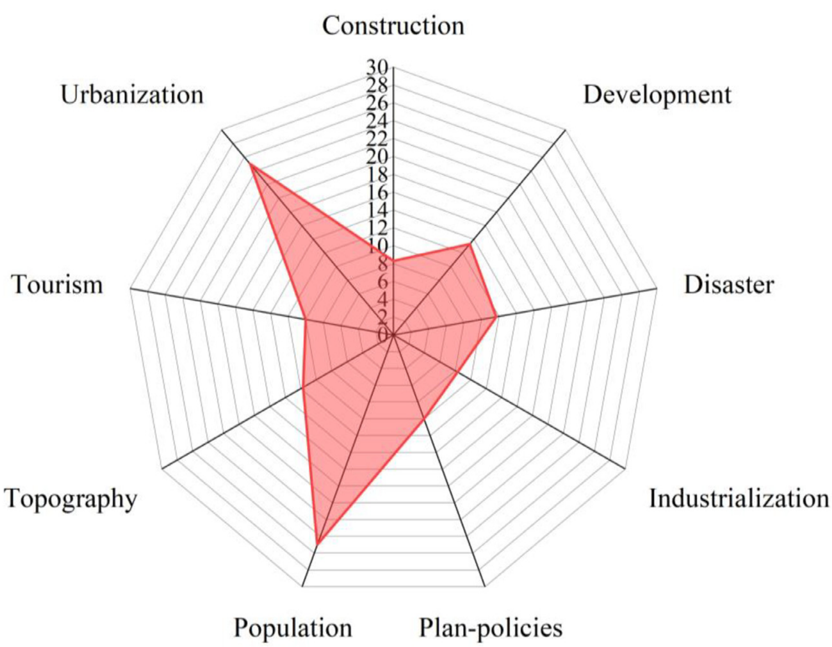

Fig. 5. Percentage of driving forces of coastal land transformation that have been found in five or more selected studies.

in turn leads to a loss of biodiversity as well as the extinction or threatened survival of various species. Destruction of ecosystems (13.3%) was identified as the most significant consequence of coastal land transformation (Akber et al., 2018; Badamfirooz and Mousazadeh, 2019; Baśnou et al., 2013; Camacho-Valdez et al., 2014; Hoque et al., 2022; Kankam et al., 2022; Rahman and Esha, 2022; Xu et al., 2022). In around 8.3% of the research, LST was also recognized as one of the impacts of coastal land transformation (Chanu et al., 2021; Ning et al., 2018; Pham et al., 2021; Rahman et al., 2017a; Rahman and Esha, 2022).

In addition, migration was investigated as an impact of coastal land transformation in approximately 5% of the studies (Asante-Yeboah et al., 2022; Rahman and Esha, 2022; Rahman and Ferdous, 2021). Similarly, about 5% of the studies looked into the topic and found that the modification of coastal land also had occupational repercussions (Rahman et al., 2017b; Rahman and Esha, 2022; Rahman and Ferdous, 2021). In addition, around 3.3% of the studies examined the effects of changes in coastal land use on water quality (Chen et al., 2020; Fuentes et al., 2017). Additionally, several insignificant repercussions of coastal land transformation have been documented. These include effects on agriculture and aquaculture (Tran et al., 2019), air temperature (Cinar, 2015), carbon stock (Hernández-Guzmán et al., 2019), dryness (Pham et al., 2021), flooding (Hussein et al., 2020), landslide susceptibility (Reichenbach et al., 2014), population (Asante-Yeboah et al., 2022), and salinity intrusion (Rahman and Esha, 2022).

