Chapter 11

Utilizing the Potential of Coastal Sand Marginal Land Resources in the Framework to Improve Food Security Post-COVID-19 Pandemic in Indonesia

Bhaskara Anggarda Gathot Subrata & Anugrah Abdillah Junaid

A. Food Security and Marginal Coastal Sandy Land Potential in Indonesia

Food security is achieved when everyone has access to sufficient, healthy, and nutritious food that is aesthetically pleasing and economically viable. Food security is concerned with providing food sources, especially for the poor, who often lack access to food and struggle to raise their standards above the poverty line. At the beginning of the COVID-19 pandemic, food availability became a serious issue, as it could jeopardize Indonesia's food security. According to the Global Hunger Index report (Grebmer et al., 2019), many people in Indonesia face severe hunger. Because Indonesia imports a variety of food commodities from many different countries, COVID-19 sig-

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B. A. G. Subrata & A. A. Junaid
Ondokuz Mayis University, Turkey, e-mail: bhaskaraanggarda@gmail.com

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nificantly impact Indonesia's trade activities, including food security and agricultural goods. This problem is caused by the slowdown in agricultural production, logistics transportation, and distribution due to movement restrictions.

On the other hand, due to land conversion and environmental factors such as climate change, the availability of productive land in Indonesia has decreased over time (Figure 11.1). Food production, food security, climate change, and the COVID-19 pandemic are inextricably linked and affect one another. Humanity's current challenges necessitate the development of novel agricultural strategies and approaches to resolve the issue of food security following the COVID-19 pandemic. Strategic decisions must be made to invest in natural capital and consider ecological, economic, and social factors when producing, distributing, and consuming food. Thus, policy must prioritize urgent food and public health needs, ensuring agriculture's long-term resilience and sustainability, and anticipating future outbreaks such as COVID-19.

While all countries have been affected by the COVID-19 pandemic, Indonesia struggles due to its large population and vast archipelago. All risks of future food crises resulting from a pandemic outbreak can be mitigated by maximizing the potential of marginal land resources, especially coastal sandy areas that are abundant in several parts of Indonesia. For example, the Special Region of Yogyakarta (DIY) Province has a coastal sand area of approximately 13,000 hectares, or 4% of the province's total area, stretching 110 km along the Indonesian ocean's southern coast (Subrata et al., 2016). This beach sand stretch extends between 1–3 km away from the coast. This land is suitable for cultivating food crops and horticulture, owing to the presence of large, shallow groundwater and abundant sunlight (Sunghening et al., 2013). Coastal sandy land, on the other hand, is marginal land with low productivity. The low productivity of coastal sandy land results from limiting factors such as limited water holding/storage capacity, high infiltration, very low organic matter, and inefficient water use.

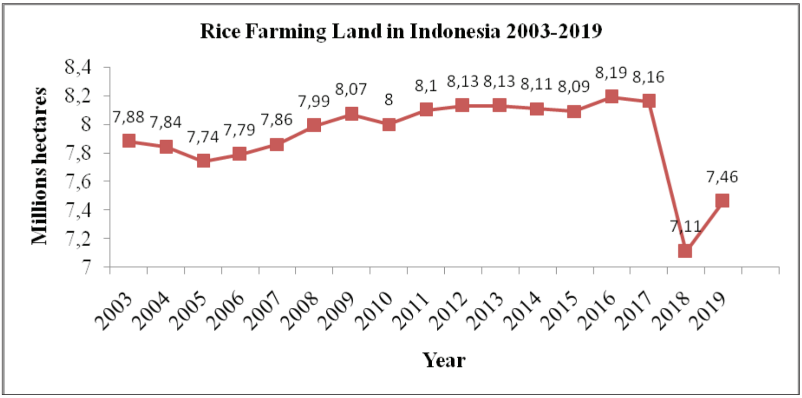
As a result, it is necessary to implement appropriate technology to convert coastal sandy land into productive agricultural land.

