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When Coconut Trees Die: Spatio-Temporal Land-Use Dynamics on Grand-Lahou Island, Côte d'Ivoire

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Abstract

In Côte d'Ivoire, coconut cultivation represents both a major cash crop and an important source of subsistence for rural communities. However, coconut plantations are increasingly threatened by Lethal Yellowing Disease, which has destroyed large areas of coconut trees and profoundly altered land-use patterns on Grand-Lahou Island. This study aims to analyze the spatiotemporal dynamics of land-use on the island from 1990 to 2025. The methodological approach combined digital processing of multi-temporal Landsat satellite images acquired in 1990, 2000, 2016, and 2025. Image classification and change detection techniques were used to quantify land-use transitions over time. The results reveal an increase in coconut plantation area between 1990 and 2000, followed by a sharp decline between 2000 and 2025, mainly due to the impact of Lethal Yellowing Disease. A significant conversion of coconut plantations into food crop areas was observed, with 43.91% of former coconut lands transformed between 2016 and 2025. These findings illustrate the severe consequences of Lethal Yellowing Disease on the local economy and landscape structure. To mitigate further losses, the establishment of an early detection system using drone imagery is recommended to identify infected coconut trees and help contain the spread of the disease.

Keywords

Lethal Yellowing Disease, Dynamics, Land-Use, Coconut Plantations, Grand-Lahou Island

1. Introduction

In Côte d'Ivoire, coconut (*Cocos nucifera* L.) is an important crop used for food, cosmetics, traditional medicine, and handicrafts [1]. It is predominantly cultivated along the coast and represents the primary source of income for over twenty thousand households in the Ivorian coastal region [2]. The Grand-Lahou area, located in southern Côte d'Ivoire, has long been a major production basin, supplying both local consumption and industrial chains for coconut oil and co-products.

However, over recent decades, this agricultural and landscape heritage has undergone significant transformations. Coconut plantations are simultaneously affected by aging, land pressures from expanding food crop cultivation, and the increasing impact of devastating diseases, particularly Lethal Yellowing Disease (LYD). This disease is caused by a phytoplasma microorganism transmitted by insect vectors [3] [4]. In Côte d'Ivoire, *Nedotepa curta* (Cicadellidae) and *Proutista fritillaris* (Derbidae) are suspected to be the vectors of lethal yellowing in the Grand-Lahou department [4]. According to [5], over 70% of coconut trees in the Grand-Lahou department have been destroyed by LYD.

To date, no chemical control method exists for LYD [6]. Current management strategies rely on identifying infected trees based on visible symptoms, followed by immediate removal [7] [8]. A major limitation of this approach is its dependence on symptom expression, which often appears several months after initial infection, leaving a critical window during which vectors can extensively spread the pathogen.

Developing early detection tools for LYD remains a major challenge for both agronomists and researchers. Studying the spatio-temporal dynamics of coconut plantations is therefore essential to understand land-use changes in affected areas. Recent advances in remote sensing and geographic information systems provide powerful tools for monitoring these transformations across different temporal and spatial scales [8] [9]. Such approaches allow not only the identification of areas experiencing disease regression or expansion but also the evaluation of underlying environmental and anthropogenic factors. Up-to-date data on plantation dynamics are crucial for guiding management policies and implementing an effective early warning system. This study aims to analyze the spatio-temporal dynamics of coconut plantations on Grand-Lahou Island from 1990 to 2025 using satellite imagery and field data.

2. Materials and Methods

2.1. Study Area

Grand-Lahou Island is located about 20 km from the town of Grand-Lahou and covers an area of 15,000 ha [6]. It lies between latitudes 5˚6'0''N and 5˚13'12''N and longitudes 5˚18'0''W and 5˚3'0''W (**Figure 1**). The island is characterized by forest cover and the presence of three major water bodies the Bandama River, the Tagba Lagoon, and the Atlantic Ocean which has earned it the name "City of

Three Waters." The area experiences an equatorial climate with two rainy seasons and two dry seasons [6] [10].