3.6. Adaptation strategies

Out of 60 studies, a total of 22 focused on the impacts of land transformation. Only four studied adaptation techniques to cope with the effects of coastal land transformation. Rahman and Esha (2022),

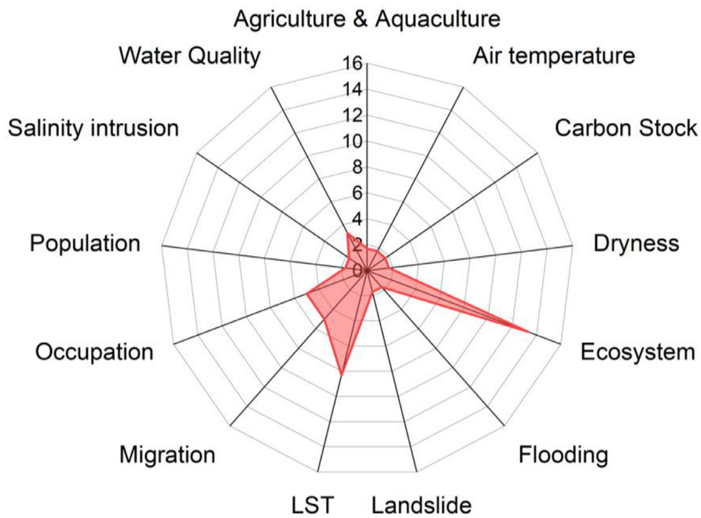

Fig. 6. Percentages of impact areas of coastal land transformation identified from the selected studies.

Table 2
Identification of research gaps based on leading focus areas.

Leading focus areas	Number of studies
Change detection (CD), top three tools	60 (100%)
a) Landsat image	52 (86.7%)
b) Aerial photograph	6 (10.0%)
c) SPOT image	5 (8.3%)
CD + Factor analysis (FA)	26 (43.3%)
CD + Impact analysis (IA)	22 (36.7%)
Adaptation strategies (AS)	4 (6.7%)
CD + FA + IA	10 (16.7%)
CD + FA + IA + AS	4 (6.7%)

Rahman and Ferdous (2021), and Rahman et al. (2017b) identified occupational change as the key adaptation strategy for coastal land transformation. Rahman and Esha (2022) found that people were compelled to alter their employment due to changes in land usage and an increase in shrimp cultivation instead of agriculture. According to Rahman and Ferdous (2021), the growing industry of shrimp and crab farming along the shore has a substantial effect on livelihood, and consequently, people are switching their employment from rice farming to shrimp culture. Further, Rahman et al. (2017b) explored that salinity intrusion has impacted agriculture yields, subsequently reducing economic benefit. Therefore, they observed a change in occupational pattern, particularly from paddy cultivation to shrimp culture in coastal salinity-prone areas. Besides, Tran et al. (2019) opined that a drought-related water shortage can cause bare (unused) land to increase slightly. They identified crop rotation and vegetative cover as adaptive measures for minimizing the impacts of drought-induced land transformation.

3.7. Research gaps and possible ways forward in the existing studies

The identification of research gaps and possible ways forward on the basis of the leading focus areas included in existing studies is presented in Tables 2 and 3. It was revealed that all the studies included a change detection focus area, as was the main inclusion criteria of this review. But the main finding of this focus area was related to its methods. Most of the studies (86.7%) included Landsat images as the main tools for detecting coastal land transformation. Therefore, researchers can use the most familiar tool for further research in terms of its acceptability. However, seasonal monitoring, using multi-temporal images, introducing retrospective analysis of land transformation between time periods to minimize errors, prediction of future land transformation, and usage of high-resolution images for analyzing and predicting coastal land transformation were also included as recommendations in the existing literature (Table 3).

Land transformation is the alteration, intensification, or modification of existing land use, which can be done through several factors (Asante-Yeboah et al., 2022; Cetin et al., 2008; Kaliraj et al., 2017; Siddik et al., 2018). This critical review identified that 43.3% of the literature included factors as the leading focus area (Table 2). In the previous research, some suggestions were made, such as focusing on comprehensive factor analysis, looking into the effects of human-made pressure, looking into the connections between land change, ethnic or minority habits, and dryness, and doing perception studies to find out what causes, impacts, and ways of adapting to coastal land change (Table 3).

