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Forecasting The Land-Use Change of Urban Coastal Area in Banda Aceh and Its Impact on Urban Sustainability Using Landusesim Cellular Automata Simulation Model

Issana Meria Burhan[1*], Ashfa Achmad[1], Putra Rizkiya[1], Zainuddin[1]

[1]Architecture and Planning Department, Engineering Faculty, Syiah Kuala University, Jl. Syech Abdurrauf No.7, Kopelma Darussalam, Banda Aceh, Indonesia
*Corresponding author email: issana.burhan@unsyiah.ac.i*d

Abstract – The dynamics of urban development, followed by various opportunities and challenges for different social groups, indicate a growing sense of complexity, unpredictability, and insecurity about cities and emphasis a need to identify new sustainability strategies. This paper aims at predicting the land-use change of urban coastal areas in Banda Aceh and its impact on urban sustainability. It used an urban simulation model using Cellular Automata (CA), integrated into a LanduseSIM platform. There were three main steps as part of the research methodology: (1) preparation of current data on land uses (2015), (2) simulation of data using CA in LanduseSIM software, and (3) visualization of data and result. Accordingly, the final simulation of the year 2030 was completed, in two scenarios, as the basis to evaluate the impact of land-use change on urban sustainability in Banda Aceh. The study has revealed that the current development trend in the coastal area of Banda Aceh is consuming natural resources such as wetlands and vegetation, driven particularly by the planning of urban coastal region as a center of tourism and fishery, complemented by the upcoming Banda Aceh Outer-Ring Road project. The study recommends a reconsideration of the city strategies by decision-makers to achieve sustainability and ensure ecological balance.

Keywords: Land use change, Cellular automata, GIS, coastal area, Banda Aceh.

Introduction

Cities have outspread very quickly as an outcome of population growth and economic development. This growth is particularly represented by the conversion of land use/land cover (LUC) to accommodate the city's augmented activity (Nong & Du, 2011). Although urban growth benefits socio-economic development and enhances livability. It is the most significant force that has induced huge conversion from natural to artificial land cover in cities worldwide (Lambin et al., 2003; Gharbia et al., 2016). The different spatial dynamics appearing in urban development can be related to the concept of urban sustainability. Changes in existing landscapes would affect urban ecosystems' capacity to sustain life's urban quality (Santos Cruz et al., 2013).

Banda Aceh, affected by the tsunami in 2004, is a developing city with beautiful coastal views. Since the rehabilitation and reconstruction period post-tsunami (2005-2009), the city has experienced steady urbanization progress. For the past five years, the population has been increasing at an average of 1.96 percent annually, influencing land use patterns changes due to productive activities and consumption behavior. The built-up area of Banda Aceh has been doubled since 1998, reaching 62.87 percent of the total land area, consuming vegetation

and bare land for buildings, roads, and other forms of structures (Achmad et al., 2019). In terms of the economic sector, the city's Gross Regional Domestic Product (GRDP) grows positively at an average of 4.6 percent per year, demonstrating a substantial growth in the economy. The growing population, as well as economic growth, has put pressure on the existing resources.

An urban growth modeling study of Banda Aceh predicted that urban growth is less likely to develop near the coastal areas, particularly induced by the low population density, the distance to the Central Business District (CBD), and the development restriction (Achmad et al., 2015). It also indicated that imminent growth tends to arise in the eastern and southern parts of the city. However, the revision of the Spatial Planning Scheme of Banda Aceh 2009-2029, which just has been approved in late 2018, presents a strategic plan of several new activity centers along the urban coastal area, namely the tsunami tourism precinct, integrated fishery precinct, and heritage precinct of Gampong Pande. Furthermore, there is an outer ring road plan to link peripheral settlements and connect existing radial roads as part of the strategic planning in the coastal area of Banda Aceh.

In many cities, growth is dominantly occurred along the main roads and existing constructed centers, the so-called induced growth that may generate a social and environmental complexity, particularly regarding the environment changes, land speculation, and community residing in the area who are mainly dependent on fishery employment (Cervero, 2001; Vermeiren et al., 2012). Residents in the adjacent bay have also commenced resettling back in the area, reaching a similar level before the 2004 tsunami (Syamsidik et al., 2018). The condition is particularly worrying because growth correlates with land use conversion that may impact urban sustainability, such as displacement of open space and agriculture/aquaculture, diminish in wetlands, the effect on hydrology and ecosystem in general (Lambin et al., 2003; Santos Cruz et al., 2013; Gharbia et al., 2016). Due to the significance of the bay area, both as a commercial port and protection zone for Banda Aceh's city (Syamsidik et al., 2018), this research aims to predict the urban land-use change in coastal areas and its impact on sustainability.
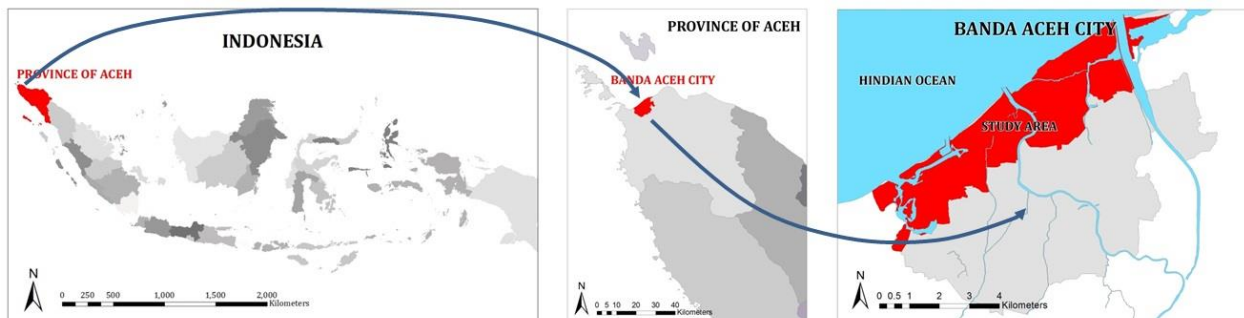

