



INITIATIVE ON
Asian Mega-Deltas

CAN THO UNIVERSITY

REPORT
LAND USE ANALYSIS FOR 13 PROVINCES IN
VIETNAMESE MEKONG DELTA IN 2022

PROJECT

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SECURING THE FOOD SYSTEM OF ASIAN MEGA-DELTAS FOR CLIMATE AND
LIVELIHOOD RESILIENCE

Can Tho, January 2024

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Abbreviations

EVI	Enhanced Vegetation Index
GEE	Google Earth Engine
LULC	Land Use Land Cover
LULCC	Land Use Land Cover Change
NDVI	Normalized Difference Vegetation Index
RF	Random Forest
SAR	Synthetic Aperture Radar
VMD	Vietnam Mekong Delta

1. Introduction

The Vietnam Mekong Delta (VMD), often referred to as the “Rice Bowl” of Vietnam, has exceptional ecological and agricultural significance (Diem et al., 2021). This delta encompasses a complex network of rivers, canals, and fertile floodplains, making it one of the most productive regions in the country. The agricultural practices and land use in the VMD have sustained the livelihoods of millions of inhabitants and contributed significantly to national food security and economy (Tran et al., 2021).

For centuries, the VMD has been famous for various agricultural activities. The rich alluvial soils and its strategic location at the end of the Mekong River have allowed for the cultivation of various crops and agricultural farming practices. Rice, undoubtedly the most prominent crop, is deeply ingrained in the culture and economic of the region. Beyond rice, the delta also supports the growth of fruits, vegetables, aquaculture, and livestock, contributing to its reputation as a diverse agricultural hub (Luu, 1999; Phong et al., 2011).

Although the region is known for producing remarkable agricultural products, the delta faces numerous challenges from economic restructuring processes and climate change impacts, including sea level rise and increased occurrences of extreme weather events (Nguyen et al., 2020). These difficulties pose significant threats to the delta's agricultural land use. Salinity intrusion, soil erosion, and loss of biodiversity are pressing concerns that demand innovative and sustainable solutions.

In response to these challenges, the region has seen the implementation of various strategies and practices. Notable solutions include the adoption of resistant plant varieties, the transformation of crops and livestock to adapt to new conditions of soil and water resources, and large-scale irrigation systems to regulate irrigation of specific sub-regions (Resolution No. 120/NQ-CP in 2017, Resolution No. 57/NQ-CP in 2022). These initiatives promise to sustain livelihoods, increase agricultural productivity, and minimize environmental degradation.

This work package aims to use remote sensing and integrated information to update the current agricultural land use maps at the provincial scale in the VMD. It serves as a premise to identify the current common agricultural land use patterns in the VMD and current transformation trends. From there, it serves the next assessments of livelihoods, costs and revenues from various agricultural farming models.

2. Data and Methodology

2.1. Data sources

2.1.1. Satellite images

An integration of Sentinel images, including active Synthetic Aperture radar (SAR) images from Sentinel-1A sensor and optical images from Sentinel-2 sensor, was utilized to delineate a land use and land cover map in the VMD. These data sources were accessed through the Google Earth Engine (GEE) (<https://code.earthengine.google.com>) platform through the Data Catalog.

- Sentinel-1 sensor provides active SAR images without atmospheric effects from cloud, fog, and other weather conditions.
- Sentinel-2 sensor observes the Earth's surface using optical multispectral instruments, which is easily affected by clouds and atmospheric disturbances. However, the spectral information from multispectral bands (i.e., from visible to red-edge, and shortwave infrared wavelengths) is useful to monitor land use land cover change (LULCC) and vegetation coverage through various spectral indices, e.g., Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI).

The Sentinel-1A and Sentinel-2 dataset were obtained within the period of November 2021 and December 2022 to capture seasonal characteristics of rice farming and other seasonal crops.

2.1.2. Supporting data

Administrative boundary and official inventory data (i.e., reports and spatial maps) from the 13 provinces of the VMD were acquired from the provincial Department of Natural Resources and Environment. These data were used to standardize provincial boundaries, hydrological systems, forests, and nature reserves. This auxiliary data assists in reducing the workload of classification and post-classification tasks because these categories are more aligned with land use rather than land cover, which can be easily delineated by using remote sensing techniques.

2.2. Methodology

2.2.1. Preprocessing and Spectral Index calculation

Sentinel images (Sentinel-1A and Sentinel-2) were collected during the specified period to ensure complete coverage of the VMD. The images underwent a series of preprocessing procedures including collection filter, spatial subset based on administrative boundaries, spatial filter, and spectral index calculation.

Sentinel-1A collection comprises images captured by the descending orbit, which corresponds to daytime acquisition. Then, these images have been processed using Speckle Noise Filtering via the Lee Sigma Filter to reduce potential noises on SAR imagery and illumination effects on each individual image. The single images were then combined into monthly composite images by the Median operator to generate the temporal time series of cross-polarization (VH) and co-polarization (VV). Besides, the Maximum and Minimum operators were also applied to generate different aspects of cross-polarization (VHmax, VHmin, VHmax - VHmin) bands (Wanninayaka et al., 2020). These different aspects of polarizations enable the differentiation of LULC categories and monitor plant growth (e.g., rice and seasonal crops) through assessing backscatter values (dB) (Kontgis et al., 2017).

Sentinel-2 collection was first selected based on a cloud cover ratio, which should be less than 20%. Subsequently, the cloud mask function based on band of quality assessment (BQA) was applied to remove cloud and cloud shadow pixels. The monthly composite

image was introduced to fill in the missing data due to cloud removal procedures. The free cloud images were then acquired to calculate NDVI for each individual image and generate a multi-temporal time series of NDVI.

$$NDVI = \frac{NIR-Red}{NIR+Red} \quad NDVI = \frac{NIR-Red}{NIR+Red} \quad (\text{Tucker, 1979})$$

The multi-temporal time series of Sentinel-1A and NDVI from Sentinel-2 were combined as the input bands for the classification.

2.2.2. Unsupervised classification using K-means clustering

K-Means is an unsupervised clustering algorithm (unlabeled clusters). In this study, unsupervised classification was used to separate the time series data into distinct clusters that are clearly different from each other in terms of spectral and temporal characteristics. Pixels were grouped together into clusters when they were homogeneous and shared the same properties. The number of clusters is defined by users as one of the input parameters ($k=50$).

The time series data of backscatter from Sentinel-1A (VV, VH, VHmax, VHmin, and VHmax - VHmin) and Sentinel-2 NDVI were used as input data for unsupervised classification. Unsupervised classification simplifies the raw data and optimizes the performance of the GEE platform for further analyses.

2.2.3 Supervised classification using Random Forest Classifier

The random forest (RF) classifier is a popular method for classification and clustering. The RF classifier uses a number of decision trees with the core algorithm based on CART (Classification And Regression Tree). It randomly combines and selects features for decision trees. In other words, it is the random selection of properties for each iteration (Breiman, 2001). The classification decision is made by the majority vote among the decision trees.

A random forest classifier with a specified number of trees ($n_{tree} = 100$) was applied for agricultural land use classification with inputs from clustered data. The classifier was trained using ground truth points (GTP), which were collected by the field data collection.

2.2.3. Field data collection and Accuracy assessment

Ground truth samples were collected from various sources, including field surveys, Google Earth, land use inventory maps, and meetings with local experts in land management. A total of 8,463 samples were collected from these sources. Information on land use types, coordinates (x, y), and changes in crop cultivation at each location was recorded during field trips for further land use analysis. A total of 2,539 samples, representing approximately 30% of the ground truth data, were used. Ten classified land use types—namely mono rice crop, double rice crops, triple rice crops, annual crops, perennial trees, sugarcane, pineapple, rice-shrimp, mangrove-shrimp, and aquaculture—were assessed for accuracy.

According to Trung (2005) accuracy assessment is performed to evaluate the suitability between classified images and ground truth points based on the comparison using confusion matrix. The accuracy assessment is assessed by the representative indices of overall accuracy (T%) and Kappa coefficient (K).

$$T = A/B$$

$$K = K = \frac{(T-E)(T-E)}{(1-E)(1-E)}$$

where, T is overall accuracy (%); A is sum of diagonal quantities; B is sum of rows (columns); E represents a predictable (expected) accurate classification.

The Kappa coefficient ranges from 0 to 1 and is divided into five levels (Table 1.1), each corresponding to different levels of classification acceptability.

Table 1.1. Kappa coefficient value range and corresponding accuracy

No.	Accuracy	Kappa
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1	Very low accuracy	$K < 0.2$
2	Low accuracy	$0.2 \leq K < 0.4$
3	Medium accuracy	$0.4 \leq K < 0.6$
4	High accuracy	$0.6 \leq K < 0.8$
5	Very high accuracy	$0.8 \leq K < 1.0$

(Source: Congalton and Green, 1999)

The classified maps were exported from GEE for post-classification tasks. The auxiliary data (hydrological systems and forests) were combined with the classified maps using the Union overlay function.

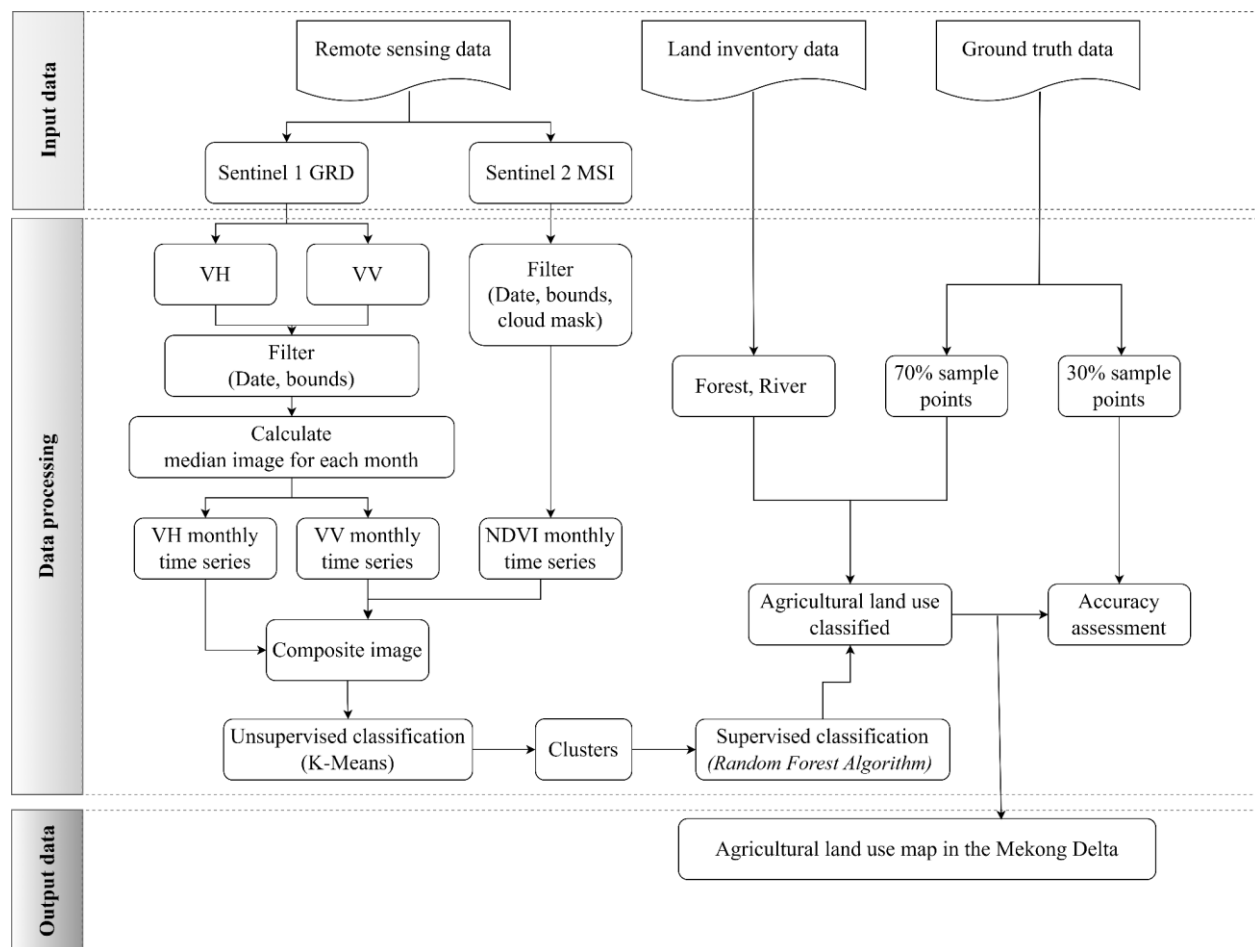


Figure 1.1. Methodology flowchart in this research

3. Result and discussion

3.1. Current agricultural land use in the Vietnamese Mekong Delta in 2022

The classification of land use is assessed for accuracy using ground truth samples and a confusion matrix table (Table 1.2). Distribution of ground truth samples is shown in Figure 1.2.