As a result, this chapter is expected to comprehensively present the potential of marginal coastal sandy land resources to support food security in Indonesia following the COVID-19 pandemic. This is in line with the primary objectives of the UN Research Roadmap for COVID-19 recovery, namely the need to develop strategies for preventing degradation and conserving land resources, particularly marginal coastal sands, to make them more integrated in the future to support Indonesia's food security.

B. The Difficulties and Dilemmas Associated with Indonesia's Agricultural Land Availability

Indonesia is one of the countries with the lowest average land per capita globally in terms of land resources. According to the FAO, Indonesia had 0.24 hectares of agricultural land per capita as of 2018. Meanwhile, the global average is 0.64 hectares, compared to 0.32 and 0.28 hectares in neighboring countries like Thailand and Malaysia (FAO, 2020). The land area per capita refers to the amount of agricultural land and pasture for cattle grazing. In Indonesia, land resources remain critically prioritized for social and economic development, frequently resulting in protracted agrarian conflicts.

Farmers and smallholders face a challenge related to agricultural land: agricultural land is becoming increasingly scarce as industry and settlements expand. Figure 11.1 depicts the land area used for rice production in Indonesia from 2003 to 2019. The figure demonstrates that the total productive land area has fluctuated yearly, with a significant decline in 2018 and 2019. For instance, one of the regions, Java Island, Indonesia's largest rice producer, has seen numerous changes in converting agricultural land to industry and settlements due to the country's growing population. Although several local governments have passed ordinances prohibiting the conversion of agricultural land, land conversion continues to increase year after year.



Source: Secretariat General Ministry of Agriculture (2020)

Figure 11.1 Rice Farming Land in Indonesia from 2003–2019

We still remember the massive land conversion incident in Kulon Progo area of DIY Province to construct the Yogyakarta International Airport (YIA). The construction of the YIA airport would then require 587 hectares in five villages in Kapanewon Temon, Kulon Progo, DIY Province. The problem is that agricultural land has been lost due to the construction of the Yogyakarta International Airport (YIA), resulting in the loss of several people's homes and livelihoods in favor of the airport construction area. This affects the environment's abiotic, biotic, and socioeconomic-cultural components. Among the ecological consequences are the loss of productive agricultural land and biodiversity. Economic effects include the loss of livelihoods for many Kulon Progo people, who rely on agriculture. Additionally, it is believed that the construction of the YIA airport made the people of Kulon Progo, especially the landless cultivators, the most vulnerable social group at the time. They possess a high probability of being "eliminated" from their life.

The aforementioned issue is only one of Indonesia's numerous examples of agricultural land conversion. The construction of a cement factory has contaminated agricultural land in the Kendeng area of Central Java. Agricultural land has been converted to develop the mineral mining industry in the Sangatta area of of East Kalimantan. There are numerous other agricultural land conversions to non-agricultural uses throughout Indonesia. The study indicated that Indonesia lost between 1,800 and 2,000 tons of rice yields yearly (Food Security Council Indonesia et al., 2015). Indeed, the government is not simply silent; it has expanded land to several areas throughout Indonesia via the food estate program. The food estate in Merauke Regency, Papua Province, with a target area of 1.2 million hectares, has converted more than half of its function to oil palm industries. Meanwhile, we have been surprised by the food estate program in Central Kalimantan Province in recent years, specifically in the Kapuas and Pulang Pisau Regencies. However, a few months after Indonesian President Joko Widodo led the initial planting, the farmers encountered crop failure. This is because inadequate technology was applied to the area's specific conditions, resulting in financial losses for many farmers.

Meyer and Früh-Müller (2020) demonstrate that the transition from land use to settlements or infrastructure has been quite extraordinary in the last few decades. Settlement development will outperform agriculture in affluent areas without prompt interventions, such as zoning planning or payments for farmland maintenance. Eventually farmers will abandon agriculture for economic reasons. According to Chrisendo et al. (2020), land-use change is common in tropical countries, with profound environmental and socioeconomic consequences. Thus, it is necessary to identify the potential for new land resources and investigate appropriate technology sources to achieve the best results possible during land conversion and agricultural land expansion.