Figure 1. Study area: the coastal area of Banda Aceh.

Materials and Methods
Study Area
This study focuses on the coastal area of Banda Aceh, Aceh Province, Indonesia. Referring to the FAO Guidelines (FAO, 1998), the coastal area is defined "by the vertical accretion of near-shore land," which depended on sediment supply from rivers or sea. In this regard, the study area's delineation includes villages directly located along the near-shore and close to the inland water body. It is located on the northern tip of the city, between the two latitudes 5⁰35'45" and 95⁰16'25" North and the two longitudes 5⁰32'8" and 95⁰22'18" east, as seen in Figure 1. The total coastal area of Banda Aceh is estimated at 2050.46 Ha in 2015. Dominant activities in the area are aquaculture and tourism activities.

Forecasting of Land Use Change
Forecasting land-use change supports infrastructure planning effectiveness and examines the probability of environmental adjustment (Nong & Du, 2011; Gharbia et al., 2016; Al-Darwish et al., 2018). Generated by multi-layer of indicators from biophysical features and human factors at different scales, space, and time, other urban modeling techniques are used to explain patterns of a spatial and temporal process in urban growth (Lambin et al., 2003; Nong & Du, 2011; Vermeiren et al., 2012; Achmad et al., 2015; Gharbia et al., 2016; Al-Darwish et al.,

2018; Pratomoatmojo, 2018). In this respect, cellular automata (CA) has been confirmed as a primary method in assessing land-use dynamics through spatial simulation and modeling process (Verburg et al., 2004; Lambin et al., 2003; Gharbia et al., 2016; Al-Darwish et al., 2018; Pratomoatmojo, 2018; (Achmad, Irwansyah, & Ramli, 2018). Derived from a simple calculation of a pixel-based on its original state, the condition in the surrounding pixels, and a set of transition rules, CA works satisfactorily in emulating spatially complex processes (Wolfram, 1984). CA model has also been utilized regarding the land use planning process by linking scenarios of constraints (Wu & Webster, 1998; Li & Yeh, 2002; Moghadam & Helbich, 2013).

Although commonly employed in land use studies, Verburg et al. (2004) and Liu (2007) argued that the quantification of neighborhood functions for the CA model is unsatisfactory due to its self-organizing nature driven by locally specified process spatial scale that includes neighborhood extent and cell size. For an urban system, which in characteristics continuous spatially and temporally, this potentially distorts urban development modeling simulation. The CA structure also lacks familiarity in assessing the impact of various urban growth catalysts (Mraz et al., 2000; Al Sharif et al., 2015). Therefore, many researchers suggested the integration of the CA model with other approaches. As such, a logistic regression-based CA, as applied by Achmad et al. (2015), is considered effective in analyzing the causation between urban expansion and its stimulants. Moreover, the integration of logistic regression, Markov Chain, and CA models, as tested by Arsanjani et al. (2013), Al Sharif et al. (2015), and Jafari et al. (2016), has resulted in an enhanced model quality of land-use change simulation. The other hybrid approach recommended by Mraz et al. (2000), Verburg et al. (2004), Liu (2012), and Al-Darwish et al. (2018) is a fuzzy set technique. The fuzzy logic supports the CA structure in defining the rules that influence the urban growth process, determining the level of these factors, isolating the neighborhood scales from other factors, and hence mimicking the real behavior of urban dynamics (Mraz et al., 2000; Verburg et al., 2004; Liu, 2007; Liu, 2012).

Among much fuzzy-CA algorithm-based software, there is a software called LanduseSim, which "focuses on future-oriented development and scenario planning" (Pratomoatmojo, 2018). It is stand-alone software with the capability to deliver significant frameworks in urban and regional planning processes. While the other forerunners disallow users to command the driving force and manage with a particular target of spatial prediction, LanduseSim enables them to control all features for simulation procedure, including growth aim, the driving factors, planning scheme such as zoning regulation, infrastructure plan, and facilitate the possibility to generate new of cell states during the simulation (Pratomoatmojo, 2018). Introduced by the Institute Technology of Sepuluh November (ITS), LanduseSim offers the opportunity to validate future planning schemes or evaluate existing plans by considering the significance and the dynamic of land use and environment (Pratomoatmojo, 2018). Many researchers have conveniently utilized LanduseSim to analyze and simulate future urban changes, notably demonstrated by Gharbia et al. (2016), Al-Darwish et al. (2018), and Santiago and Natasha (2018). Therefore, this study assumes that the LanduseSim simulation model would better forecast the expected pattern of future land-use change in the coastal area of Banda Aceh. Consequently, the predicted model will evaluate the important features in the land use pattern and assess the driving forces that contribute to this change. Adopting the LanduseSim simulation procedures recommended by Pratomoatmodjo (2014), this study has three main steps. The initial step involves data setup and processing in the Esri GIS programs, preparing base land use maps and thematic maps of factors affecting land-use changes. Based on these initial data, data simulation is executed to predict land use's future pattern, utilizing the LanduseSim program environment's CA model. Finally, data visualization leads to results presentation and discussion.