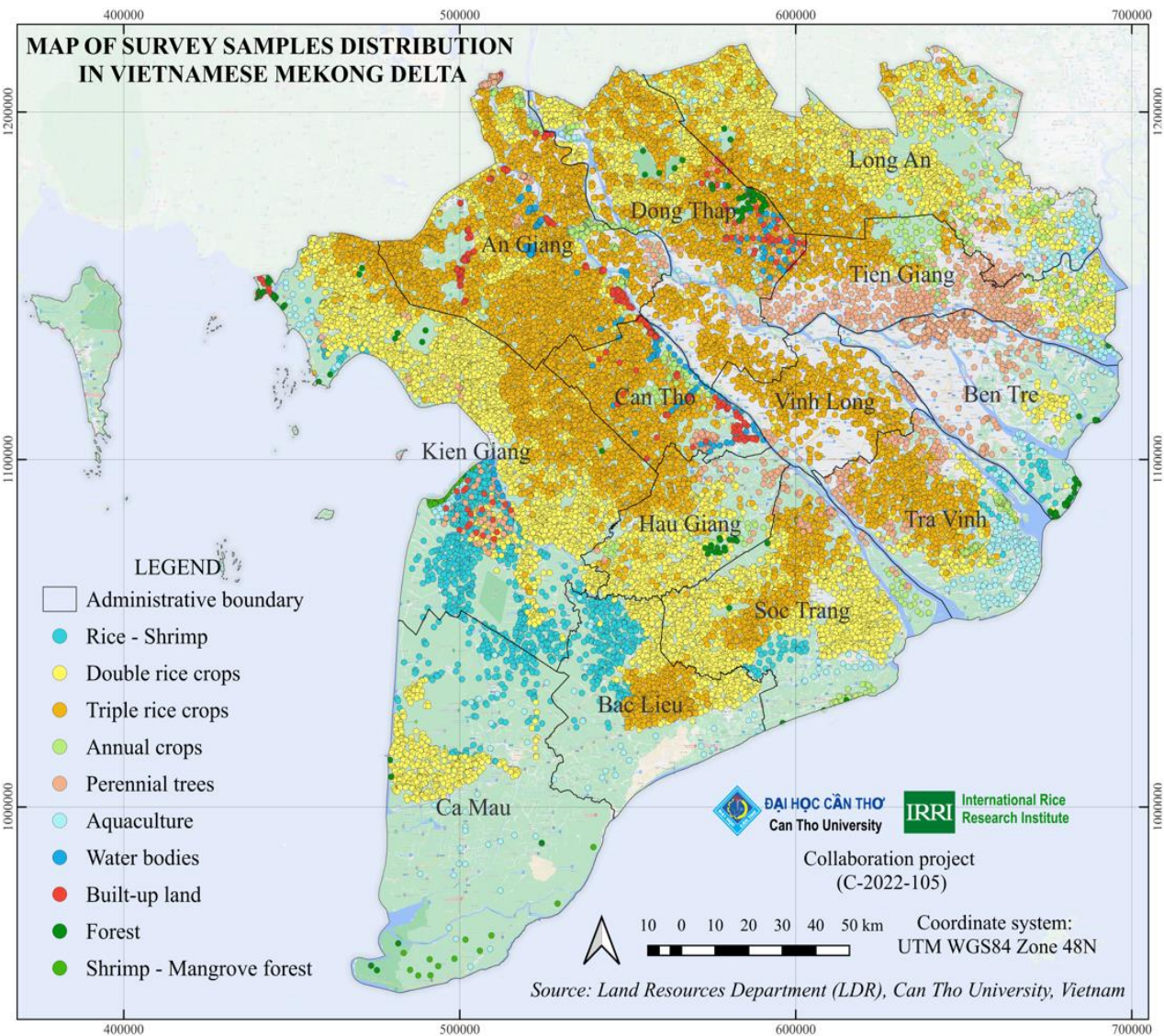


Figure 1.2. Map of survey samples distribution in Vietnamese Mekong Delta

Table 1.2. Land use classified confusion matrix

Predicted data	
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	Land use	Double rice crops	Triple rice crops	Rice-shrimp	Pineapple	Sugarcane	Perennial trees	Annual crops	Shrimp-Mangrove	Aquaculture	Built-up land	Accuracy
Field survey data	Double rice crops	256	30	22	0	0	32	11	0	0	4	72.1%
	Triple rice crops	30	201	0	0	0	8	3	0	0	6	81.0%
	Rice-shrimp	2	0	173	0	0	23	2	0	30	2	74.6%
	Pineapple	0	0	0	10	0	0	0	0	0	0	100.0%
	Sugarcane	0	0	0	0	20	1	0	0	1	1	87.0%
	Perennial trees	0	3	0	0	1	731	18	0	0	24	94.1%
	Annual crops	27	21	4	0	0	58	232	0	23	9	62.0%
	Shrimp-Mangrove	0	0	0	0	0	0	0	12	0	0	100.0%
	Aquaculture	1	0	14	0	0	25	6	4	194	13	75.5%
	Built-up land	0	2	0	0	0	15	5	0	16	213	84.9%
Reliability		81.0%	78.2%	81.2%	100%	95.2%	81.9%	83.8%	75.0%	73.5%	78.3%	80.4%

According to the accuracy assessment results, agricultural land use classified from Sentinel images was analyzed with an overall accuracy of 80.4% and a Kappa coefficient of 0.61. A total of 13 land use types were classified, as shown in Figure 1.3.

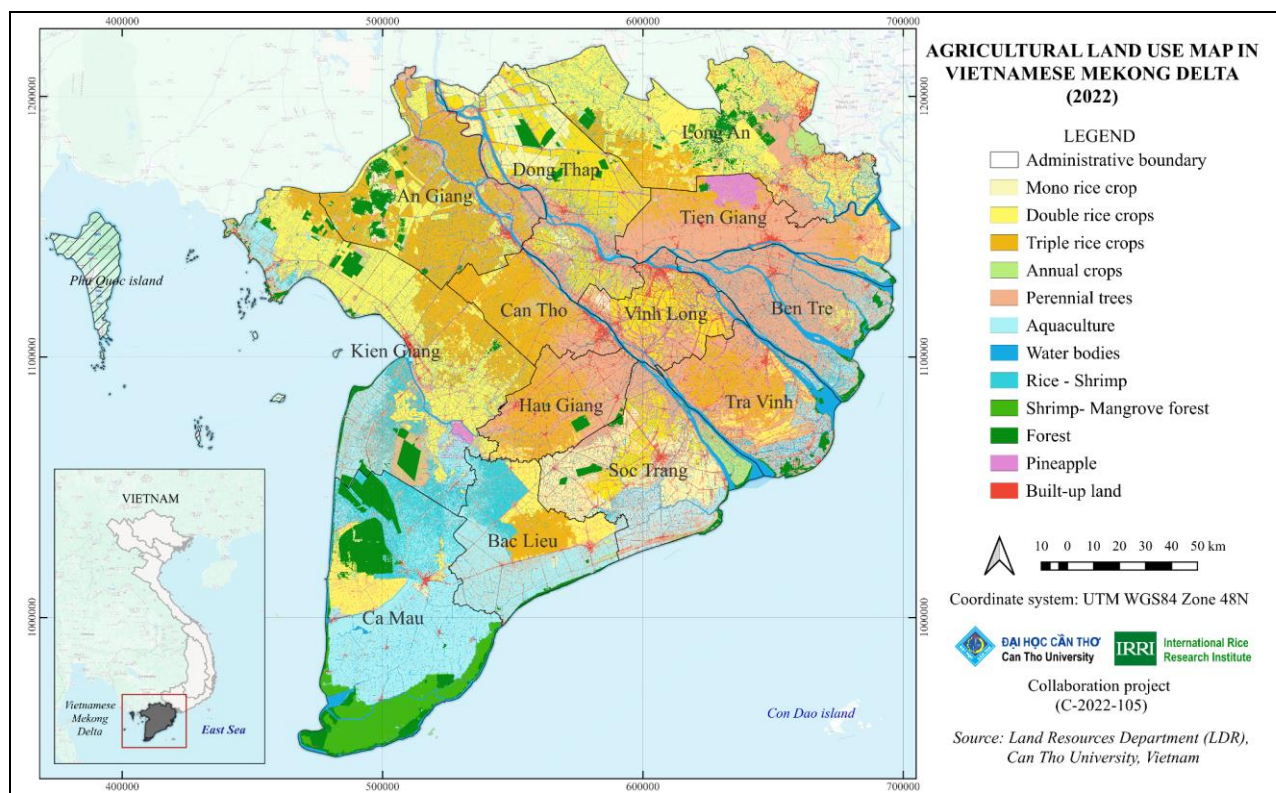


Figure 1.3. Agriculture land use map in Vietnamese Mekong Delta in 2022

In general, about 80% of the total area of the VMD is characterized by agricultural farming, including rice-specialized farming (double rice and triple rice crops), rice-shrimp, annual crops, perennial plants, pineapple, aquaculture, forest, and mangrove-shrimp.

Rice farming is the dominant land use in the delta, covering 1,337,089.9 ha (about 37.6%). This includes rice-specialized farming (double and triple rice crops), rice-shrimp rotational farming, and mono rice crops. Double rice and triple rice crops account for a large proportion of rice cultivation (about 88.6% of the total rice cultivation area). Double rice crops cover an area of 501,945.74 ha, mostly distributed in the coastal areas of the Long Xuyen Quadrangle and U Minh Thuong regions (Kien Giang province), Thoi Binh district (Ca Mau province), the freshwater region in Bac Lieu province, Dong Thap Muoi (Long An province), and Tran De district (Soc Trang province). The total area of triple rice crops is 683,207.02 ha in the inland regions. Key rice production areas include An Giang, Hau Giang, Vinh Long, Dong Thap, Tra Vinh (Cau Ke, Tieu Can, and Chau Thanh), Kien Giang

(Tan Hiep, Giong Rieng), and Bac Lieu provinces (freshwater region north of the 1A national road). Rice-shrimp farming accounts for only 10% of the total rice cultivation area, corresponding to 140 thousand hectares. This practice is prevalent in the U Minh regions (U Minh Thuong and U Minh Ha) in Ca Mau and Kien Giang provinces, and in the transformative sub-regions in Hong Dan and Phuoc Long districts (Bac Lieu province). Mono rice crops are a minor land use in rice cultivation, with 11,864.14 ha (nearly 1% of the rice cultivation area). This is mainly the rain-fed rice system in Ca Mau city, Tinh Bien, and Tri Ton districts (An Giang province).

Perennial plants (mostly orchards or fruit farms) constitute the second-largest system, covering 980,987.19 ha across the delta. Key regions for perennial plants are located along the Bassac River (Tien and Hau Rivers), including Hau Giang, Vinh Long, Ben Tre, Tien Giang, and Dong Thap provinces. The delta is known for its tropical and subtropical fruits, such as orange (king mandarin), tangerine, pomelo, rambutan, durian, soursop, and coconut.

Aquaculture is a key agricultural sector in the VMD, covering 444,765.77 ha (12.5% of the total area). This includes both brackish and freshwater aquaculture, depending on water resource availability. Brackish aquaculture is distributed along the coastal regions in Ca Mau province (Cai Nuoc, Dam Doi, and Phu Tan districts), Bac Lieu province (Dong Hai, Hoa Binh, and Gia Rai districts), Soc Trang province (My Xuyen and Vinh Chau districts), Kien Giang province (An Bien, An Minh, Vinh Thuan, Kien Luong, and Ha Tien districts), Tra Vinh province (Duyen Hai district and Duyen Hai town), Ben Tre province (Thanh Phu, Binh Dai, and Ba Tri districts), Tien Giang province (Tan Phu Dong district), and Long An province (Can Duoc and Can Giuoc districts). Black tiger shrimp, whiteleg shrimp, crab, and blackish fish are commonly farmed in these regions. Among the provinces, Ca Mau has the most extensive aquaculture area in the VMD. Freshwater aquaculture primarily raises catfish, red tilapia, and giant freshwater shrimp in Dong Thap, An Giang, and Long An provinces.

Annual crops cover 149,206.62 ha, scattered across the delta. Specialized regions with geographical indication crops are found in the delta, mainly concentrated in the river isles on the Hau River (Soc Trang, Vinh Long, Tien Giang, and Long An provinces). Typical annual crops in the delta include sugarcane, leafy vegetables, spice vegetables, lemongrass, onion, and white radish.

Pineapple is a typical plant in the delta, covering about 16,979.68 ha. It is mainly cultivated in Tien Giang and Kien Giang provinces and is often integrated into intercropping systems (e.g., with coconut, durian, and mango) to optimize cultivation space. Forests in the VMD include three types: production, protection, and special-use forests. These include mangrove, Melaleuca, and natural forests, covering about 176,275.5 ha (5.0%). Ca Mau and Kien Giang provinces have the most extensive mangrove forests. Melaleuca forests are primarily found in Soc Trang province (Nga Nam and My Tu districts), An Giang province (Tinh Bien district), Long An province (Tan Hung, Duc Hue, and Thu Thua districts), and Hau Giang province (Phung Hiep district).

Mangrove-shrimp farming is a highlight of agricultural production in the VMD, considered an environmentally friendly and efficient system. This farming is concentrated in Ca Mau province, covering about 78,290.89 ha, particularly in Ngoc Hien and Nam Can districts.

3.2 Agricultural land use map by provincial level

3.2.1. Current agricultural land use in Can Tho city

The 2022 classified agricultural land use map shows that the current provincial land use consists of 8 main land use types: double rice crops (DRC), triple rice crops (TRC), annual crops, perennial plants, aquaculture, built-up land, and water bodies (Figure 1.4).

6	Water bodies	7,445.01	5.2
7	Built-uplands	8,478.48	5.9
Total		144,393.85	100.0

Rice is the main seasonal crop in Can Tho city, with over 55% of the total area dedicated to cultivating triple rice crops in the districts of Co Do, Thoi Lai, Vinh Thanh, O Mon, and Thot Not. Additionally, double rice crops account for a small proportion of the total rice farming (about 2.8%) and are distributed in Vinh Thanh and Thoi Lai districts.

Perennial plants (or fruit farms) are the second most important agricultural land use in Can Tho city, covering 37,887.44 ha (26.2%). The most extensive orchards are found in Phong Dien district. In addition to cultivating various fruits for the market, this district also focuses on eco-gardens and eco-tourism integrated with different fruit farms (e.g., Burmese grape, rambutan, mangosteen, and durian). Other major fruit farms are located in the "Nong Truong Song Hau" zone, particularly in Thoi Hung and Dong Hiep communes (Co Do district), with over 2,000 ha dedicated to fruits such as mango, soursop, and Thai custard apple.

Annual crops cover a smaller proportion of the city, with over 6,000 ha (4.3%), distributed throughout the city, especially in the "Nong Truong Song Hau" zone, where vegetables and tubers are cultivated.

The Bassac River flows through the eastern part of Can Tho city, affecting the districts of Thot Not, O Mon, Binh Thuy, Ninh Kieu, and Cai Rang. The abundant freshwater resources facilitate freshwater aquaculture along the riverbanks. However, the aquaculture area is smaller compared to upstream areas, totaling only about 936.89 ha (0.6%). Aquaculture ponds are also found in the "Nong Truong Song Hau" zone, where they are interplanted with other annual crops due to agricultural transition processes.

3.2.2. Current agricultural land use in An Giang

An Giang ranks second in the VMD for rice cultivation areas. Agricultural production is crucial to the provincial economic structure. The delineated map from remote sensing reveals that the province has eight major land use types: mono rice crop, double rice crops, triple rice crops, annual crops, perennial plants, aquaculture, built-up lands, and water bodies (Figure 1.5). Table 1.4 shows the area and proportion of agricultural land use types in 2022.