Land transformation produces several socio-economic and environmental impacts (Badamfirooz and Mousazadeh, 2019; Baśnou et al., 2013; Chanu et al., 2021; Hoque et al., 2022; Kankam et al., 2022; Pham et al., 2021; Rahman and Esha, 2022; Xu et al., 2022). This review identified that 36.7% of existing studies incorporated the impacts of coastal land transformation as one of the leading focus areas. Several researchers further recommended focusing on comprehensive impacts analyses, analyzing regional impacts of land transformation, impacts on livelihood, and environmental impacts (Table 3).

And finally, adaptation strategies can help to cope with the impacts of land transformation (Rahman et al., 2017b; Rahman and Esha, 2022; Rahman and Ferdous, 2021; Tran et al., 2019). These four areas of research, i.e., change detection, factor analysis, impact analysis, and adaptation strategies, were identified as the leading focus areas. Table 2 shows that only 6.7% of studies included all of these focus areas, indicating huge gaps in existing studies. Still, there is scope to work in the field of coastal land transformation, addressing comprehensive analysis including change detection, factor analysis, impact analysis, and adaptation strategy identification.

4. Discussion

4.1. Leading focus areas

Sixty scholarly journal articles have been selected using the PRISMA-2020 guideline. Many researchers also follow PRISMA for ensuring comprehensive and transparent reporting of meta-analyses and systematic reviews (Liberati et al., 2009; Page et al., 2021; Swartz, 2011). This review identified four leading focus areas incorporated in the selected studies. After analyzing the first focus area (change detection), this review found Landsat to be the most often used satellite image for assessing coastal land transformation. Nearly 86.7% of the study used Landsat imagery, with 71.7% exclusively using it and 15% using

Table 3
Possible ways forward included in the existing studies.

Leading focus area	Possible ways forward
Change detection	1. Seasonal monitoring of land transformation (Kolios and Stylios, 2013). 2. Multi-temporal analysis of land transformation (Tran et al., 2019). 3. Retrospective analysis of land transformation between time periods (Avelar and Tokarczyk, 2014). 4. High resolution images (Datta and Deb, 2012; Kolios and Stylios, 2013). 5. Predictive studies (Hoque et al., 2022; Idowu et al., 2020).
Driving factor analysis	1. Comprehensive factors of land transformation (Kolios and Stylios, 2013; Tran et al., 2015). 2. Human impacts on land transformation (Tran et al., 2019). 3. Nexus among land transformation, ethnic/minority habits, and dryness (Pham et al., 2021). 4. People's perceptions of land transformation (Asante-Yeboah et al., 2022).
Impact analysis	1. Comprehensive impacts of land transformation (Rahman et al., 2017a; Tran et al., 2015). 2. Impacts of land transformation on region (Baśnou et al., 2013), livelihood (Tran et al., 2015), atmospheric temperature (Cinar, 2015), environment (Chen et al., 2020; Tran et al., 2015), bio-diversity conservation (Baśnou et al., 2013), water quality (Chen et al., 2020; Nelson et al., 2002), and social (Chen et al., 2020). 3. Ecological services mapping (Kankam et al., 2022). 4. Man-land relationship and the quality as well as benefit of land use (Lin and Qiu, 2022).
Adaptation strategies	Not included

other satellite images. Since 1972, Landsat images have been widely used to determine land transformation (Campbell, 2007). Researchers typically employ Landsat images for land change detection investigations because of their vast collection, high spectral resolution, accessibility, simplicity, and free availability (Gani et al., 2023; Reis, 2008). These images are also widely used because of their extensive coverage and extractability (Zhan et al., 2021). In addition, Landsat images are reliable because of atmospheric correction (Liang et al., 2001). Landsat data are sensitive to plant composition and consistent with stand and patch size, making them ideal for analyzing changes in field biomass (Avitabile et al., 2012). Even though Landsat-5 doesn't cover the whole world and Landsat-7 doesn't give complete data in each image (22%–25% data loss due to the Scan-Line Corrector), Landsat images are still essential for figuring out how tropical forests are changing (Wijedasa et al., 2012).