Data setup

The base map used for simulation is the data on land use in the coastal area of Banda Aceh in 2015. The geo-referenced satellite image is obtained from Landsat at 15 m resolution, captured on August 14th, 2015. The idea was digitized on a scale of 1:5000, produced by the Banda Aceh Geospatial Agency. Following the classification used in a previous study (Achmad et al., 2015), land use delineation in this study consists of six land use classes (Figure 2); (1) water body, (2) wetland, (3) vegetation, (4) bare land, (5) settlement and road (representing the built-up area), and (6) activity centers. Additionally, the data on driving factors and constraint factors affecting land-use change are also prepared. These are the so-called transition maps, which include the Euclidean distance (ED) to roads (both primary and secondary), ED to settlement, ED to activity centers, and reserved area (Figure

3). All final maps are converted in raster format, consisting of grid cells with 10x10 meter square resolution dimensions considered satisfactory to represent reality.
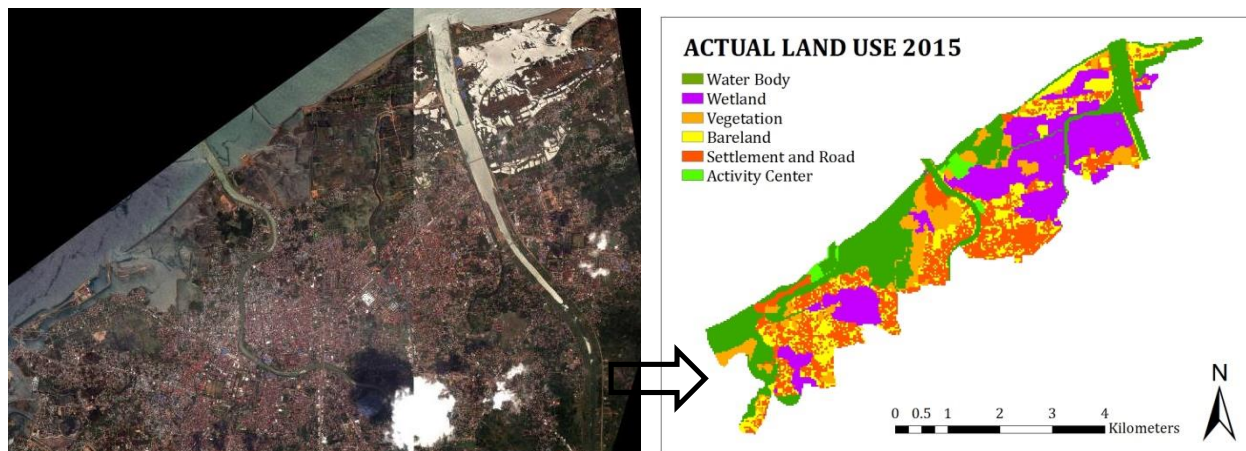

Figure 1. Satellite image and land use map of coastal area Banda Aceh 2015 (source: Banda Aceh Geospatial Agency, 2015).

The driving and constraint factors above are considered determinants of urban growth, thus creating urban modeling in this study (Table 1). First, an activity center is defined as a concentration of employment-rich area, serving the residents' socio-economic needs (Casello & Smith, 2006). In the coastal area of Banda Aceh, there are some recent and planned strategic activity centers allocated for tourism and port area, fishery center, and heritage district (Achmad et al., 2018). These precincts play a significant role in Banda Aceh's urban development and have begun to induce the evolution of new housings and commercial strips in the adjacent area. As argued by Gharbia et al. (2016) and Moniruzzaman et al. (2017), proximity to jobs, goods, and services indicates benefit and opportunity for further expansion of the activity center.

Second, the distance to the road network has been seen as part of good accessibility, promoting growth in the surrounding area. Transportation infrastructure allows the connection from residential to activity centers, which encourages urbanization, as a higher share of traveled trips arise (Cervero, 2003; Kasraian et al., 2019). Particularly in a private vehicle-dependent city with a hierarchical road network, such as Banda Aceh, development is likely to emerge in a linear direction along primary and secondary roads (see Figure 2(a). Researchers argued that transportation network and land use development are interdependent variables in which the existence or expansion of road network would affect firm/household location choice, and vice versa, land-use changes would impact travel demand (Cervero, 2003; Rui and Ban, 2011; Kasraian et al., 2019). In the study area, existing roads and the outer ring road plan that links the outskirts of Banda Aceh's settlement to the urban core are assumed to contribute to growth in the coastal area.