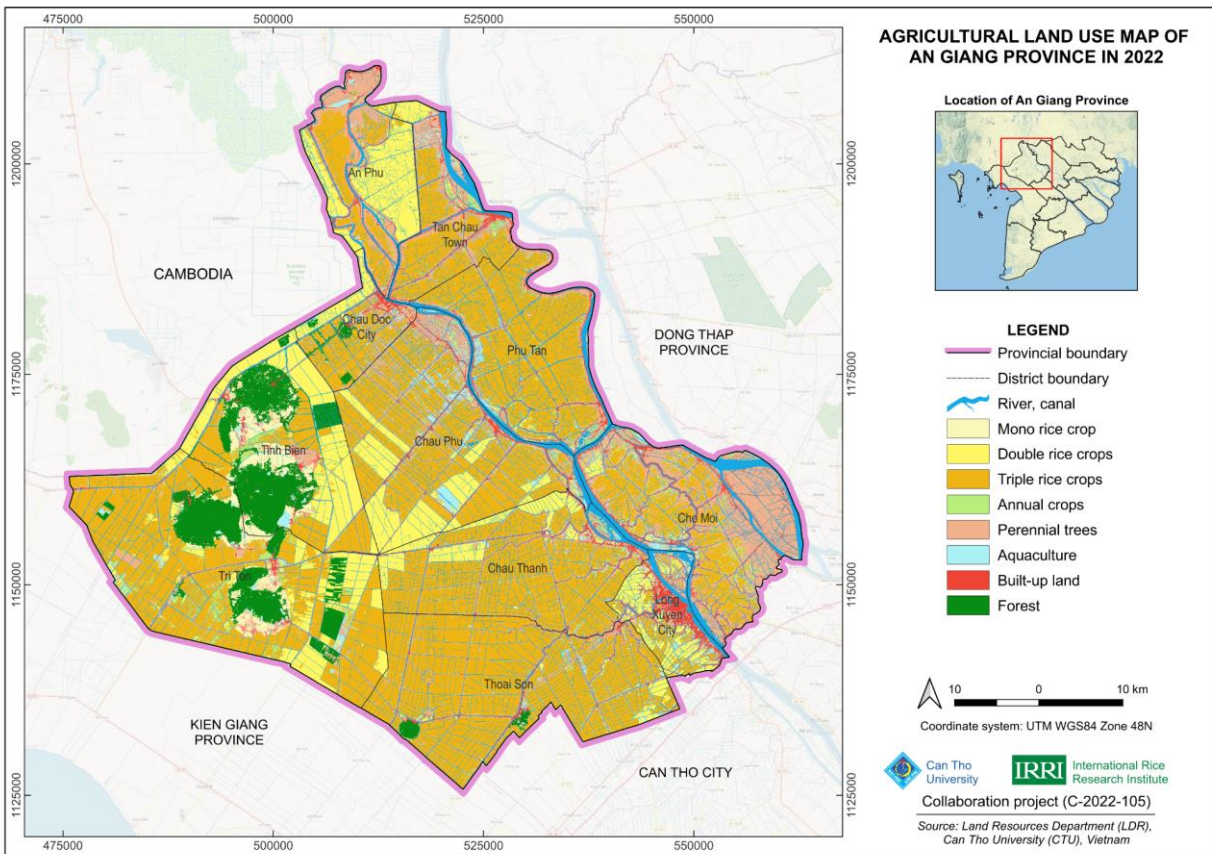


Figure 1.5. Current land use map in An Giang province in 2022

Table 1.4. Area and proportion of land use units in An Giang province in 2022

No	Land use types	Area (ha)	Proportion (%)
1	Mono rice crop	7,069.90	2.0

2	Double rice crops	42,527.30	12.0
3	Triple rice crops	171,036.90	48.4
4	Perennial plants	54,317.90	15.4
5	Annual crops	17,670.4	5.0
6	Built-up lands	9,019.40	2.6
7	Aquaculture	7,069.10	2.0
8	Water bodies	25,497.00	7.2
9	Forest	19468.1	5.5
Total		353,676.00	100

Rice farming is present in all 11 districts and towns in An Giang province. The major rice cultivation areas are Tri Ton, Thoai Son, Chau Phu, and Chau Thanh districts. The province employs three main rice cultivation models. Triple rice crops are the most extensive, covering 171,036.9 ha (48.4% of the total area). The full dike system, completed in the mid-2000s, has prevented flooding and facilitated the increase in area for the third rice crop (Autumn-Winter crop) each year. Double rice crops account for 12% of the area (42,527.3 ha) and are found in areas with active flood regimes. Mono rice crops cover about 7,069.9 ha (2.0%).

Perennial plants constitute a significant proportion of the total land use area, with approximately 54,030.3 ha (15.4%) along the Bassac River in Cho Moi, An Phu, Chau Phu, Phu Tan, and Chau Thanh districts. Although the remote sensing image delineation cannot distinguish between fruit categories, field surveys have identified three main fruit groups in An Giang province:

1. Tropical and subtropical fruits: The principal fruits are mango including large green mango (Cho Moi), Hoa Loc mango (Tri Ton, Tinh Bien, Long Xuyen, and Tan Chau), acacia mango (An Phu and Tan Chau), and a small proportion distributed in other districts of Chau Phu, Chau Doc, and Chau Thanh. Besides, the province also has a small area for bananas and custard apples that are located in Tri Ton districts.

2. Citrus fruits (orange, lemon, tangerine, and pomelo): In recent years, the selling price of these fruits has been always stable at a high level because of high market demand, so many districts have expanded the farms' scale of these fruits.

3. Longan and durian: mostly distributed in Chau Phu, Cho Moi, Tinh Bien, and Thoai Son districts. Longan growing area in Chau Phu has been trained and granted certificates of food safety and hygiene and traceability stamps. It is also preparing for the next steps of issuing the geographical designation code for exporting raw materials. Durian mainly concentrated in Cho Moi and Chau Phu districts.

In addition to rice farming, annual crops (i.e rotational cultivation and specialized cultivation) are also popular in An Giang province. Regarding rotational cultivation, it is frequently combined with mono rice crop or double rice crops. For example, the rainfed rice farming (or “upland rice field”) often cultivates other annual crops, which is common in the highland area of Tri Ton and Tinh Bien districts. The area specializing in annual crops cultivate leafy vegetables and cucurbitaceae vegetables, particularly in Cho Moi and Chau Phu districts. Besides, the other major annual crops of the province comprise Corns (Chau Phu, Cho Moi, Tan Chau, and Phu Tan districts), Sweet potato (Tri Ton and Tinh Bien districts), Cassava (Tinh Bien and Tri Ton districts), Peanut (Tinh Bien, An Phu, and Tri Ton districts), Sesame (An Phu, Cho Moi, Phu Tan, Tri Ton districts, and Long Xuyen city).

Aquaculture is one the key sectors in An Giang province. The total surface area of aquaculture is about 7,000 ha, consisting of fish ponds and floating cages in Chau Phu, Thoai Son, Phu Tan, Chau Thanh, and Long Xuyen city. The largest proportion of the

aquaculture sector belongs to catfish farming (53%) and aquaculture nursery and rearing (46%). Shrimp farming and other forms of aquaculture only account for around 1% of the total area.

Forests in An Giang are primarily nature forest on hills and cajeput forests (“Tra Su”). Other land use categories such as built-uplands and water bodies make up a small proportion of the total area.

3.2.3. Current agricultural land use in Bac Lieu

Bac Lieu is a coastal province in the VMD, where the key agricultural sector is aquaculture. The current agricultural land use map of Bac Lieu includes 10 land use types (Figure 1.6).

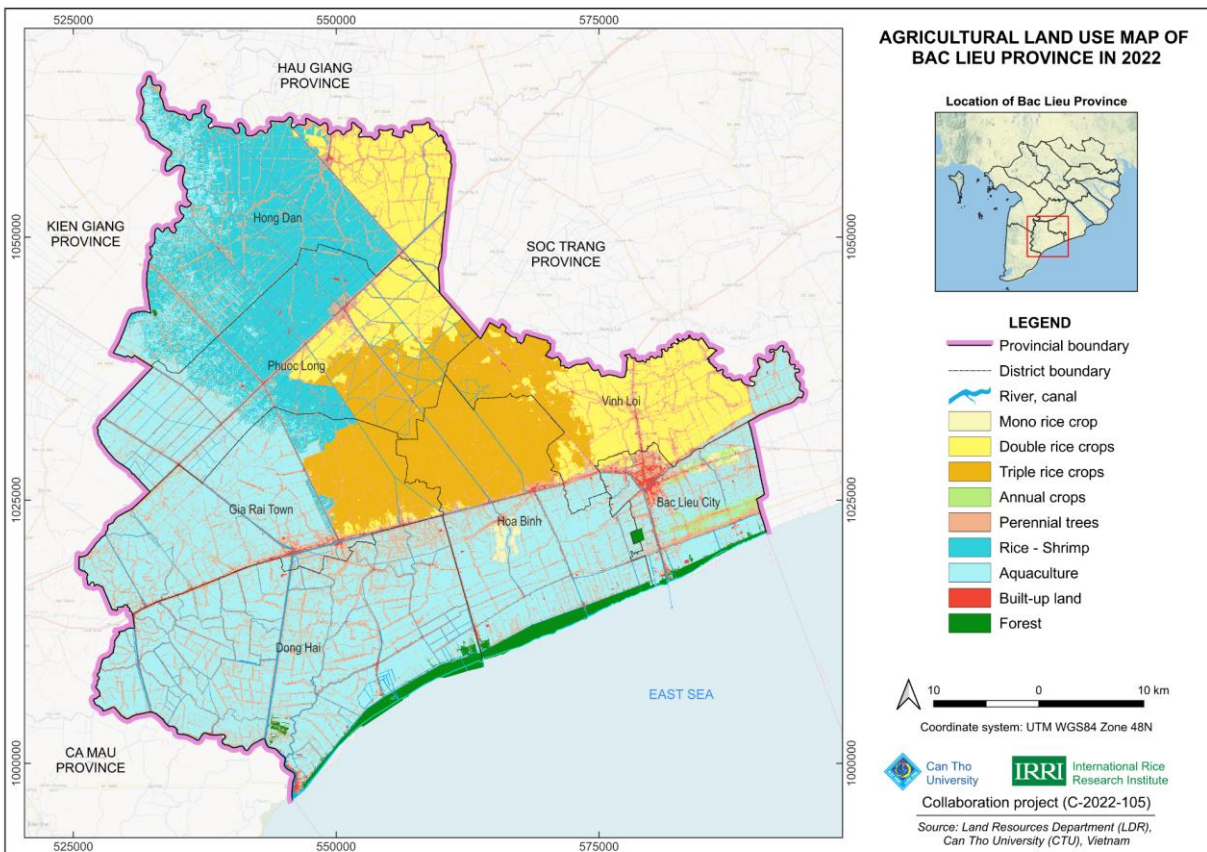


Figure 1.6. Current land use map in Bac Lieu province in 2022

With the advantages of a 56-km long coastline, Bac Lieu has favorable conditions to be a specialized area for aquaculture farming. It is the second-largest aquaculture production

province following Ca Mau. National Road 1A is the natural boundary dividing the province into three distinct eco-regions based on differences in soil, irrigation, saltwater intrusion, and climate.

- Stable freshwater region (freshwater eco-region) located north of National Road 1A, adjacent to Soc Trang province, including Vinh Loi, Phuoc Long, and Hong Dan districts.
- Farming transition region (brackish water eco-region) located north of National Road 1A, on the west side of Ca Mau province, consisting of Phuoc Long and Gia Rai towns.
- Year-round saline region (saltwater eco-region) located south of National Road 1A, including Dong Hai, Hoa Binh, and Bac Lieu City.

The areas and proportion of each land use type are shown in Table 1.5.

Table 1.5. Areas and proportion of land use types in Bac Lieu province in 2022.

No.	Land use types	Area (ha)	Proportion (%)
1	Rice - Shrimp	34,107.43	13.7
2	Mono rice crop	780.35	0.3
3	Double rice crops	28,013.25	11.3
4	Triple rice crops	32,754.89	13.2
5	Annual crops	1,019.28	0.4
6	Perennial plants	42,322.51	17.0
7	Aquaculture	96,269.94	38.7
8	Water bodies	5,135.63	2.1

9	Built-up lands	3,643.64	1.5
10	Forest	4,515.99	1.8
Total		248,562.91	100.0

The total aquaculture area is estimated at about 96,269.94 ha (38.7% of the total area), including two main zones. The first zone is located south of National Road 1A in Hoa Binh district and Bac Lieu City, where shrimp are cultivated using three different models: intensive, semi-intensive, and improved extensive shrimp farming. The second zone is located north of National Road 1A in Phuoc Long and Hong Dan districts, Gia Rai town (Hung Thanh), and Vinh Loi district (adjacent to Soc Trang province). The common models in this zone are improved extensive farming and freshwater fish.

Rice-shrimp farming is also popular, covering about 34,107.43 ha (13.7%). It is distributed in Hong Dan district and parts of Phuoc Long district and Gia Rai town, which are affected by saltwater intrusion from the west with active transformations in agricultural farming. The local government currently has a policy to actively introduce saltwater into traditional fields for brackish shrimp farming. This ongoing transformation causes heterogeneities in land use within a small area, as evidenced by the interweaving of specialized aquaculture and rice-shrimp farming. Rice is cultivated during the rainy season (September to December), while the dry season (January to August) is reserved for extensive shrimp farming.

Rice fields are mostly distributed in the freshwater eco-region, which has favorable conditions for stabilizing freshwater irrigation for rice cultivation year-round. The rice cultivation area in this region is about 60,768.14 ha. Specifically, double rice crops are cultivated in Hong Dan district (Ninh Hoa, Ninh Quoi, and Ninh Quoi A communes, totaling 9,239 ha), Vinh Loi, and parts of Phuoc Long districts. Irrigation in this region and neighboring areas is controlled by the Au Thuyen-Ninh Quoi sluice (2018), which regulates freshwater for rice cultivation and controls saltwater intrusion for shrimp farming north of

National Road 1A. Triple rice crops account for 32,754.89 ha (13.18%) north of National Road 1A (Lang Tron and Phong Thanh Dong wards of Gia Rai town). This area is also prone to flooding, so many regions have abandoned the Autumn-Winter crop to avoid flood damage to rice farms. Additionally, the province still has mono rice crops in Bac Lieu City (1,500 ha) and Vinh My A commune (Hoa Binh district) with 780.35 ha, which have been transformed from inefficient rice farming.