After analyzing the second focus area (factor analysis), this review identified a total of 41 different driving factors. Amongst them, population growth, urbanization, socioeconomic development, natural disasters, topography, tourism, planning policies, construction, and industrialization were found five or more times in the selected studies. The rapid growth of population has put tremendous pressure on nature and the environment, especially on the land (Maja and Ayano, 2021). It is predicted to have a significant impact on the distribution of arable land, vegetative cover, and wetlands across the world (Garg, 2017). Urbanization is the process of increasing urban areas, with their population coming from rural areas, other urban hemispheres, built-up areas, etc. The growth of the population also supports the urbanization process (Elmqvist et al., 2008). It is one of the key factors in the current land use pattern worldwide. Typically, non-urban areas are converted to urban. However, urban land use change can vary depending on population and building density, local legislation, layout, market pressure, and other aspects (Domingo et al., 2021; Nuissl and Siedentop, 2021). Socio-economic development is also identified as one of the key driving factors in coastal land transformation. For example, monetary rationality focuses on economic benefit in terms of higher income (Asante-Yeboah et al., 2022; Pham et al., 2021; Rahman et al., 2017a; Rahman et al., 2017b; Sönmez et al., 2009; Tran et al., 2015), gross domestic product, investment scenario in fixed assets, household consumption, revenue and expenditure of local government (Lin and Qiu, 2022), and level of economic growth (Zhao et al., 2021). The expansion of industry is the key to encouraging economic development in many coastal areas. It is also regarded as the preeminent driving force of coastal land transformation (Li et al., 2010). Land transformation is also considered the result of the construction of roads and bridges and the establishment of wetlands (Siddik and Rahman, 2022). Further, coastal hazards, including floods, cyclones, storm surges, sea level rise, etc., have short-term and/or long-term effects on land use change (Hartanto and Rachmawati, 2017; Kaliraj et al., 2017; Rahman et al., 2017b; Rahman and Esha, 2022; Rahman and Ferdous, 2021; Tran et al., 2015, 2019). Additionally, the topography of that region has an impact on the structure of land use and its spatial distribution (Bian et al., 2023). The intensification process of land use depends on the nature of the terrain in floodplains. Not only that, but the gradient and altitude are so important that they regulate other physical factors such as soil quality and at the same time affect social factors (Havlíček and Chrudina, 2013; Nabiollahi et al., 2018). The development of tourist sites and tourism infrastructure usually contributes to changes in land use and land cover (Wang and Liu, 2013). Besides, Dong et al. (2008) found that farmers willingly change their occupation from farm to non-farm activities and subsequently change land use patterns to support tourism development. Furthermore, government policies or legislation can act as contributing factors to land transformation. For instance, China's land use regulations prioritize various afforestation programs and other ecological initiatives to increase ecosystem services (Huang et al., 2020).

After analyzing the third focus area (impact analysis), this review found that about 37% of the selected studies included at least one of the identified 13 main impact areas. Out of these impact areas, four were found in five or more studies, e.g., disruption of ecosystems, changes in LST, migration, and occupational impacts. Tiwari et al. (2019) explored that human-caused land transformations such as landscape modification, decreasing forest cover, and farmland expansion are some of the most significant ecological problems impacting soil, ecological systems, and sustainability. They also found land transformation may cause various negative subsurface and environmental changes that influence the subsurface diversity of microorganisms, population size, and productivity. Besides, land transformation has a major effect on the increasing trends of LST. The urban environment, well-being of people, and ecology were all severely harmed by the rise in LST. The LST was found to be considerably different amongst the various types of land use, with greater LSTs being found on developed land (Tan et al., 2020). Kafy et al. (2021) found a highly favorable relationship between LST and the normalized difference built-up index (NDBI). Imran et al. (2021) found that urbanization triggers land use transformation through constructing physical structures for dwellings, transportation, the marketplace, and other uses. These physical structures further significantly impact LST by disrupting the surface energy equilibrium. Further, migration, either internal or international, contributes to changes in transforming land. Bell et al. (2010) explored increased multi-occupancy and urban density as two main effects of migrants' settling in the cities of many European countries, where they often occupy low-rent housing at first. Rahman and Ferdous (2021) found increasing trends in waterbodies in coastal Bangladesh, indicating more fish firm-