The third is the proximity to the existing settlement. Researchers believe that land-use change potentially occurs in the current urban areas (Cervero, 2003; Gharbia et al., 2016; Al Darwish et al., 2018; Kasraian et al., 2019). Notably, new residentials tended to grow in areas where settlement is already established due to infrastructure availability and the so-called neighborhood effect (Nijs and Pebesma, 2010). It is right in the context of the urban coastal area in Banda Aceh. Urban dwellers have begun to inhabit the lands in or near the current housing areas, converting the surrounding vacant lands and even wetlands to built-up areas (Syamsidik et al., 2018).

In addition to the above growth stimulating factors, the urban modeling also includes a constraint factor as part of the transition maps, the planned reserved area. According to Nijs and Pebesma (2010), policy variables, such as land-use regulations, tend to restrict urban development, especially in areas with high ecological functions, and if followed by legal sanctions. In the context of this study, the planned reserved areas are mapped

based on the Spatial Planning Scheme of Banda Aceh 2009-2029, including the Special Protection Areas (SPAs) and the Green Open Spaces (GOS), which are particularly limited for development.
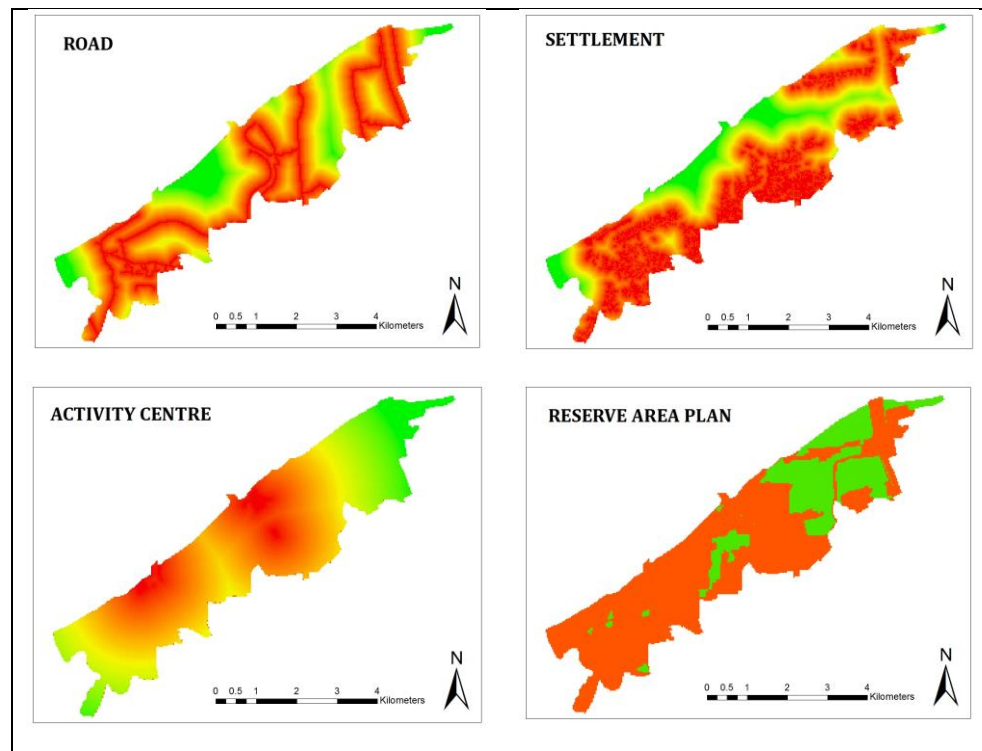

Figure 2. Driving-factors maps 2015: (a) ED_ Roads. (b) ED_ Existing Settlements. (c) ED_Activity Centres. Constraint factor map 2015: (d) Planned Reserved Area.

Table 1. Driving factors and their descriptions.

Variable	Nature of variable	Unit	Previous study
Distance to Roads	Continuous	Km	Achmad, et al. (2015)*;* Gharbia, et al (2016); Moniruzzaman, et al. (2017); Al-Darwish et al. (2018).
Distance to existing settlements	Continuous	Km	Rui and Ban (2011); Achmad, et al. (2015); Gharbia, et al (2016); Al-Darwish et al. (2018); Kasraian (2019).
Distance to activity centres	Continuous	Km	Cervero (2003); Gharbia, et al. (2016); Al Darwish, et al. (2018); Kasraian, 2019
Distance to planned reserved area	Continuous	Km	Nijs and Pebesma (2010); Achmad, et al. (2015), Gharbia, et al. (2016); Al-Darwish et al. (2018)

Data simulation

LanduseSim simulation works as an iteration mechanism, involving the preparation of transition rules, application of neighborhood filtering procedure, and simulation of future land-use change in the CA model according to expected/unexpected scenario (Figure 4). As illustrated in Figure 4, LanduseSim requires a set of transition rules. In the case of Banda Aceh's coastal area, accessibility factors such as distance to roads, settlement, and activity centers were assumed as driving forces that influence the growth of settlement and activity centers. Meanwhile, reserved plan area was considered as constraints, signifying the limitation of land use expansion. The standardization process to establish the distance map of both driving factors and restriction was completed through the Fuzzy set's linear method by transforming the distance value (Euclidean distance map) to real numbers. The value spans between 0 for the farthest distance and 1 for the closest distance. In other

words, growth potential will likely occur in the area most adjacent to the driving factors. Consequently, the further the cell reaches any of the driving forces, the probability of its land-use conversion decreases.