Forest is an important land use type in Bac Lieu province, with a total area of 4,515.99 ha along the coast. Dong Hai district has about 152 ha of special use forest in Long Dien Tay commune, while the special use forest area in Nha Mat ward belongs to “Bac Lieu bird yard.”

Annual crops account for only a small proportion of the total land use structure, about 1,019.28 ha (nearly 0.5%). These crops are mainly upland vegetables, scattered in Vinh Trach Dong and Vinh Thanh communes, the area along the Truong Son dyke of Bac Lieu City, and Long Dien commune (Dong Hai district).

Perennial plants (or fruit farms) are not a key sector in this province due to soil properties and irrigation conditions. They mostly consist of small-scale home gardens around residential areas, along canals, and transportation systems. Notably, there is a small area specializing in longan along the Truong Son dyke (Vinh Trach Dong commune), which has been developed in recent years according to field surveys.

3.2.4. Current agricultural land use in Ben Tre

The current agricultural land use map in Ben Tre shows 08 land use types, including double rice crops, rice-shrimp, perennial plants, annual crops, aquaculture, forest, built-up land, and water bodies (Figure 1.7).

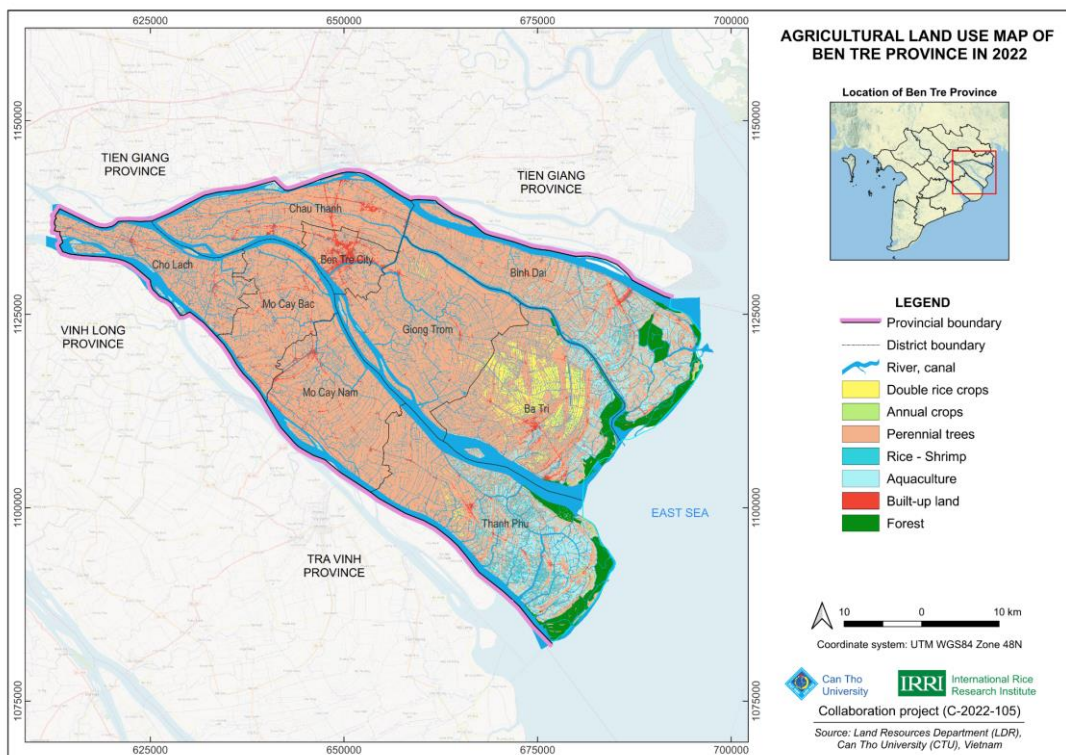


Figure 1.7. Current land use map in Ben Tre province in 2022

Perennial plants (fruit farms) play a vital role and account for a considerable proportion of the agricultural structure in Ben Tre province, distributed across various districts. In 2022, the total area of perennial plants was estimated at about 159,828.6 ha (67.2%), with key fruits including coconut, durian, and rambutan.

Double rice crops are mostly distributed in Ba Tri and part of Giong Trom districts, covering about 5,951.21 ha (2.5%). The Summer-Autumn crop is typically cultivated from June to September, while the Autumn-Winter crop occurs from September to December. Conversely, rice fields are abandoned during the dry season due to a lack of freshwater and saltwater intrusion. During this season, farmers also plant other short-term crops, although these areas are relatively small.

Forest in Ben Tre province consists of three categories (production, protection, and special use forests) with a total area of 7,486.55 ha (3.2%).

Annual crops dominate an area of 490.05 ha (0.2%), with typical vegetables including watermelon, cruciferous vegetables, beans, and spring onions.

Rice-shrimp farming is located in the coastal regions of Thanh Phu, Ba Tri, and Binh Dai districts, with a total area of about 3,193.81 ha (1.3%). The cultivation period for rice and shrimp typically aligns with the rainy and dry seasons, respectively, though it is slightly adjusted to regional conditions. For instance, rice crops are planted from July/August to November/December, while shrimp farming lasts from January to June.

The province has about 11,500.9 ha (4.8%) of aquaculture along the coastal areas of Thanh Phu, Ba Tri, and Binh Dai districts. The popular aquaculture models include brackish shrimp and crab, using improved extensive, intensive, and "super" intensive farming methods.

Table 1.6. Areas and proportion of land use types in Ben Tre province in 2022.

No.	Land use type	Area (ha)	Proportion (%)
1	Rice - Shrimp	3,193.81	1.3
2	Double rice crops	5,951.21	2.5
3	Annual crops	490.05	0.2
4	Perennial trees	159,828.60	67.2
5	Aquaculture	11,500.90	4.8
6	Water bodies	44,490.14	18.7
7	Built-up land	4,794.01	2.0
8	Forest	7,485.55	3.2

Total**237,734.27****100.0**

Curently, the province focuses on aquaculture, especially whiteleg shrimp (*Litopenaeus vannamei*) in semi-intensive and intensive farming to increase up to two crops per year.

3.2.5. Current agricultural land use in Ca Mau

Ca Mau is the southernmost province with a long coast of 254 km along both the west and east sides. The total area may fluctuate yearly due to coastal dynamics (e.g., erosion and accretion). The estimated area in 2022 was about 527,806.9 ha, characterized by eight land use types: aquaculture, rice-shrimp, double rice crops, mono rice crop, perennial plants, forest, built-up lands, and water bodies (Figure 1.8).

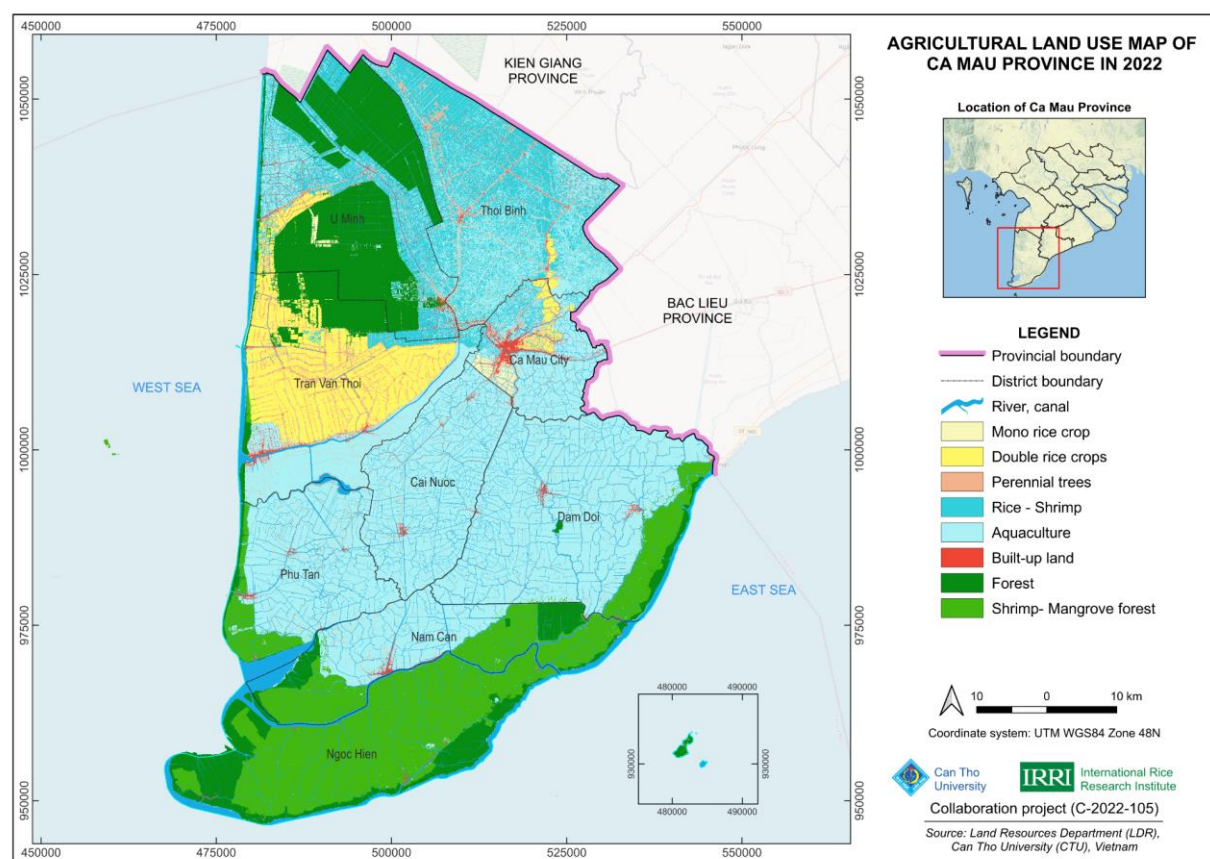


Figure 1.8. Current land use map in Ca Mau province in 2022

Aquaculture has been the most prominent sector in Ca Mau province for several decades. It is the province with the most extensive area of aquaculture in the country, covering 201,854.88 ha (38.2% of the total area). According to the agricultural reconstruction project aimed at enhancing economic value and sustainable development, shrimp farming is a key sector in the economic structure. The specialized aquaculture areas are located in Phu Tan, Cai Nuoc, Dam Doi districts, parts of Tran Van Thoi, Nam Can districts, and Ca Mau city.

In addition to specialized aquaculture, the province is characterized by mangrove-shrimp models and rice-shrimp farming. The mangrove-shrimp model is concentrated in Nam Can, Ngoc Hien, and parts of the coastal areas in Dam Doi and Phu Tan districts, with a total area of about 78,290.89 ha. According to the Department of Agriculture and Rural Development of Ca Mau, mangrove-shrimp farming is considered environmentally friendly, assisting in mangrove protection and restoration. Shrimp farming under the mangrove canopy accounts for 50-60% of the total area (i.e., 30-40% dominated by water surfaces). This model not only increases mangrove forest area but also helps protect soil against erosion and climate change. It is considered a suitable model for ensuring both economic profits and environmental sustainability.

The rice-shrimp area is mainly distributed in U Minh, Thoi Binh districts, parts of Ca Mau city, and Tra Van Thoi district, covering about 59,933.06 ha (11.4%). Rice-shrimp farming is resilient to climate change and promotes environmental sustainability through integrated management measures for both shrimp and rice crops, which help reduce the use of chemical fertilizers and pesticides. There are two models of rice-shrimp farming: rotational cultivation and intercropping. Giant freshwater shrimp intercropping in rice fields is common in Bien Bach Dong and Tan Loc Bac communes (Thoi Binh district). In rice-shrimp rotational farming, black tiger shrimp are raised during the dry season, and crab is also raised in conjunction with shrimp to increase income within the same cultivation area.

Although Ca Mau is predominantly aquaculture-based, it also has significant rice fields, including mono rice and double rice crops, mainly rained farming in Tran Van Thoi district and Ca Mau city. The total area of mono rice crop is about 1,870.94 ha, in Ly Van Lam commune and Ca Mau city (rice-watermelon rotational farming), and the core area of U Minh Ha forest (organic rice production).

Ca Mau has the largest forest area in the VMD, distributed along the coast in Ngoc Hien, Nam Can, Dam Doi, Tran Van Thoi, and the National Forest of U Minh Ha. The forest area is about 77,657.83 ha (14.7%), including 54.5% production forest, 23.8% protection forest, and 21.7% special use forest.

Perennial plants account for 6.2% of the total area, with 32,844.96 ha, mainly consisting of mixed gardens along transportation routes, rivers/canals, and around residential areas.

Table 1.7. Areas and proportion of land use types in Ca Mau province in 2022

No.	Land use type	Area (ha)	Proportion (%)
1	Rice - Shrimp	59,933.06	11.4
2	Mono rice crop	1,870.94	0.4
3	Double rice crops	37,705.7	7.1
4	Perennial plants	32,844.96	6.2
5	Aquaculture	201,854.88	38.2
6	Water bodies	33,335.34	6.3
7	Built-up lands	4,313.3	0.8
8	Forest	77,657.83	14.7

9	Mangrove-Shrimp	78,290.89	14.8
Total		527,806.9	100.0

3.2.6. Current agricultural land use in Dong Thap

The current agricultural land use map of Dong Thap in 2022 includes 08 land use types (Figure 1.9).