C. Coastal Sand Marginal Land Resources: Opportunities and Challenges

Land resources are one factor contributing to an agricultural business system's success. Due to limiting factors, not all land can be planted with crops. Land subject to these limitations is frequently referred to as marginal land. Some land resource experts define marginal land are "characterized by land uses that are at the margin of economic viability" and "lands unsuitable for continuous tillage or lands where there were major constraints to economical use of industrial inputs" (Scherr & Hazell, 1994; Strijker, 2005). There are potential marginal land resources in Indonesia, one of which is coastal sand. Several islands are covered in millions of hectares of marginal land made up of coastal sand. The prospects for agricultural development are favorable, but they are currently being mismanaged. Due to the low fertility of these lands, technological innovation is required to increase productivity.

Indonesia is an archipelagic state with the world's second-longest coastline, after Canada (Gumbira & Harsanto, 2019). A country's vast coastline is a valuable asset to optimize. With 17,504 islands and a sea area of 7.9 million km^2, or 81% of Indonesia's total land area, coastal sandy land resources can be used to expand agricultural land. According to Samantha (2013), the Geospatial Information Agency estimates Indonesia's coastline total of 99,093 km. Coastal sandy land can be developed into agricultural land, given the vast amount of coastal land that has been underutilized.

Source: Lahan Pasir Pantai (2017). *Lahan pasir pantai.* https://pxhere.com/id/photo/1183739

Figure 11.2 Coastal Sand Marginal Land

Table 11.1 Some of the Characteristics of the Coastal Sandy Land at Bugel Beach, Kulon Progo, DIY Province

Soil characteristics	Value	Description
Soil dry moisture content (%)	0.68	-
pH (H2O) (1:2,5)	6.7	(neutral)
Electrical Conductivity (mS)	0.20	(very low)
Soil C-organic content (%)	0.23	(very low)
Soil Organic Matter (%)	0.40	(very low)
N-total (%)	0.02	(very low)
P-availability (ppm)	16.67	(high)
K-availability (me 100 g^{-1})	0.03	(very low)
Ca-availability (me 100 g^{-1})	0.63	(very low)
Na-availability (me 100 g^{-1})	0.29	(low)
Mg-availability (me 100 g^{-1})	0.18	(very low)
Cation Exchange Capacity (me 100 g^{-1})	3.81	(very low)
Sand fraction (%)	98.5	
Dust fraction (%)	1.5	Sandy land
Clay fraction (%)	1.0	
Soil volume weight (g cc^{-1})	1.79	(bit high)
Soil density (g cc^{-1})	2.75	(bit high)

Source: Kertonegoro et al. (2007); Subrata et al. (2016)

As shown in Table 11.1, coastal sandy land is marginal land with low productivity characteristics, including sandy texture, loose structure, low nutrient content, low cation exchangeability, low water holding capacity, very high evaporation rate, and very minimal nutrients, containing clay and dust (Budiyanto et al., 2020; El Sayed Said et al., 2020; Xue et al., 2016). As a result, the buffering capacity for water and fertilizer is deficient (Minasny & McBratney, 2018). The sandy soil easily drains water at around 150 cm per hour, affecting the root system and water depth (Basso et al., 2013). On the other hand, sandy soils have a limited capacity to store water, storing only about 1.6–3% of available water (Yost & Hartemink, 2019). The coastal area's wind is powerful, ranging between 4.9–5.1 m sec^{-1} (Table 11.3). At that speed, the wind easily uproots roots and knocks plants over, and it can carry salt particles that can obstruct plant growth (Downs & Hellmers, 1975).

Temperatures in coastal areas can reach 43°C during the day, with humidity reaching 39% (Table 11.2), while rainfall is extremely low, around 86–378 mm year^{-1} (Table 11.3). This results in groundwater loss due to extremely high evaporation rate.