Transition potential maps for land-use change were created by the super-impose of each ED map and its compatible weighted raster value. Usually, a more scientific approach in weighting processes such as Analytical Hierarchical Process (AHP) is considered more reliable. However, in this research, the score was determined by a qualitative approach of generic viewpoint and area observation. The score for each driving factor to land-use change includes distance to roads (0.35), distance to the existing settlement area (0.25), and distance to activity centers (0.40).

To implement the transition rule, the CA model used the six land use classes; (1) water body, (2) wetland, (3) reserved area, (4) bare land, (5) settlement and road (representing the built-up area), and (6) activity centers. Once all the transition rules are set, the CA iteration in this research uses neighborhood filter 3x3 of some operation. The land-use change simulation for the coastal area of Banda Aceh is produced for the period 2020, 2025, and 2030 within two scenarios. The final targeted year's basis is attributed to the Spatial Planning Scheme of Banda Aceh, which will be expired in 2029. However, to simplify the iteration and identify the staging of land-use changes, the simulation is conducted within five years from the base map in 2015, the first forecast in 2020, the second process in 2025, and the final projection in 2030.

The first scenario (S0) is to predict the growth of land use based on the current trend (business as usual), and the latter (S1) is to forecast the land use pattern if zoning regulation of planned reserved area is applied in the scenario. While the business usual scenario enabled another land to expand according to the existing tendency, the second scenario classified water bodies and vegetation as restricted areas. The basis of zoning regulation refers to the Spatial Planning Scheme of Banda Aceh 2009-2029. Among the advantages of the CA model in LanduseSIM is its ability to forecast both according to trend and target (planning scenario).
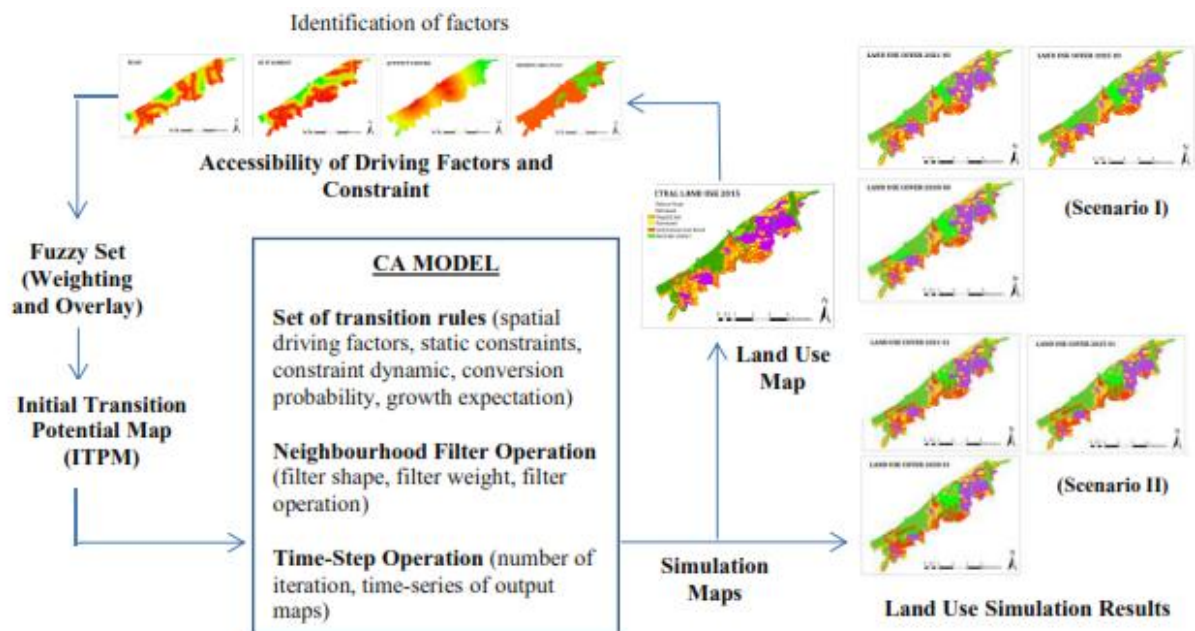

Figure 3. General Framework of CA Model in LanduseSim (Adapted from Pratomoatmodjo, 2018 and Al Darwish et al., 2018).

Results

The simulation of the land-use change forecasting process in 2020, 2025, and 2030 demonstrates slightly different results for both scenarios due to the variation in the driving factors for each scenario. In scenario one, the simulated land-use change reveals a pattern that is similar to the current growth. According to Figure 5 and

Table 1, the water body is predicted to remain in the same condition, while wetland and vegetation are likely to be moderately diminished by the end of 2030. The most considerable land-use change would be converting bare land and settlement area, which is predicted to be steadily decreasing, into activity centers. The forecast indicates that activity centers' land would increase seven times fold than the existing hectares, expanding from only 29.59 Ha to 194.25 Ha. Although the coastal area of Banda Aceh is legally allocated for several new activity centers, it seems that the expansion would occur at the expense of wetland, vegetation, and even settlement. As shown in Table 1, residential areas are expected to decline to 15 percent by 2030 gradually. The reduction of settlement land is a concern in terms of the social aspect of sustainability, mainly if it involves relocation to other places, not in compliance with residents' employment characteristics. Instead, urban growth can be optimized by cultivating the bare land for more productive use, such as into settlement.