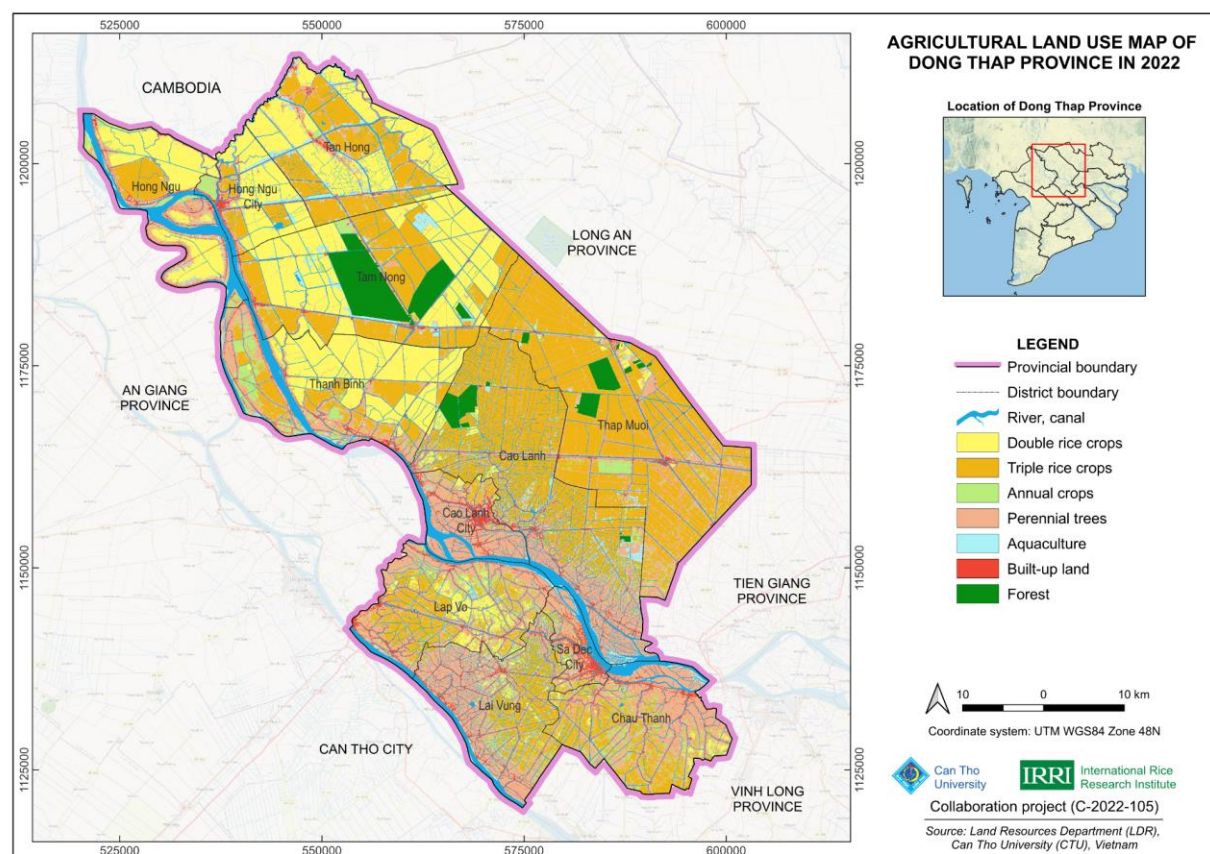


Figure 1.9. Current land use map in Dong Thap province in 2022

Table 1.8. Area and proportion of land use types in Dong Thap province in 2022

No.	Land use type	Area (ha)	Proportion (%)
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1	Double rice crops	63,786.5	17.3
2	Triple rice crops	108,216.6	29.4
3	Annual crops	37,004.7	10.1
4	Perennial plants	72,856.3	19.8
5	Aquaculture	7,424.8	2.0
6	Built-up land	9,395.1	2.6
7	Water bodies	29,021.4	7.9
8	Forest	40,043.2	10.9
Total		367,748.7	100

In general, there is significant variation in the landscape of Dong Thap province across its districts. The major agricultural land use is rice cultivation, with both double and triple rice crops comprising over 50% of the total area. Triple rice crops cover 108,266 ha (29.4%), while double rice crops occupy a smaller area, accounting for 17.3% of the total area. Perennial plants cover 72,856.3 ha (19.8%), making them the second-largest land use type. Other land use categories account for smaller proportions, such as annual crops (10.1%), aquaculture (2%), construction lands (2.6%), water bodies (7.9%), and forests (10.9%).

Thap Muoi has the most extensive rice cultivation area in Dong Thap province, covering about 35,112 ha (22.6%). It is followed by Cao Lanh district (27,232 ha), Tam Nong (15,485 ha), Tan Hong (13,928 ha), and Hong Ngu (6,473 ha). Although Cao Lanh and Sa Dec cities are urban areas, they still have rice cultivation areas of 812 ha and 449 ha, respectively.

There is notable divergence in fruit farming across the subregions of Dong Thap province. Specifically, Cao Lanh city leads in mango cultivation with 4,318 ha, while Lai Vung district is renowned for tangerine and orange cultivation (1,405 ha and 1,490 ha, respectively). Lai Vung also grows a certain amount of mango. Chau Thanh district is prominent for longan (3,696 ha) and guava (738 ha), alongside a considerable area of mango. The highlight fruits in Thap Muoi district are jackfruit (2,136 ha) and lemon (463 ha). The remaining districts, such as Tan Hong, Hong Ngu, and Tam Nong, have smaller fruit farm areas with less notable geographical indication compared to the earlier regions.

Annual crops in Dong Thap are diverse in both variety and distribution areas. Hong Ngu town and Tan Hong district excel in vegetable cultivation. Sa Dec city is famous for decorative trees and flowers, with the largest area in the province. Lap Vo and Thanh Binh districts also have significant vegetable farming areas. Notably, Thanh Binh, Chau Thanh, and Thap Muoi districts are known for their extensive cultivation of leafy vegetables, tubers, fruit vegetables, spice vegetables, and pharmaceutical plants.

Tam Nong, Cao Lanh, and Chau Thanh districts are leaders in aquaculture production with extensive areas dedicated to this sector. Catfish farming is a key economic sector in the provincial agricultural structure, with catfish raising areas distributed in Thanh Binh, Cao Lanh, and Chau Thanh districts. Additionally, Tam Nong and Thap Muoi districts have smaller areas for raising a variety of other freshwater fishes.

3.2.7. Current agricultural land use in Hau Giang

The delineated map from remote sensing and field surveys revealed that Hau Giang province currently has 9 land use types: double rice crops, triple rice crops, annual crops, perennial plants, aquaculture, water bodies, built-up lands, forest, and rice-shrimp (Figure 1.10).

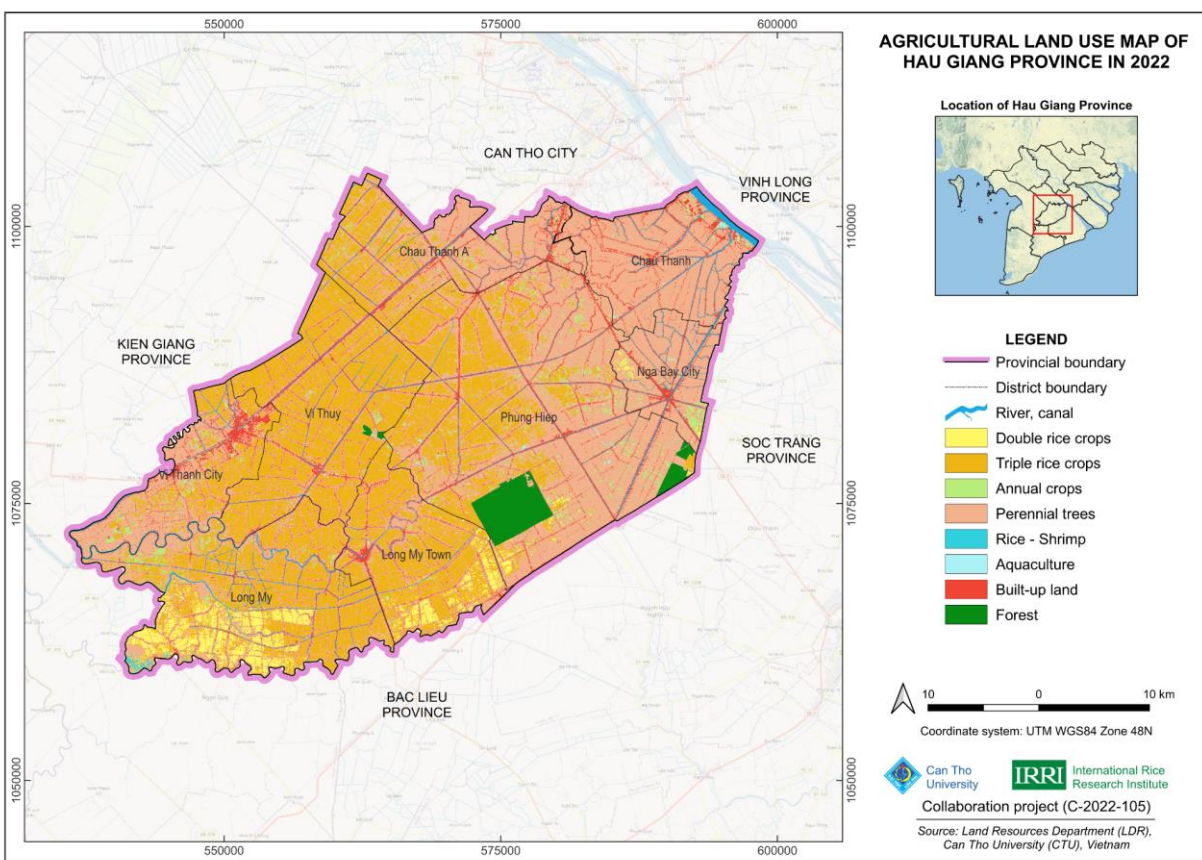


Figure 1.10. Current land use map in Hau Giang province in 2022

Table 1.9. Area and proportion of land use types in Hau Giang province in 2022.

No.	Land use type	Area (ha)	Proportion (%)
1	Double rice crops	6,053.7	3.7
2	Triple rice crops	53,383.16	32.9
3	Annual crops	38,363.81	23.6
4	Perennial plants	47,638.21	29.4
5	Aquaculture	4,230.24	2.6

6	Water bodies	263.96	0.2
7	Built-up lands	4,823.28	3.0
8	Forest	7,448.82	4.6
9	Rice-Shrimp	121.35	0.1
Total		162,326.52	100

About 32.9% of the total area in Hau Giang province is dominated by triple rice crops, covering 53,383.16 ha across Vi Thuy, Phung Hiep, Long My, Chau Thanh A, Vi Thanh districts, Long My town, and Hiep Thanh commune (Nga Bay district). However, the planting calendar in these districts varies due to differences in soil and irrigation conditions between subregions. Currently, there are five agricultural cooperatives in Vi Thuy, the largest rice production district, including Tan Long (Vinh Tuong), Vi Thuy 1 (Vi Thuy), Thuan Phat (Vinh Trung), Thuan Tien (Vinh Thuan Tay), and Kien Thanh (Vi Binh), which cultivate according to VietGAP standards.

Double rice crops account for only 3.5% (8,200.01 ha) of the total area, primarily distributed south of the “inner water boundary” dyke in Long My district and Long My town. This region practices the Winter-Spring and Summer-Autumn crop seasons, focusing on double rice and rice-vegetable rotational farming. Popular vegetables in rice-vegetable farming include watermelon, okra, and chili, found in Luong Tam (Long My district) and Hiep Loi (Nga Bay city). The total estimated area for vegetable cultivation is about 438.49 ha. Cultivating watermelon on rice fields has become popular in Hau Giang province due to higher incomes compared to traditional rice production.

Rice-shrimp farming is practiced south of the “inner water boundary” dyke in Long My district (adjacent to Soc Trang province) with 121.35 ha. Luong Nghia commune (Long My district) is a notable example of this dynamic transformation due to challenges from

saltwater intrusion. Farmers have shifted from traditional rice farming to rice-shrimp rotational farming (black tiger shrimp) to utilize saltwater and natural food sources for shrimp, thus increasing income compared to the previous monoculture of rice. The shrimp season lasts from March to September, followed by a saltwater washing period to reduce soil salinity for the next rice crop.

Perennial plants cover 29.4% (47,638.21 ha) of the area, with various fruit varieties such as pomelo, jackfruit (Chau Thanh, Chau Thanh A, Phung Hiep, and Nga Bay city), seedless lemon, custard apple, and pineapple (Vi Thanh city and Long My district). Specifically, pineapple cultivation is concentrated in Tan Tien, Vi Thanh, and Hoa Tien communes (Vi Thanh city) and Vinh Vien town (Long My district).

Annual crops account for 23.6% of the total area, including sugarcane (Phung Hiep district and Nga Bay city) and corn (Chau Thanh district and Vi Thanh city). Long Tri A (Long My town) specializes in leafy vegetables (pennywort, water spinach, and cruciferous vegetables), and an agricultural cooperative was established in this region in 2020.

Forests in Hau Giang province are mainly concentrated in the Vi Thuy Melaleuca forest in Vinh Tuong commune, Vi Thuy district, and the Lung Ngoc Hoang nature reserve in Phung Hiep district. These areas host more than 500 species of plants and animals listed in the Vietnam Red Book and many valuable herbs.

Aquaculture covers 2.6% of the total area, but its distribution is less concentrated compared to other areas. The largest aquaculture areas are in Chau Thanh, Chau Thanh A, Phung Hiep (Hiep Hung, Phuong Phu, Phuong Binh, Hoa An, and Cay Duong towns with rice-fish intercropping), Vi Thuy district, Long My town, and Nga Bay city. Freshwater aquaculture, including featherback fish, snakehead fish, eel, and trionychid turtles, is common in these districts.

3.2.8. Current agricultural land use in Kien Giang

Kien Giang is the largest province with diverse terrain characteristics, which can be divided into 03 eco-regions including:

- The Long Xuyen Quadrangle region consists of Kien Luong, Hon Dat, Giang Thanh districts, and Ha Tien city, as well as parts of Tan Hiep, Chau Thanh districts, and Rach Gia city.
- The West Hau River region includes Giong Rieng, Go Quao districts, and parts of Tan Hiep, Chau Thanh districts, and Rach Gia city.
- The U Minh Thuong region encompasses An Bien, An Minh, Vinh Thuan, and U Minh Thuong districts.

The province has a diverse range of agricultural products in its agriculture-silviculture-aquaculture structures. The current agricultural land use map presents 09 land use types (Figure 1.11).