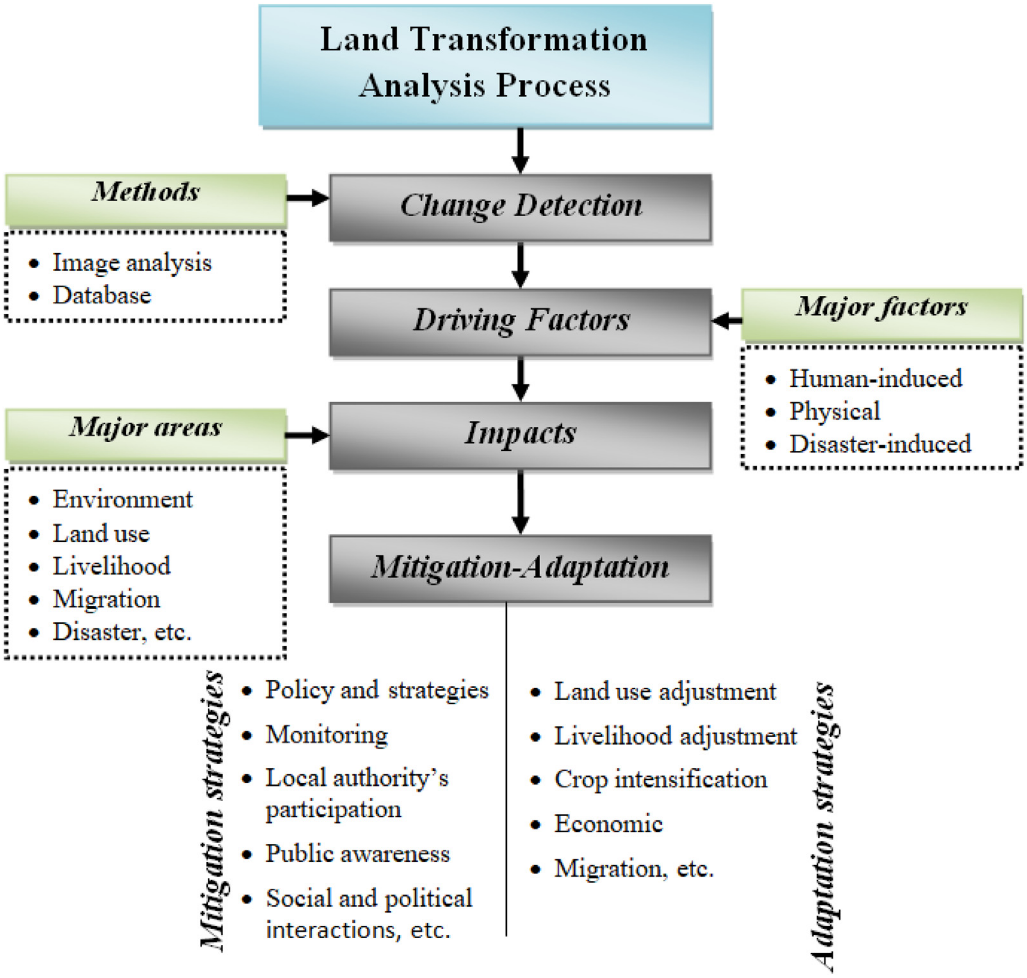

Fig. 7. Proposed framework for comprehensive systematic land transformation analysis.

ing. The growth of fisheries often leads to occupational hazards because of the loss of crop land, which further leads to migration and changes in employment. Further, Asante-Yeboah et al. (2022) observed that land use change through industrial development acted as a pull factor for migration and population increase. Migration may also happen with a line of government development projects, including settlement schemes, industrial zoning, tourism development, etc. (Lambin et al., 2001).