The second scenario considerably offers a better scheme. Waterbody and vegetation tend to encounter zero growth due to land use regulation aiming to retain these ecological function areas. In terms of sustainability, preserving them as green open spaces will improve urban life quality, balance the metabolism of urban energy flow, support citizens' wellbeing and health, and induce economic and social welfare. Within this scenario, settlement expansion can also be accommodated, not to provide new residential areas but to serve the projected population's housing needs solely. The other important note, as shown in Figure 6 and Table 2, bare land is predicted to be decreased quite progressively from 302.18 Ha to only 153.80 Ha, implying an upsurge of land use. Half of the bare land area would likely be converted into a settlement and, dominantly, into activity centers. In particular, for activity centers, the simulation forecast the growth of 740 percent, indicating a possibility for Banda Aceh to develop the coastal areas as tourism, fishery, and heritage precincts, optimally.

Despite the opportunity for more growth, the expansion of activity centers should avoid the conversion of wetlands in the area. There is an indication of a diminishing number of wetlands in both scenarios, most notably in scenario two. Moderately expected to decrease by 9 percent in the first scenario, it shrinks significantly in the other scheme, contributing only 18.06% of total land area in 2030. In other words, 27 percent of the wetlands are likely to be transformed into activity centers. This conversion will have substantial impacts on the environmental aspect of sustainability. In ecological terminology, wetlands have natural and economic values such as flood mitigation, storm control, aquifer recharge, water quality improvement, biomass production, and biodiversity (Mitsch & Gosselink, 2000). In cities where wetland preservation and restorations have been successfully implemented, it is considered a valuable ecosystem as it supports all-natural services (Bolund & Hunhammar, 1999).

Table 2. Simulation accuracy under all transition rules overtime of scenario one (2015–2030).

Land use (LU) – Code		LU_2015		LU_2020		LU_2025		LU_2030		LU growth (2015-2030)
		Actual area (Ha)	%	Simulated area (Ha)	%	Simulated area (Ha)	%	Simulated area (Ha)	%	
Water body	1	574.98	28.04	574.98	28.04	574.98	28.04	574.98	28.04	0%
Wetland	2	507.70	24.76	483.84	23.60	473.50	23.09	464.38	22.65	-9%
Vegetation	3	205.41	10.02	199.37	9.72	195.99	9.56	189.95	9.26	-8%
Bare land	4	302.18	14.74	280.58	13.68	270.54	13.19	259.17	12.64	-14%
Settlement	5	430.59	21.00	410.21	20.01	387.58	18.90	367.72	17.93	-15%
Activity center	6	29.59	1.44	101.48	4.95	147.87	7.21	194.25	9.47	556%
		2050.46	100	2050.46	100	2050.46	100	2050.46	100	

Discussion

The forecasting of land-use change in the urban coastal area of Banda Aceh implies that the current development trend is consuming natural resources such as wetlands and vegetation, driven mainly by the local spatial planning policy that allocates the area as the designated activity centers. The stimulants to land use pattern changes include the proximity to activity centers, distance to roads, and adjacency to an existing settlement.

Although some areas are already zoned as the reserved areas, namely the water body and vegetation/GOS, the forecast demonstrated that the growth expansion in the northern-coastal part of Banda Aceh would be significant.
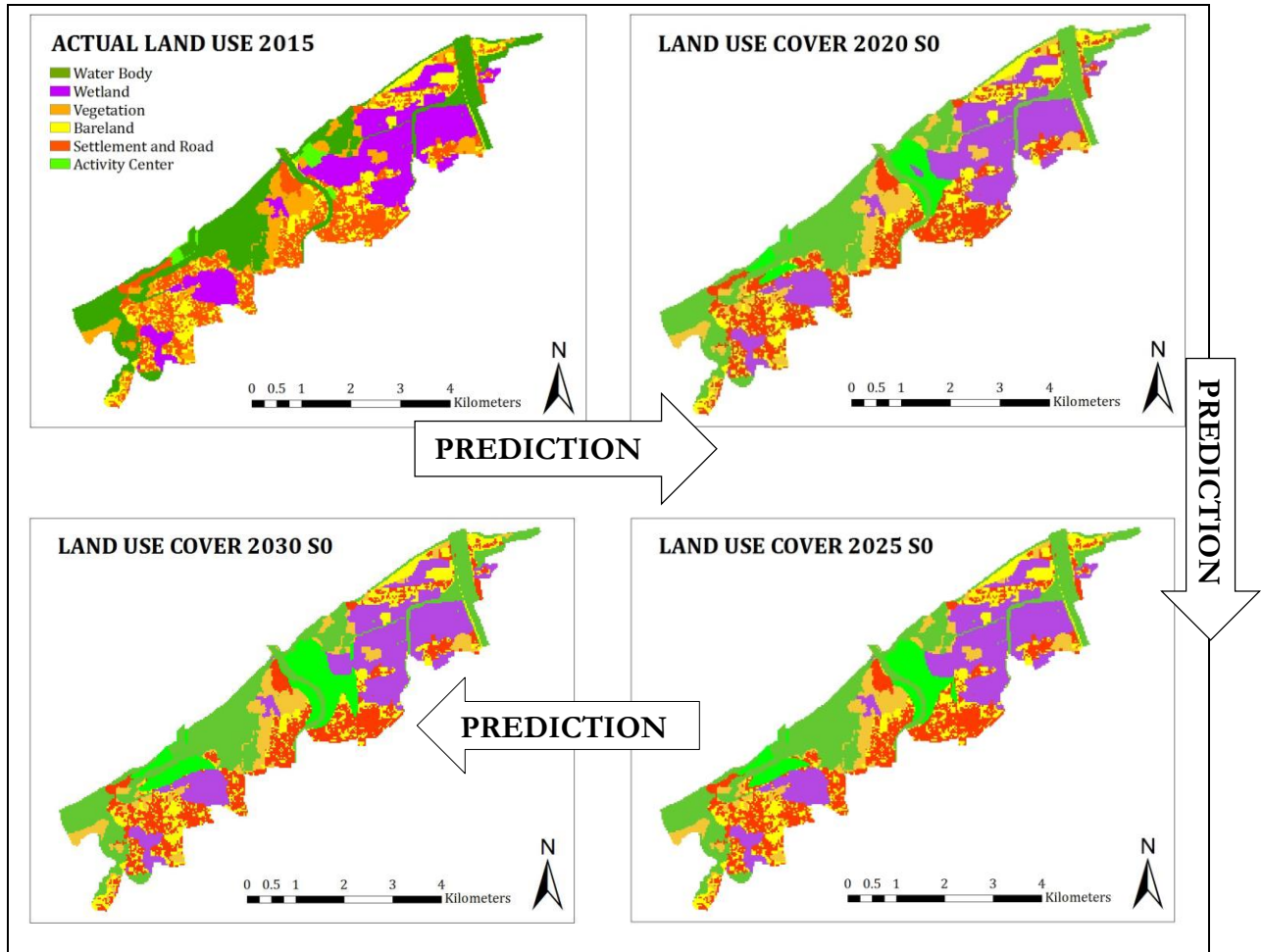