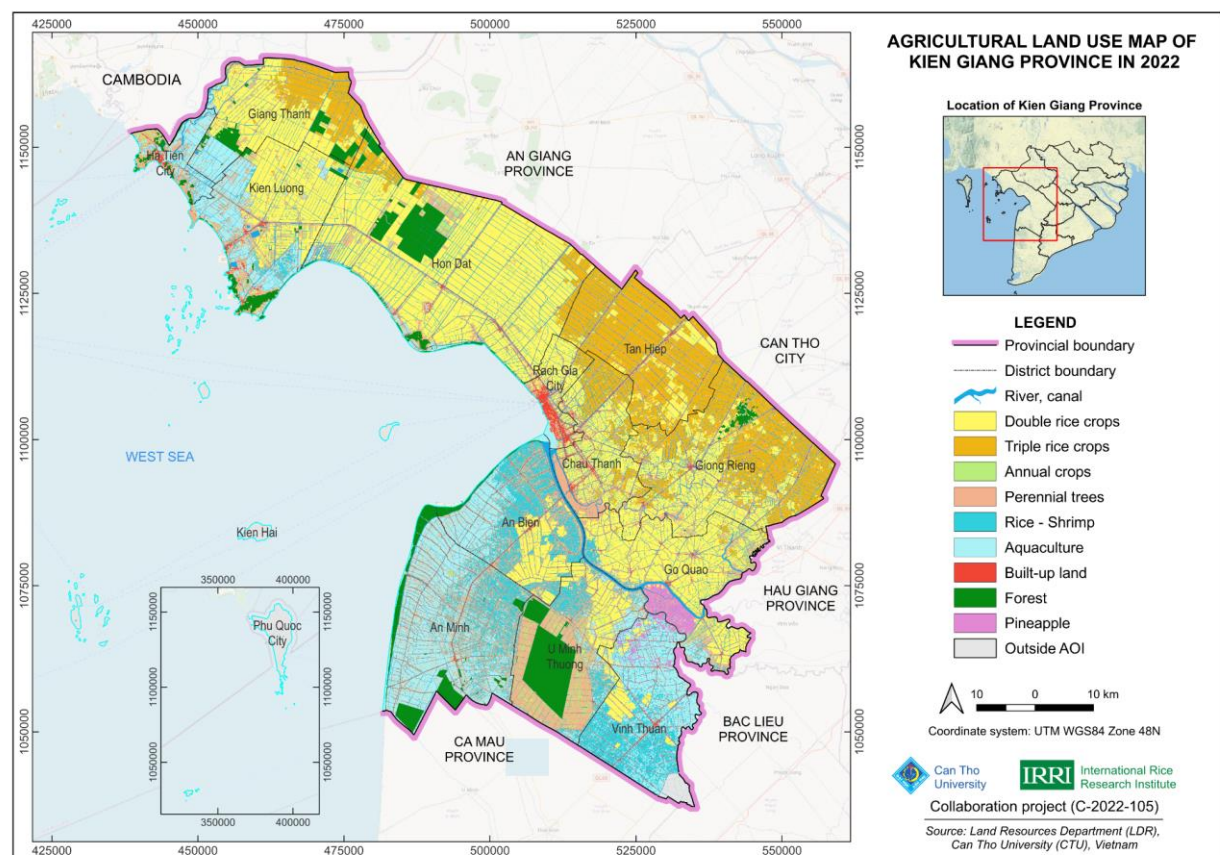


Figure 1.11. Current land use map in Kien Giang province in 2022

Table 1.10. Area and proportion of land use types in Kien Giang province in 2022.

No.	Land use type	Area (ha)	Proportion (%)
1	Rice-shrimp	37,752.2	6.6
2	Double rice crops	195,280.6	34.3
3	Triple rice crops	77,107.4	13.5
4	Annual crops	49,140.7	8.6
5	Perennial plants	81,137.7	14.2
6	Aquaculture	57,916.7	10.2
7	Built-up lands	7,484.8	1.3
8	Water bodies	26,693.7	4.7
9	Forest	32,867.0	5.8
Total		569,751.6	100

In the agricultural structure, double rice crops dominate the largest area with 195,280.6 ha (34.3%), distributed over three ecoregions. However, it is significantly located in the Long Xuyen Quadrangle region, the region south of National Road 80, and the U Minh Thuong region (Go Quao and An Bien) due to saltwater intrusion, alum, and a lack of freshwater for rice production.

Triple rice crops are mostly distributed in the West of Hau River and Long Xuyen Quadrangle regions (adjacent to inland An Giang province) with about 77,107.7 ha (13.5%). The triple rice crop in the Long Xuyen Quadrangle region is established in the north of National Road 80 (Giang Thanh districts, adjacent to An Giang province), which

is affected by tidal flooding from Hau River, supporting enough freshwater for the third rice crop. In contrast, triple rice crops in the West of Hau River region benefit from a year-round freshwater supply with a low flooding level, which is favorable for three rice crops per year.

Aquaculture (brackish shrimp) is distributed along the coast in the communes belonging to Long Xuyen Quadrangle and U Minh Thuong regions with two models of extensive and intensive farming. The total aquaculture area is about 57,916.7 ha (10.2%). An Minh and Vinh Thuan are the districts with the most extensive aquaculture areas. The remaining districts have smaller areas with less concentration.

Rice-shrimp regions are often integrated with the coastal aquaculture areas. The total rice-shrimp area is about 2,605.4 ha. This is one of the provinces with the largest aquaculture areas in the VMD. Specifically, Tan Hiep, Go Quao, Kien Luong, and An Bien districts hold the largest areas for cultivating rice-shrimp rotational farming.

Annual crops are commonly found in U Minh Thuong and parts of Long Xuyen Quadrangle regions. A large proportion of annual crops consists of cassava, sweet potato, ginger, and lotus (during the flooding period). Additionally, vegetables are scattered throughout the province with a total area of over 14 thousand hectares.

Perennial plants also make up a significant proportion of the total area, about 14.2%. The main crops are sugarcane and pineapple (over 4,000 ha), while other fruits (such as mango and coconut) account for only a small proportion in U Minh Thuong, Vinh Thuan, and Go Quao districts. Some districts in this province are experiencing trends in agricultural transformation, especially for pineapple and ginger. For example, Go Quao district has a considerable area converted into pineapple farms. Additionally, U Minh Thuong holds a significant area cultivating bananas in the buffer area of U Minh Thuong Forest (>3,000 ha).

3.2.9. Current agricultural land use in Long An

Long An province is situated at the boundary between the VMD and Southeast region, making industrial zones a notable feature alongside traditional agricultural production. It can be divided into two distinct regions: the Dong Thap Muoi region (including six districts—Tan Hung, Vinh Hung, Moc Hoa, Tan Thanh, Thanh Hoa, Duc Hoa—and seven communes in the north of Thu Thua and Ben Luc) and the Lower region (Can Duoc and Can Giuoc districts). The current land use in Long An province comprises eight categories: double rice crops, triple rice crops, perennial plants, annual crops, aquaculture, forest, built-up lands, and water bodies (Figure 1.12)

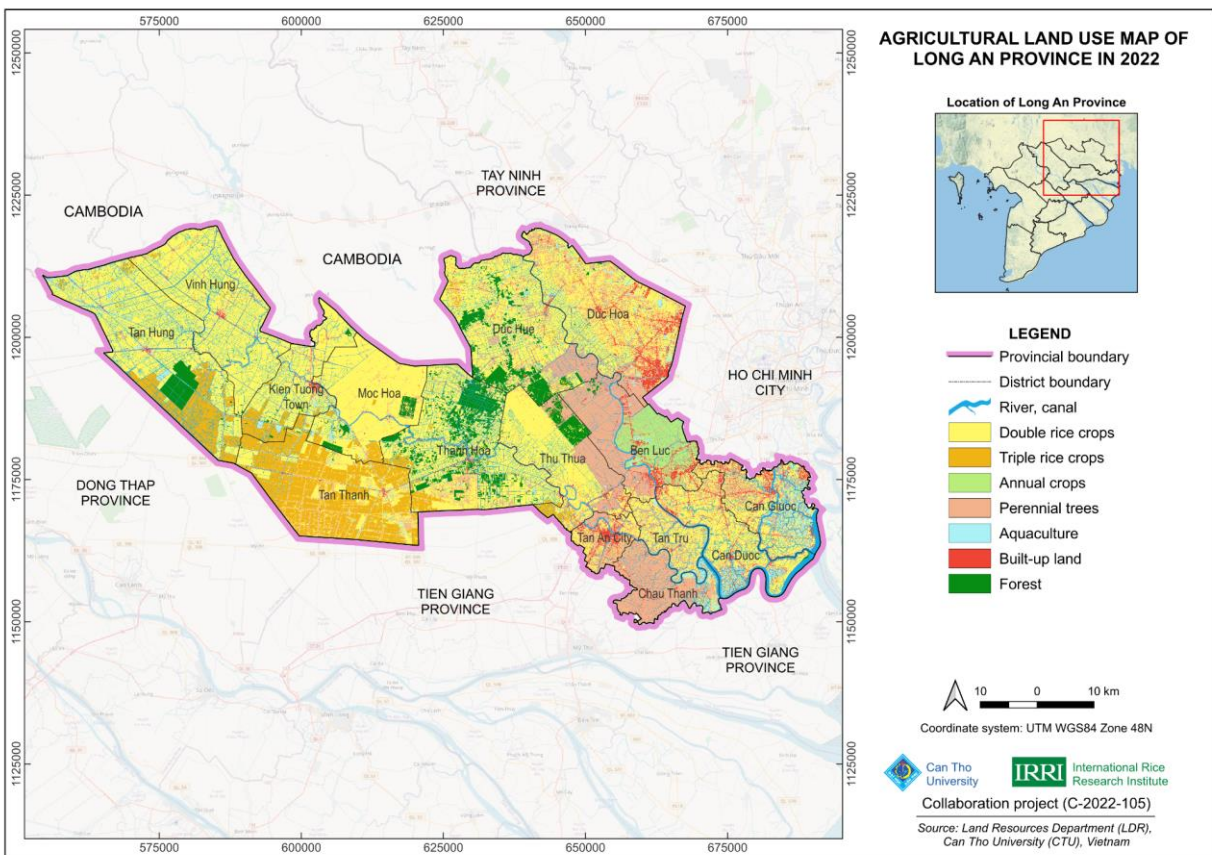


Figure 1.12. Current land use map in Long An province in 2022

Table 1.11. Areas and proportion of land use types in Long An province in 2022.

No.	Land use type	Areas (ha)	Proportion (%)
1	Double rice crops	286,510.13	63.6
2	Triple rice crops	43,412.38	9.6
3	Annual crops	1,506.23	0.3
4	Perennial plants	51,933.06	11.5
5	Aquaculture	9,890.83	2.2
6	Water bodies	23,550.18	5.2
7	Built-up lands	12,595.35	2.8
8	Forest	21,171.46	4.7
Total		450,569.62	100

Rice production is the key agricultural sector in Long An province, with over 70% of the total area characterized by double and triple rice crops. The major cultivation area is in the Dong Thap Muoi region, a low-lying area frequently affected by flooding. Therefore, the agricultural structures in this region are inconsistent and depend on the flood protection dyke system and irrigation regimes.

Double rice crops are distributed in the north of the Vam Co Tay river, in Tan Hung, Vinh Hung, Moc Hoa, Thanh Hoa, and Duc Hue districts. This is the most common agricultural land use, with 286,510.13 ha (63.6%). Triple rice crops are concentrated in the south of the Vam Co Tay river, adjacent to Tien Giang province, in Tan Thanh and Tan Hung districts. Triple rice crops account for 9.6% (about 43,412.38 ha).

Perennial plants are found in Chau Thanh, Tan Tru, Ben Luc districts, and parts of Can Giuoc and Can Duoc districts. The total area is about 51,933.06 ha (11.5%), including dragon fruit and lemon.

Annual crops and vegetables account for a small proportion with a relatively stable area, scattered in Chau Thanh, Can Duoc, and Can Giuoc districts. Typical vegetables cultivated in these regions include leafy vegetables, spice vegetables, cruciferous vegetables, gourd, and sponge gourd. The total area of annual crops is about 1,500 ha. Annual crops in Long An province are characterized by their small scale and scattered distribution, as farmers often cultivate on a household scale, with average areas ranging from 1,500 to 5,000 m².

Forest is mostly melaleuca forest in Thanh Hoa, Thu Thua, Duc Hue, Tan Hung, and Tan Thanh districts, with a total area of about 21,171.46 ha.

Aquaculture is located along the riverbanks of the Vam Co river (Can Duoc, Can Giuoc, and Chau Thanh districts). The total area of aquaculture is estimated at about 9,890.83 ha, including fish ponds, floating fish cages, brackish shrimp, and other aquacultures.

3.2.10. Current agricultural land use in Soc Trang

The agricultural land use in Soc Trang province is characterized by 09 land use categories: rice-shrimp, double rice crops, triple rice crops, annual crops, perennial plants, aquaculture, water bodies, built-up lands, and forest (Fig. 1.13).