After analyzing the final (fourth) focus area, this review explored only three types of adaptation strategies in four studies. The strategies are occupational change, crop rotation, and vegetative coverage. Tran et al. (2019) found rotating crop and vegetative coverage as coping strategies for reducing drought-related water shortage-induced land use change. Paudel (2002) explored that intensification of land use and introducing new crops can be adaptive measures to increase both crop production and income in a shrinking land use environment. Detail mitigation-adaptation strategies for coastal land transformation are discussed in the following section (Section 4.2).

4.2. Conceptual framework for comprehensive systematic land transformation analysis

Fig. 7 presents a conceptual framework for comprehensive land transformation analysis. The framework is distinctive because of its comprehensiveness. It includes all of the leading focus areas (i.e., change detection, driving factors analysis, impacts analysis, and adaptation measures) that are identified in this review. It also illustrates the relationship among the leading focus areas. For analyzing land transformation, one first explores whether any changes happen or not during a time period. The change detection of land use and land cover can effectively represent the key attributes of land resources (Zhao et al., 2021). There are several data sources for detecting such changes, including field data, satellite images, topographic maps, databases, etc. According to this study, image analysis or information retrieval from databases are considered popular data sources for change detection. Image or database analysis can provide more accurate information, and they are more accessible and cost-effective (Reis, 2008). On the other hand, there are limitations with field data when considering geographical and temporal coverage. Additionally, collecting data in the field has frequently resulted in redundant efforts or instances when data obtained for one reason was useless for another (Anderson et al., 1976).

There are several driving factors for changing land use and land cover. The study explored that land transformation is the result of several human-induced (e.g., demographic, urbanization, industrialization), natural (e.g., slope, elevation), and disaster-related driving factors. This transformation further impacted the environment (e.g., water quality, ecosystem, land surface temperature, soil salinity), land use pattern, livelihood, migration, disaster (e.g., flooding), etc.

The adaptation strategies can be grouped as land use adjustment, livelihood adjustment, crop intensification, economic issues, migration, etc. Land use adjustment is the replacement of one use by another, for example, forestry instead of crop culture or shrimp culture in saline areas instead of crop or other use (Siddik et al., 2018). The increase in salinity is a complicated process that involves the meteorological, socio-economical, and biological processes that are present in coastal environments. The growing salinity of the land has a detrimental effect on both the quality of life and the livelihoods that depend on the agricultural system (Habiba et al., 2013; Rabbani et al., 2018). Coastal agricultural practices are some of the most dynamic in the country. Monoculture shrimp aquaculture has emerged as a prevalent method of land management around the world as a means of mitigating the effects of soil salinization (Akter et al., 2023; Faruque et al., 2017).

Livelihood adjustment is the changing of livelihood strategies in response to changes in the current environment. We have found only three studies focusing on the economic capital of livelihood adjustment (Rahman et al., 2017b; Rahman and Esha, 2022; Rahman and Ferdous, 2021). However, livelihood status can be accessed on the basis of DFID's sustainable livelihood approach. There are five capitals in livelihood resources: human capital, social capital, natural capital, financial capital, and physical capital (DFID, 1999).

Crop intensification can be a key adaptation strategy for maximizing food production on a parcel of land in a land transformation context. Sethi et al. (2014) suggested undertaking intensive agricultural transformation planning to improve food stock and meet food scarcity challenges. Tran et al. (2019) identified crop rotation and vegetative cover as adaptive measures for minimizing the impacts of drought-induced land transformation. Even in the midst of a drought, rotating crops on a piece of land over the course of several growing and seeding seasons can help mitigate some of the negative impacts of an intensifying drought. It has the potential to significantly improve climate resilience and decrease the sensitivity of farming crops (Yu et al., 2022).