Figure 4. Cellular automata (CA) predicted land-use change for 2020, 2025, and 2030 in the coastal area of Banda Aceh - Scenario I (S0).

Table 3. Simulation accuracy under all transition rules overtime of scenario two (2015–2030).

| Land use (LU) Name – Code		LU_2015		LU_2020		LU_2025		LU_2030		LU growth (2015-2030)
		Actual area (Ha)	%	Simulated area (Ha)	%	Simulated area (Ha)	%	Simulated area (Ha)	%	
Water body	1	574.98	28.04	574.98	28.04	574.98	28.04	574.98	28.04	0%
Wetland	2	507.70	24.76	457.01	22.29	410.11	20.00	370.38	18.06	-27%
Vegetation	3	205.41	10.02	205.41	10.02	205.41	10.02	205.41	10.02	0%
Bare land	4	302.18	14.74	238.59	11.64	199.78	9.74	153.80	7.50	-49%
Settlement	5	430.59	21.00	457.22	22.30	477.18	23.27	497.15	24.25	15%
Activity center	6	29.59	1.44	117.25	5.72	182.99	8.92	248.73	12.13	740%
		2050.46	100	2050.46	100	2050.46	100	2050.46	100	
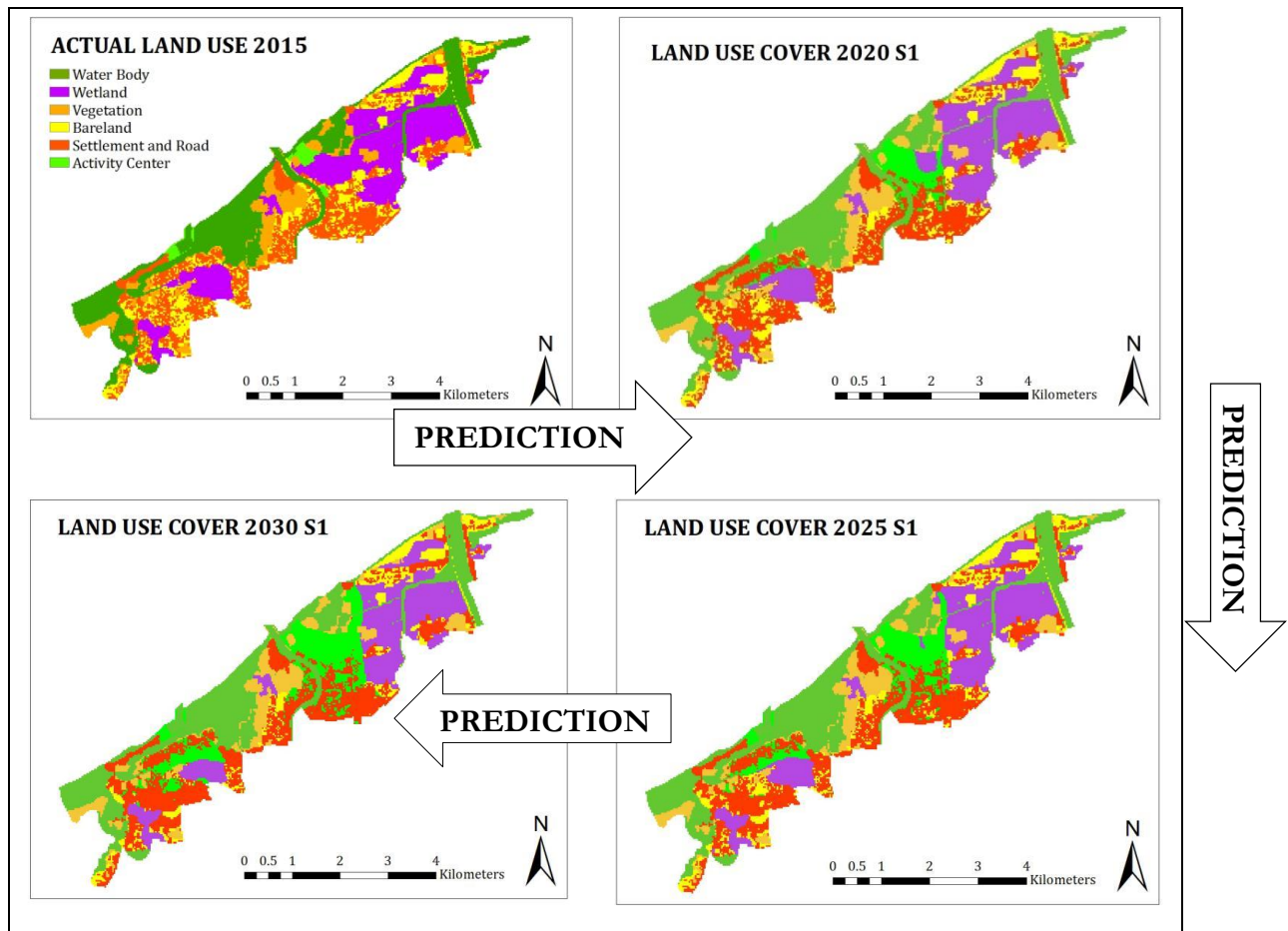
Figure 5. Cellular automata (CA) predicted land-use change for 2020, 2025, and 2030 in the coastal area of Banda Aceh - Scenario II (S1).