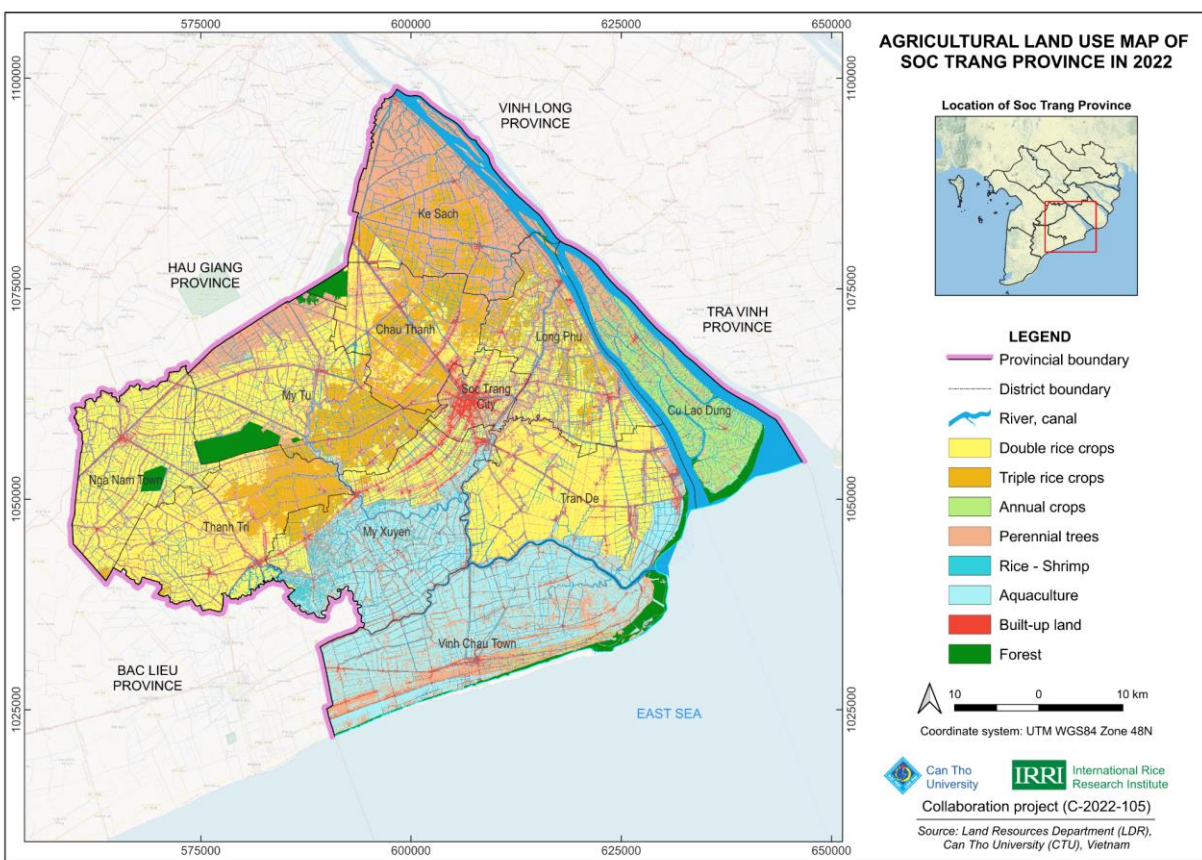


Figure 1.13. Current land use map in Soc Trang province in 2022

Table 12. Areas and proportion of land use types in Soc Trang province in 2022

No.	Land use type	Areas (ha)	Proportion (%)
1	Rice - Shrimp	2139	0.7
2	Double rice crops	90,651.06	27.7
3	Triple rice crops	31,069.21	9.5
4	Annual crops	9,020.97	2.8
5	Perennial trees	113,228.4	34.6

6	Aquaculture	34,982.8	10.7
7	Water bodies	29,672.73	9.0
8	Built-up land	8,197.03	2.5
9	Forest	8,657.66	2.6
Total		327,618.9	100

The entire province can be divided into six agricultural eco-regions: Isles on the Hau River, Long Phu-Tiep Nhut, Thanh My, Quan Lo Phung Hiep, Ba Binh Ta Liem, and Ke Sach regions. Saline intrusion frequently occurs in the Isles on the Hau River, Thanh My, and parts of Long Phu-Tiep Nhut (adjacent to Thanh My and Isles on the Hau River regions).

Perennial plants make up a considerable percentage of the total area distributed across the province. However, the specialized area in fruit farms is concentrated in Ke Sach and Cu Lao Dung districts. In 2022, the total perennial area was about 113,228.4 ha (34.6%). Key fruit farming in Soc Trang includes durian, rambutan, mango, jackfruit, and pomelo, with a flexible cultivation calendar throughout the year. Major fruit farms are mainly distributed in communes along the Hau River (Ke Sach and north of Cu Lao Dung).

Approximately 90,651.06 ha (27.7%) of the total area is dedicated to double rice crops, located in Tran De, Long Phu districts, Nga Nam town, parts of My Tu, Thanh Tri, Chau Thanh, My Xuyen districts, and Soc Trang city.

Triple rice crops account for only a small proportion of the total rice cultivation area, about 9.5% (31,069.21 ha). Major cultivation areas are in Ke Sach and parts of Chau Thanh, My Tu, Thanh Tri, and My Xuyen districts. The growing calendar in Soc Trang depends on irrigation conditions, including Summer-Autumn (May-August), Winter-Spring (September-December), and late Winter-Spring (December/January-March).

Rice-shrimp rotational farming in Soc Trang tends to be narrow in terms of cultivation area. Although this is considered a relatively resilient farming practice, it shows low productivity and efficiency in actual practices. Currently, there are only about 2,139 ha (0.7%) dedicated to rice-shrimp farming in My Xuyen district (Gia Hoa 2). In rice-shrimp farming, rice is grown during the rainy season (September-December), while the dry season is the main period for shrimp farming.

The province has approximately 8,657.66 ha (2.6%) of forest (production, protection, and special use forests) in Vinh Chau, Tran De, My Tu, and Nga Nam districts. The sandy dunes along the coast also feature specialized areas for annual crops (e.g., onion, white radish, and watermelon) with a total area of up to 996.52 ha (0.3%). Additionally, other annual crops (corn, sugarcane) are prominent in Cu Lao Dung, with a total area reaching 8,024.45 ha (2.5%).

Aquaculture (brackish aquaculture) is highly concentrated in the coastal areas of My Xuyen, Cu Lao Dung, and Vinh Chau districts, and parts of Tran De district, with a total estimated area of approximately 34,982.8 ha (10.7%).

Recently, the provincial government has implemented strategies to diversify agricultural farming and products, transforming traditional farming into high-value agricultural chains. This aims to provide long-term resistance to climate change and stabilize livelihoods. For example, monoculture rice has been converted into combination models (e.g., rice-shrimp, rice-fish, and rice-vegetables) and fruit farms.

3.2.11. Current agricultural land use in Tien Giang

There are 10 land use types in the current structures of agricultural land use in Tien Giang province, which includes rice-shrimp, double rice crops, triple rice crops, annual crops, perennial plants, aquaculture, water bodies, built-up lands, pineapple, and forest (Figure 1.14).

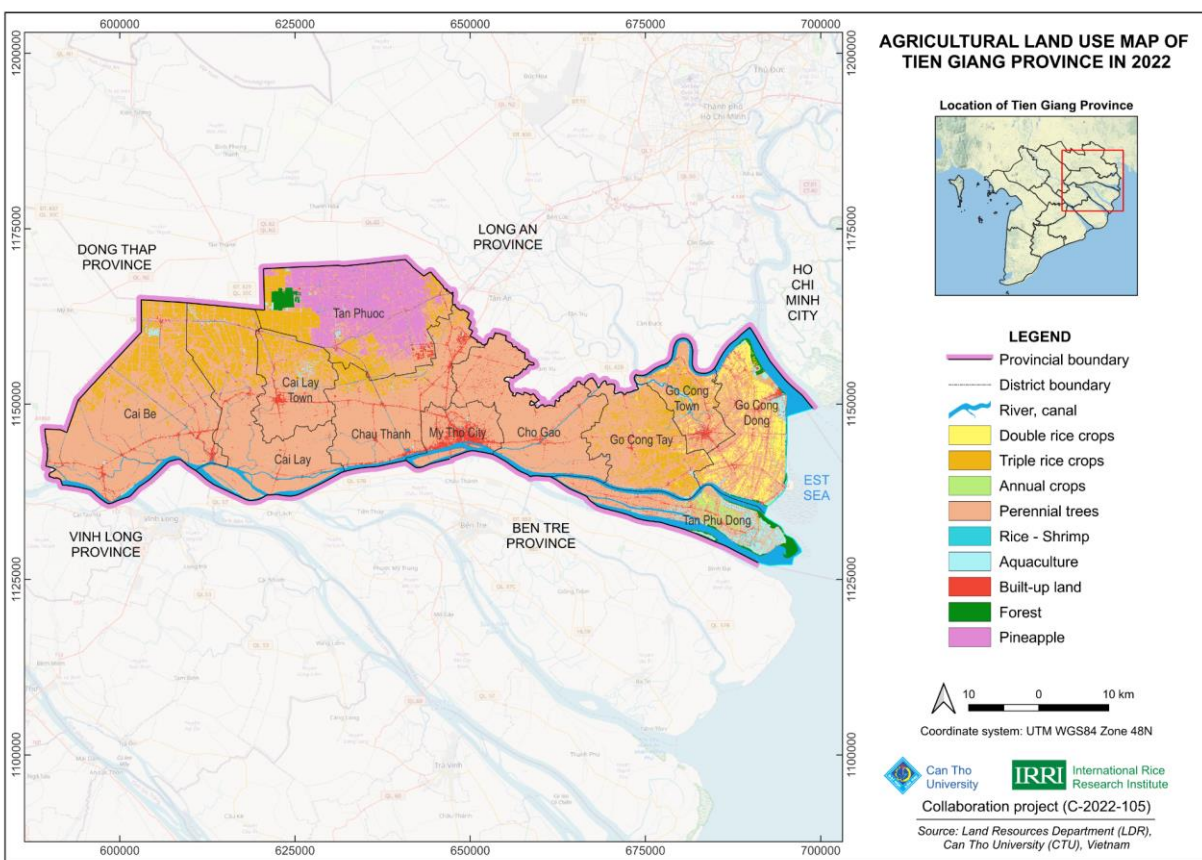


Figure 1.14. Current land use map in Tien Giang province in 2022

Table 1.13. Area and proportion of land use types in Tien Giang province in 2022

No.	Land use type	Areas (ha)	Proportion (%)
1	Rice - Shrimp	205.78	0.1
2	Double rice crops	8,279.9	3.5
3	Triple rice crops	34,141.64	14.4
4	Annual crops	1,910.92	0.8
5	Perennial trees	152,309.1	64.4

6	Aquaculture	3,784.3	1.6
7	Water bodies	14,706.99	6.2
8	Built-up land	6,967.47	2.9
9	Forest	31.98	0.01
10	Pineapple	14,282.53	6.0
Total		236,620.6	100

Tien Giang is one of the most famous provinces for fruit production in the VMD. The total area of perennial plants is estimated at about 152,309.1 ha (64.4% of the total area). The key fruits in this province are durian (North of the 1A National Road in Cai Lay district and Cai Lay town), rambutan, and dragon fruit (Chau Thanh and Cho Gao districts). Dragon fruit is a relatively new fruit, mostly cultivated in the western side of Tien Giang (adjacent to Cho Gao). Acerola cherry and soursop are considered geographical indication fruits along the coast of Go Cong due to suitable soil and water properties.

Double rice crops are mostly cultivated in Go Cong Dong, parts of Go Cong Tay districts, and Go Cong town, with a total area of 8,279.9 ha (3.5%). Farmers often skip the Autumn-Winter crop due to high production costs and other difficulties affecting productivity and profits. They have also adjusted the growing calendar to be earlier by one month to adapt to drought and saline intrusion episodes each year.

Triple rice crops are commonly found north of the 1A National Road and in the freshwater region of Go Cong (Go Cong town, Go Cong Dong, and Go Cong Tay districts), Cai Be, Cai Lay districts, and Cai Lay town, with a cultivation area of 34,141.64 ha (14.4%).

Forest (mangrove) is distributed along the coastal areas with a corresponding area of 31.89 ha, found mainly in Tan Phuoc, Go Cong Dong, and Tan Phu Dong districts.

Rice-shrimp farming is also popular in Tan Phu Dong district, covering approximately 205.78 ha (0.09%). Rice crops are cultivated from July/August to November/December, while the dry season (January-June) is the main period for shrimp farming.

The coastal areas (Tan Phu Dong, Go Cong Dong districts, and riverbank communes of Tan Phong and Ngu Hiep) also offer advantages for aquaculture farming. The total area is about 3,784.3 ha (1.6%), which includes shrimp farms in high-tech production, improved extensive, intensive, and “super” intensive farming.

Annual crops mainly consist of spice vegetables, leafy vegetables, and lemongrass, covering 1,910.92 ha (0.8%), which are common in Tan Phu Dong, Go Cong Dong, and Go Cong Tay districts. Pineapple is grown in Tan Phuoc district and parts of Cai Lay town and Chau Thanh district, covering about 14,282.53 ha (6.04%). Lemongrass accounts for 1,434.54 ha (0.6%) in the coastal areas of Tan Phu Dong.

3.2.12. Current agricultural land use in Tra Vinh

The current agricultural land use map of Tra Vinh, delineated from remote sensing, presents 09 land use types: rice-shrimp, double rice crops, triple rice crops, annual crops, perennial plants, forest, aquaculture, built-up lands, and water bodies (Figure 15).

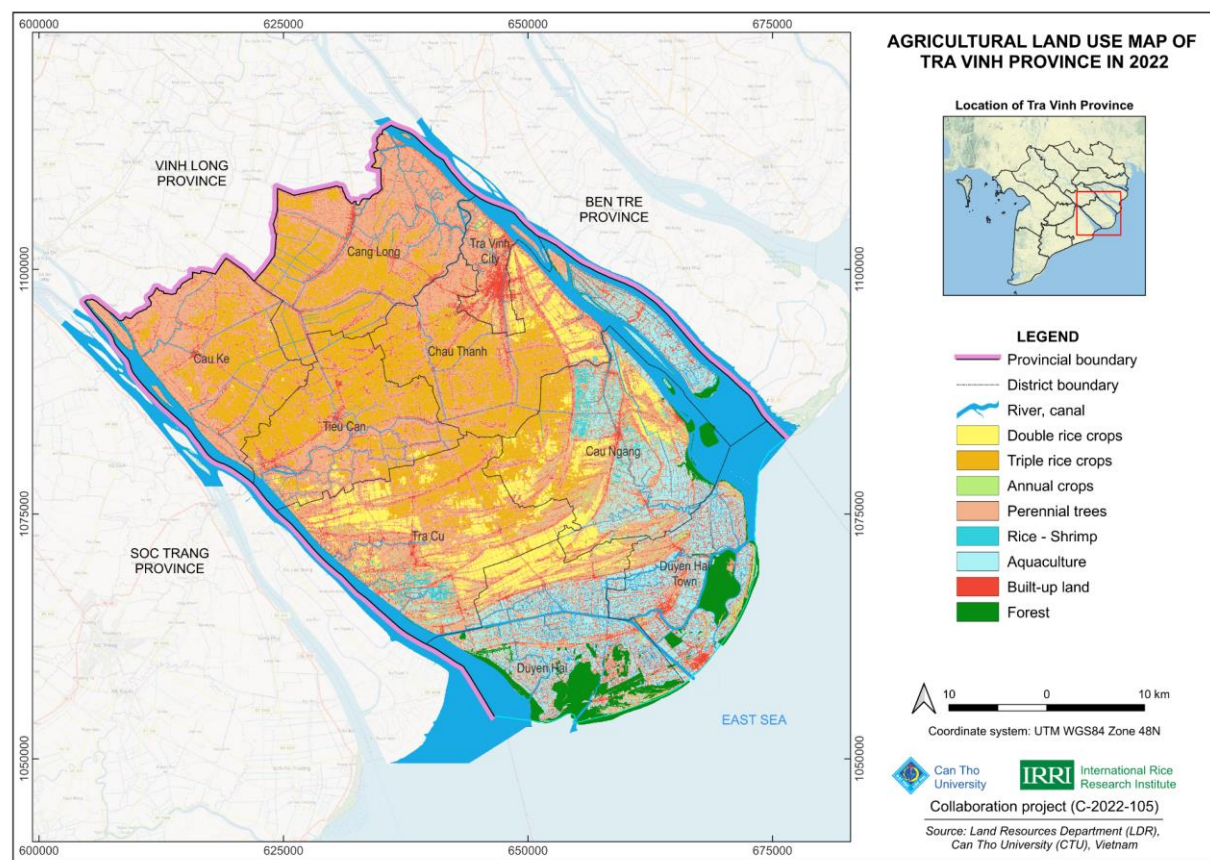


Figure 1.15. Current land use map in Tra Vinh province in 2022

Table 1.14. Area and proportion of land use types in Tra Vinh province in 2022

No.	Land use type	Areas (ha)	Proportion (%)
1	Rice-shrimp	2,584.8	1.1
2	Double rice crops	17,945	7.6
3	Triple rice crops	47,553.1	20.2
4	Perennial plants	90,200.4	38.3
5	Aquaculture	22,844.1	9.7