Table 11.2 Average Temperature (°C) and Humidity (%) for 3, 6, 9, and 12 Months

Time	Temperature (°C)				Average	Humidity (%)				Average
	3	6	9	12		3	6	9	12	
Morning (06.00–07.00)	28	30	28	29	28.75	69	65	69	67	67.50
Noon (12.00–13.00)	45	43	45	42	43.75	39	38	39	40	39.00
Afternoon (17.00–18.00)	34	34	35	31	33.50	58	58	61	63	60.00

Source: Subrata et al. (2016)

Additionally, coastal sandy land is defined by a soil composition predominantly composed of sand (>80%). The availability of plant nutrients, particularly nitrogen, is extremely low. Coastal dunes are also highly porous. As a result, chemical fertilizers are easily washed out of the root zone and lost. Another characteristic is cation exchange capacity, and soil biota has a very low standard of living.

Table 11.3 Average Rainfall (mm), Long Sunshine (%), and Wind Velocity (m sec-1)

Time	Rainfall (mm)				Long Sunshine (%)				Wind Velocity (m sec^{-1})			
	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016
Jan	427	334	249	227	92	89	94	90	4.84	4.3	5.78	5.04
Feb	226	175	208	521	89	94	87	88	4.85	5.08	4.29	5.1
Mar	511	133	137	594	94	90	88	86	5.16	5.17	4.83	5.29
Apr	89	59	149	461	90	91	89	94	4.54	5.97	4.1	4.73
May	8	14	74	48	91	87	94	83	4.96	6.5	5.03	4.35
Jun	0	9	29	416	89	88	89	94	4.29	5.04	5.09	5.29
Jul	0	0	2	84	94	89	94	90	4.83	4.64	5.08	5.17

Time	Rainfall (mm)				Long Sunshine (%)				Wind Velocity (m sec^{-1})			
	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016
Aug	2	0	0	41	94	94	90	91	4.1	4.6	4.3	5.08
Sep	0	5	62	407	94	90	89	94	4.83	5.03	6.5	5.04
Oct	0	0	65	372	90	94	94	90	5.04	4.35	5.29	4.87
Nov	99	202	447	808	91	90	90	88	5.78	4.29	4.83	4.1
Dec	270	102	124	566	87	91	88	82	6.5	6.2	6.7	6.9
Ave	136.0	86.8	128.8	378.7	91.2	90.5	90.5	89.1	4.9	5.1	5.2	5.1

Source: Meteorology, Climatology, and Geophysical Agency Indonesia (2022)

D. Innovation in Management Technology Coastal Sandy Lands

Coastal sandy lands in the south of Java have not been yet used extensively as agricultural land in the last decade. This is because the land is made of sand, has a high wind speed, and contains salt, making it unsuitable for agriculture, particularly food crops. However, coastal land is potential as agricultural land for food crops and horticulture in the last decade, despite its low productivity (Kurniasih et al., 2021; Parwata et al., 2013; Putra et al., 2017a). This demonstrates the potential for developing coastal sandy lands throughout Indonesia as an option for agricultural land expansion programs.

Through technology and community empowerment, efforts can be made to utilize, improve, and increase the fertility of agricultural land in naturally less productive coastal sand areas. The first step toward using this arid land is to manipulate the soil by adding soil enhancers such as clay, lime, zeolite, manure, or compost to improve the soil's physical, chemical, and biological properties. Soil improvement services can be provided at least once a year, if not more frequently. Adding clay has increased clay content, and soil aggregation in coastal sandy areas. According to Putra et al. (2020), applying organic manure at a rate of 30 tons $hectare^{-1}$ can increase the C-organic content by 7.8%. Meanwhile, zeolite application can improve soil characteristics by increasing clay content, between pF 4.2 and 2.54, moisture-holding capacity, volume weight, specific gravity, soil pH, nitrogen, phosphorus, and potassium availability from 11.25% to 23.9%, respectively (Rajiman et al., 2021).

Due to the low biological fertility of coastal sandy soil, biological fertilizers are the best technology to apply. Soybean plants increased the number of root nodules by up to 120% and seed yield by 68% when inoculated with *Rhizobium japonicum* bacteria (Purwaningsih et al., 2019). *Trichoderma asperellum* and *Trichoderma* spp., free-living fungi found in soil and root ecosystems, have also been studied in coastal sandy areas. Trichoderma inoculation of shallots in sandy coastal soils can increase fresh shallot yields by 21–25% (Setyaningrum et al., 2019).