It seems that the finding is not in accordance with the predicted growth stimulated by Achmad et al. (2015), which argued the development of Banda Aceh would be less likely to extend in the coastal areas. At the time of the study, Achmad et al. (2015) used the former version of the spatial planning scheme. The coastal zone is identified as a high-risk tsunami area and, thus, allowed only for low-density development. Nevertheless, the different findings proved the dynamic process of the spatial-temporal characteristics in land-use changes, as many researchers argued. Not only influenced by the driving factors but also by a policy applied for the area. Studies of urban growth and simulation are useful to illustrate the change history, rhythm, speed, and behavior of land use transformation. Such information would help decision makers and urban planners anticipate the related impacts and proceed with a better planning scheme.

Considering the significance of wetlands for the urban ecology, both urban planners and policymakers in Banda Aceh should aim attention at wetland reserve programs. First, comprehensive and continuous wetland monitoring and assessment program should be established to regulate and conserve wetland resources, including providing a baseline in wetlands extent, condition, and function, identifying the transformation, and observing overall trends. These data potentially become the basis for enacting wetland restoration or conservation projects in the longer term and the basis to regulate the prevention of inappropriate land-use changes in the surrounding wetland area. Second, there is the need to implement particular procedures on zoning regulation of areas allocated for wetlands (wetland zoning) as part of the planning/building/activity permit. In general, the conduct should prevent or reduce impacts on wetlands resulting from those activities. Using the wetland database, specific areas can be delineated into several zones, for example, protected and recreational zones. While activities leading

to a significant change of wetland value will be prohibited in the protected zone, the recreational zone will provide opportunities for other activities with minimum impact. The programs should also be followed by a public awareness campaign to promote wetland values, threats, and impacts.

Conclusion

The land-use change simulation implies that uncontrolled growth and incompatible land use would likely result in environmental, social, and economic problems. Most pressure can especially be observed on non-urban lands, such as the vegetation and wetlands; the so-called locally generated ecosystem services significantly impact the environment. Particularly within scenario two, wetlands have commenced to continuously disappear due to the expansion of activity centers, decreasing from 507.70 Ha to 370.38 Ha. The most significant factor contributing to land use pattern changes is the distance to activity centers since the coastal area of Banda Aceh has been allocated for several attractive precincts for the community. Therefore, a focus on wetland preservation should be addressed in the land use planning of Banda Aceh.

Regarding the simulation process, the CA model in LanduseSIM has presented a systematic analysis of land-use change that can be operated over a range of time phases, considerably useful in assisting planners in explaining and predicting the land's possible growth. Unlike the conventional CA method, examined as a relatively complicated theory and calculation process, CA in LanduseSIM incorporated "fuzzy" that simplifies the mathematical and computer technologies and the land-use dynamics mechanism. The ability to forecast land use within expected scenarios is also an advantage of the CA model.

This study has developed the determinants of land use change from previous research in terms of driving factors. Although considered sufficient, it is also worth studying the other potential trigger, such as land price. According to Nijs and Pebesma (2010), underdeveloped lands in the urban periphery, such as agricultural land and bare land, are relatively cheaper than locations in the urban core. In the context of this study, the coastal area was so restricted as a tsunami-prone area, affecting its land value to decrease. Lower prices usually become the housing option for the low-income population. However, there is no study yet to confirm the relationship between land price and residential location preference in Banda Aceh.

Acknowledgments

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