6	Water bodies	23,518.8	10
7	Forest	9,165.9	3.9
8	Built-up lands	8,321.4	3.5
9	Annual crops	13,489.4	5.7
Total		235,622.8	100

Over 70% of the provincial area is dedicated to agricultural production. Perennial plants are the strength of this province (coconut, citrus fruits, and dragon fruit), with 90,200.4 ha (38.3%) in Cau Ke, Chau Thanh, Tieu Can, Tra Cu, Cang Long districts, and Tra Vinh city. Coconut is a common fruit in Tra Vinh, with Macapuno coconut being the provincial specialty. Cang Long is the largest district with an extensive area of coconut production, about 7,664 ha.

Triple rice crops also play an important role in the agricultural structure, covering 47,553.1 ha (20.2%). These are found in inland districts adjacent to Vinh Long province (e.g., Cau Ke, Cang Long, Chau Thanh, and Tieu Can districts). In contrast, the more distant districts of Tra Cu, Cau Ngang, and Duyen Hai are characterized by double rice crops and rice-shrimp farming, with areas of 17,945 ha and 2,584.8 ha, respectively.

Annual crops account for 13,489.4 ha (5.7%). These crops are mainly found on sandy dunes along the coast of Cau Ngang, Tra Cu, Duyen Hai districts, and Duyen Hai town. Typical vegetables include corn, sweet potato (Cau Ngang and Tra Cu districts), peanut, and sugarcane (Cau Ngang and Cang Long districts).

Aquaculture in this province primarily consists of brackish aquacultures such as black tiger shrimp, whiteleg shrimp, and crab (Duyen Hai, Cau Ngang districts, and Duyen Hai town). This is a key strength of Tra Vinh province, particularly in Duyen Hai district, which has

the largest farming area and diverse cultivation models. Additionally, freshwater aquaculture is also focused in Tra Cu (e.g., catfish, snakehead fish, and giant freshwater shrimp).

3.2.13. Current agricultural land use in Vinh Long

The integrated information from satellite image interpretation and field surveys revealed that Vinh Long province currently has 08 main land use categories, including mono rice crop, double rice crops, triple rice crops, annual crops, perennial plants, aquaculture, built-up lands, and water bodies (Figure 1.16).

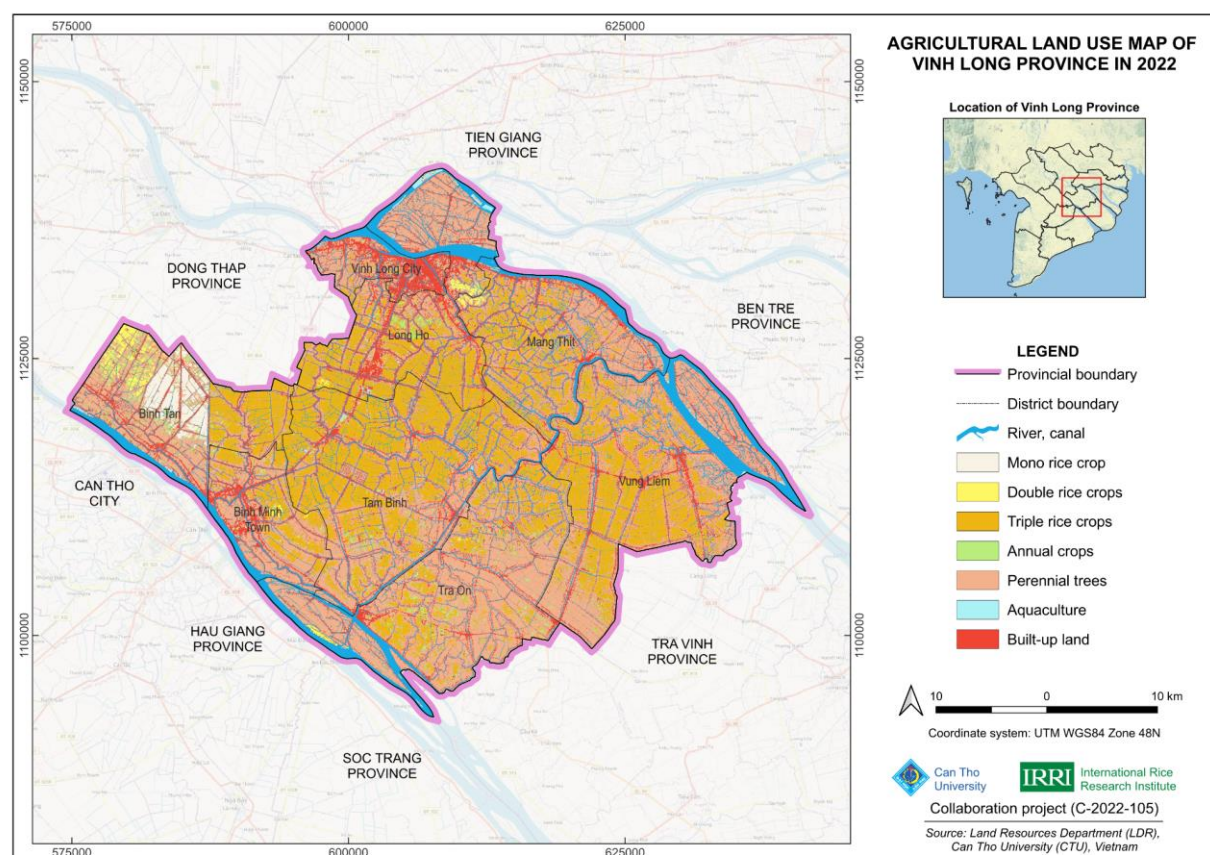


Figure 1.16. Current land use map in Vinh Long province in 2022

Table 1.15. Areas and proportion of land use types in Vinh Long province in 2022

No.	Land use type	Areas (ha)	Proportion (%)
1	Mono rice crop	2,135.99	1.3
2	Double rice crops	1,477.81	1.0
3	Triple rice crops	45,193.9	29.6
4	Annual crops	5,502.1	3.6
5	Perennial plants	68,716.3	45.0
6	Aquaculture	1,068.81	0.7
7	Water bodies	14,978.3	9.8
8	Built-up lands	13,776.8	9.0
Total		152,850.01	100

Vinh Long is also a province with a strong focus on fruit farms. The total perennial plantation area is about 668,716.3 ha (45.0%) across the province. Typical fruits include longan (Vinh Long city), rambutan, durian (An Binh Isle, Long Ho, Mang Thit, and Vinh Liem districts), pomelo (Binh Minh and Tra On districts), and orange (king mandarin, in Tra On and Tam Binh districts).

Triple rice crops account for 29.6% (corresponding to 45,193.9 ha), mainly in Tam Binh, Vung Liem, Long Ho, Mang Thit, and Binh Tan districts. However, this farming area is expected to decrease in the future under provincial strategies for agricultural restructuring, which aim to convert disadvantageous rice fields, due to a lack of freshwater for irrigation, into annual crops, fruit farms, and combinations with freshwater aquacultures.

Double rice crops dominate only 1,477.81 ha (1.0%) scattered in Tra On, Tam Binh, and Binh Minh districts. This farming includes traditional double rice crops and double rice

crops combined with vegetables (2 rice - 1 vegetable; 1,391.83 ha in Tra On district). The rice crops are Summer-Autumn and Autumn-Winter crops. Common vegetables in the rotational crop are white radish and Mexican turnip (or Jicama). In Binh Tan, farmers often plant watermelon in the rotational crop for the domestic market during the Lunar New Year festival.

There are about 2,135.99 ha of mono rice crops in Vinh Long province, which are part of the 2 vegetables - 1 rice model, in Tan Thanh, Thanh Dong, and Thanh Trung communes (Binh Tan district). The rice crop is a Summer-Autumn crop, while vegetable crops are cultivated in Autumn-Winter and Winter-Spring. Typical annual crops in this region include sweet potato, corn, and winter melon. The two farming models of 2 rice - 1 vegetable and 2 vegetables - 1 rice are considered a leap in agricultural restructuring in Vinh Long province, leveraging cultivation experience to increase income in the same area.

Annual crops cover an area of 5,505.07 ha (3.6%). The province currently has 05 agricultural co-operatives for safe vegetable production, including Phuoc Hau, Thanh Loi, Vung Liem, Tan Quoi, and Tam Vu. Annual crops are scattered over the province, especially in Binh Tan and Long Ho districts, where green onion, watercress, and leafy vegetables are commonly grown. Binh Tan is known for cultivating sweet potatoes. However, according to the district Department of Agriculture and Rural Development, the current area of sweet potato has decreased (only remaining 746 ha) compared to 6,493 ha in 2021.

Aquaculture accounts for a small proportion, only about 0.7% (1,068.81 ha). The most prominent model is catfish farming along the Co Chien and Hau Rivers in Long Ho, Vung Liem, Binh Tan, and Tra On districts.

4. Conclusions

The VMD is one of the main agricultural production regions in Vietnam with diverse agricultural products. As the “rice bowl” of the country, the delta has over 80% of its total

area covered by rice farming, which is relatively diverse depending on geographical and water resource conditions. The rice-specialized areas (double and triple rice crops) are mainly concentrated in the Dong Thap Muoi and Long Xuyen Quadrangle regions (e.g., Kien Giang, An Giang, Can Tho, Dong Thap, and Long An provinces). Meanwhile, rice farming with fewer crops and rotation with brackish aquaculture (double rice crops and rice-shrimp) is found in more remote coastal areas (e.g., Kien Giang, Bac Lieu, Soc Trang, and Tra Vinh provinces). This region is also home to extensive fruit orchards along the Bassac River and on fertile isles in Tien Giang, Ben Tre, Vinh Long, Can Tho, Hau Giang, and Soc Trang provinces, featuring numerous geographical indication fruits (e.g., pomelo, orange, longan, dragon fruit, rambutan, durian, soursop, and coconut). Brackish aquaculture is prominent in the coastal areas of the Ca Mau peninsula (Ca Mau, Kien Giang, Bac Lieu, and Soc Trang provinces), where the mangrove-shrimp combination model has become an environmentally friendly aquaculture practice (especially in Ca Mau province).

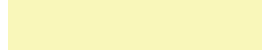
The distribution of current agricultural land use in the VMD mainly depends on water resources and irrigation systems. Currently, the delta is facing numerous changes due to global climate change and extreme climate events such as severe drought, saltwater intrusion, water shortage, and soil degradation. These challenges threaten food security, incomes, and livelihoods for millions of people in the delta. Therefore, local authorities have developed various strategies to transform agriculture in response to these new conditions. The general trend is to reduce the area of specialized rice cultivation and convert it to fruit farms and vegetable crops. Coastal areas have been transformed into large, specialized aquaculture farming zones.

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Appendix

Appendix 1. Based color for land use mapping in Mekong delta

Land use 2022	Code	Color	Red	Green	Blue
Rice - Shrimp	0		48	209	220
Mono rice crop	1		249	247	186
Double rice crops	2		255	247	99
Triple rice crops	3		239	181	21
Annual crops	4		185	238	125
Perennial trees	5		243	177	140
Aquaculture	6		171	242	246
Water bodies	7		23	170	229
Built-up land	8		240	68	53
Mangrove forest	9		7	140	20
Shrimp – Mangrove Forest	10		67	184	17
Pineapple	11		227	136	213
Sugarcane	12		142	40	229

Appendix 2. Land use types by provincial level

Land use 2022	Code	An Giang	Dong Thap	Can Tho	Kien Giang	Tra Vinh	Bac Lieu	Vinh Long	Hau Giang	Ca Mau	Soc Trang	Ben Tre	Tien Giang	Long An
Rice - Shrimp	0	-	-	-	x	x	x	-	x	x	x	x	x	-
Mono rice crop	1	x	-	-	-	-	x	x	-	x	-	-	-	-
Double rice crops	2	x	x	x	x	x	x	x	x	x	x	x	x	x
Triple rice crops	3	x	x	x	x	x	x	x	x	-	x	-	x	x
Annual crops	4	x	x	x	x	x	x	x	x	-	x	x	x	x
Perennial trees	5	x	x	x	x	x	x	x	x	x	x	x	x	x
Aquaculture	6	x	x	x	x	x	x	x	x	x	x	x	x	x
Water bodies	7	x	x	x	x	x	x	x	x	x	x	x	x	x
Built-up land	8	x	x	x	x	x	x	x	x	x	x	x	x	x
Mangrove forest	9	x	x	-	x	x	x	-	x	x	x	x	x	x
Shrimp - Mangrove Forest	10	-	-	-	-	-	-	-	-	x	-	-	-	-
Pineapple	11	-	-	-	x	-	-	-	-	-	-	-	x	-
Sugarcane	12	-	-	-	-	-	-	-	-	-	x	-	-	-