Irrigation of the coastal sand area will require the construction of several communal wells (Figure 11.3). Communal wells are a network of irrigation wells and water reservoirs connected approximately 10 m apart. Pumps deliver well water directly to the land via pipes connected in an open and closed system. With the availability of shallow water sources, it is possible to anticipate drought when conducting plant cultivation (Yuwono, 2009). Maintaining soil moisture requires careful management that considers the presence of freshwater sources. Micro-irrigation can also be used to conserve water. Micro-irrigation is a type of irrigation that delivers water directly to the root zone of plants. Drip irrigation, micro sprays, mini sprinklers, and subsurface irrigation are all types of micro-irrigation. Micro-irrigation systems are more effective and efficient in water use than conventional irrigation systems. Micro-irrigation using various models has been shown increased shallot yields from 2–4 tons ha^{-1} to approximately 7–9.4 tons ha^{-1}. Chili commodities can increase crop yields from 8 tons ha^{-1} to 17 tons ha^{-1} by extending the harvest season from 12 to 19 times (Indradewa et al., 2021).

Tree planting in the zone adjacent to the beach must occur concurrently with the rest of the coastal area (0–200 m). Planting trees can generate biomass that can be used to replenish the soil's

Source: Amelia (2012); Department of Soil Science-Universitas Sebelas Maret (2021)

Figure 11.3 Communal Wells System in Coastal Sandy Land

organic matter, improve the microclimate, break wind from the sea, and prevent the spread of salt carried by the wind (Yuwono, 2009). Wind speed reduction alters the microclimate within the protected zone. The temperature will drop, and the air humidity will rise, decreasing water loss via evapotranspiration (Sunaryo & Darini, 2010). Numerous plant species that grow along the coast and act as a barrier include pandan laut (*Populneatectorius*), pandan wong (*Pandanus* sp.), keben (*Barringtonia asiatica*), ketapang (*Terminalia catappa*), waru laut (*Hibiscust iliacerus*), borogondolo (*Hernandia peltata*), nyamplung (*Calophyllum inophyllum*) and cemara laut (*Casuarina equisetifolia*) (Mile, 2007).

Cropping patterns are appropriate for coastal sand farming due to the season and low rainfall. Cropping patterns enhance crop productivity during certain seasons, and farmers can forecast the types and varieties of crops that will thrive during that season. Crop rotation or relay cropping can effectively control pests, diseases, and weeds, and improve soil fertility (He et al., 2019). Additionally, cropping patterns can be used to determine the optimal variety to harvest at the optimal price-to-profit ratio (Pandit et al., 2018).

Coastal sand farming can also benefit from multiple cropping systems. Due to coastal sandy land's relatively rapid drainage rate, watering must be more intensive. Fertilizer application is also increased due to the fertilizer's increased evaporation rate. Intercropping has been shown to increase the Land Equivalent Ratio (LER). The best LER value was 1.47 for intercropping upland rice and mung beans (Subrata et al., 2016), 1.89 for intercropping upland rice and soybeans (Putra et al., 2017b), and 1.13 for tomatoes and cabbage (Rusbiyati et al., 2018). Multiple cropping can increase crop efficiency in fertilizer, watering, and pesticide use. Additionally, even with a small land area, farmers can maximize their harvests because they can plant two or more crops in a single planting season, increasing farmers' income.

E. Conclusion

Although the end of the COVID-19 pandemic is unknown, its impact has been felt thus far. This will directly affect the community's food security, such as purchase power eroding, food prices increasing, and there may be a food shortage or insufficient supply. On the other hand, with its enormous population, Indonesia needs to reconsider efforts to increase the availability of high-quality food ingredients in both quantity and quality. Increasing cultivation on marginal coastal sandy land is the best option for increasing food availability in Indonesia's declining productive land. Indonesia, which has the world's second-longest coastline, can capitalize on the potential of coastal sandy land as a new chapter in agricultural production following the COVID-19 pandemic and into the future.

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