Land use adjustment, livelihood adjustment, and crop intensification are highly related to economic profitability. In some cases, people are supposed to migrate from one location to another because of land transformation, for example, relocation or migration due to disaster-induced land transformation, e.g., cyclones or river bank erosion (Siddik et al., 2017, 2018).

To mitigate the challenges of land transformation, several researchers have proposed different measures, including policy and strategies, monitoring, local authority participation, public awareness, social and political interactions, etc. Among them, Rahman et al. (2017b), Rahman and Esha (2022), Rahman and Ferdous (2021), and Yılmaz (2010) recommended comprehensive land use planning to promote a stable, equitable, and diverse use of coastal land. Kurt (2013) and Kara et al. (2013) suggested a sustainable coastal land management plan ought to be implemented in order to preserve the coastal areas. According to Akber et al. (2018), Pham et al. (2021), and Hoque et al. (2022), rules about land use might help change or lower the amount of land used for farming, raise the amount of land covered by forests, and create ways of making a living that are more flexible and long-lasting while also making people more resistant to the effects of climate change. Further, Liang et al. (2022) proposed that an effective coastal management legislation system be formulated so as to control and govern the land development activities in the coastal regions. Enaruvbe and Ige-Olumide (2015) strongly suggested developing land use zoning in order to safeguard the ecosystems from quick deterioration and, as a result, to ensure environmental as well as human well-being. Moreover, Kuleli and Bayazıt (2022) advised formulating policies, including roadmaps based on worldwide sustainability standards, to minimize issues related to over-urbanization and excessive tourism.

Local authorities (local governments and municipalities) are the key actors or execution agencies for implementing land use planning at the local level. Hence, they need to pay careful attention to the alternation of land use and take necessary measures in response to the effects of such changes in the built environment (Zhu et al., 2012).

Given that human-induced land transformation hinders the built environment, a public awareness campaign should take precedence. In addition, interaction among social and political entities should be enhanced so that coastal land use change can be managed (Cetin et al., 2008).

According to several researchers (Kesgin and Nurlu, 2009; Muttitanon and Tripathi, 2005; Nosakhare et al., 2012), intensive and regular monitoring of coastal land use is crucial to address the land transformation and reduce the associated challenges. Among them, Kesgin and Nurlu (2009) recommended remote sensing to accurately monitor the status of coastal land transformation. On the other hand, Muttitanon and Tripathi (2005) suggested that integrating and analyzing the raster images in GIS may be able to accomplish effective monitoring and management of land utilization in coastal areas.

5. Conclusions

This is the first attempt to present a critical overview of the global coastal land transformation and its associated primary research areas. Results revealed that most of the coastal land transformation-related research was carried out in Asian countries, especially in China, Bangladesh, and India. Therefore, we can name these countries as Asian coastal land transformation hotspots. However, more research is recommended in these areas. Four leading focus areas, i.e., change detection, factor analysis, impacts analysis, and adaptation measures, have been identified considering coastal land transformation. Existing literatures has mainly focused on identifying the key driving factors (e.g., population growth, urbanization, etc.) of coastal land transformation. Future studies can consider factor-based coastal land transformation, e.g., disaster-induced or human-induced land transformation. The main impact areas of coastal land transformation were the destruction of ecosystems, changes in LST, migration, occupational repercussions, and changes in water quality. More studies can be done addressing the comprehensive impact analysis on livelihood, agriculture, the economy, etc. Moreover, we found existing studies had given little consideration to mitigation-adaptation strategies. More studies are needed to address these strategies. Finally, comprehensive research (change detection, factors, impacts, and adaptation strategies) on coastal land transformation is strongly recommended, following the proposed conceptual framework for comprehensive land transformation analysis.

Declaration of competing interests

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

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.geosus.2024.01.010.

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