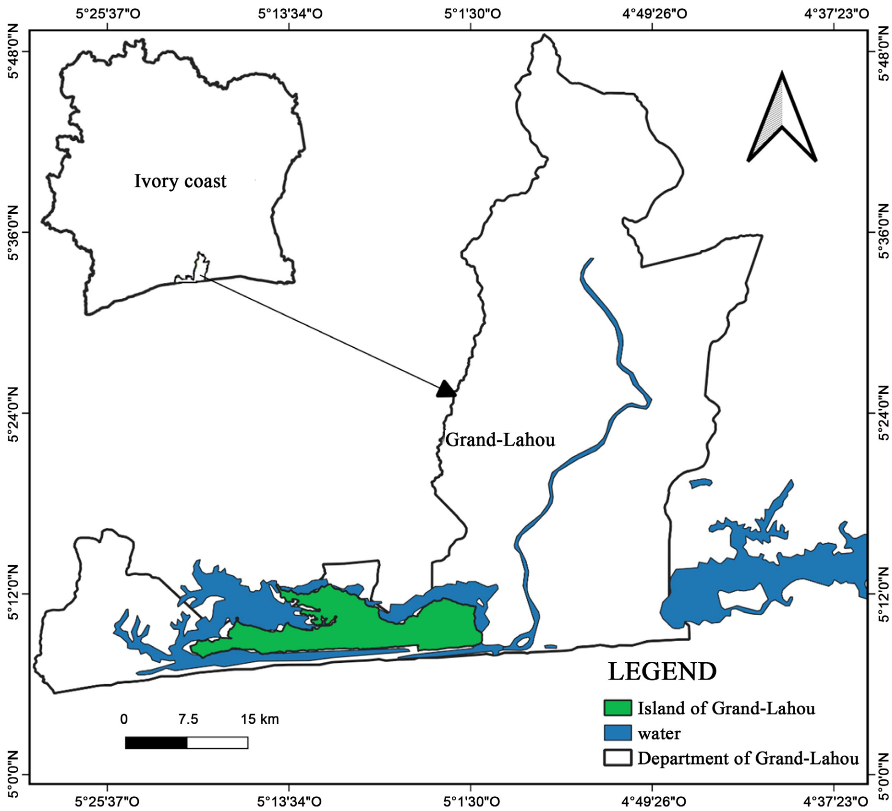

Figure 1. Location of Grand-Lahou Island.

2.2. Data Collection

In this study, four LANDSAT satellite images from 1990, 2000, 2016, and 2025, with a spatial resolution of 30 m (**Table 1**), were used. All images were acquired during the dry season, as this period corresponds to the lowest levels of cloudiness and cloud cover throughout the year. The LANDSAT data were freely obtained through download from the USGS Earth Explorer platform (http://earthexplorer.usgs.gov/).

Table 1. Characteristics of the satellite images used.

Acquisition Dates	Sensor	Spatial Resolution
30/12/1990	LANDSAT 4 TM	30 m
09/02/2000	LANDSAT 7 ETM	30 m
01/04/2016	LANDSAT 8 OLI TIRS	30 m
09/03/2025	LANDSAT 8 OLI TIRS	

2.3. Field Survey and Delineation of Training Samples

Color composite of the 2025 satellite image was used to identify areas with distinct color, texture, and shape, which were subsequently visited during a field verification mission. This enabled the definition of land-use types for mapping (**Table 2**). GPS points and plot boundaries were recorded for the mainland-use categories, including coconut, forest, food crop, and other crop.

Table 2. Description of land use categories.

Land use	Characteristics
Forest	Dense vegetation characterized by tall tree species
Food crop	Area under annual or subsistence crops
Coconut grove	Coconut plantation zone (monocrop system)
Other crop	Cocoa and/or coffee plantations associated with shade trees. Rubber and oil palm plantations in monoculture
Mangrove	Flooded area composed of water-tolerant trees and shrubs
Water	Water body
Bare ground	Built-up and bare land areas

2.4. Image Classification and Accuracy Assessment

The Maximum Likelihood classification (MLC) was employed to map land-use types [11] [12]. The maximum likelihood algorithm was selected because of its ability to exploit the statistical distributions of classes derived from the spectral signatures of pixels [11]. It models class distributions from training areas under the assumption of normality and assigns each pixel to the class with the highest probability [13] [14]. Classification was performed on the 2025 image, using 147 training plots covering 70% of the field data. Refinement and calibration produced the most accurate map. The spectral signatures from the 2025 classification served as training areas for supervised classification of the 2016, 2000, and 1990 images. Classifications were conducted in ENVI 4.7, and results were exported to QGIS 3.28 for map generation.

Map quality was assessed through cross-validation using 63 control plots excluding from training [15]. Validation was based on overall accuracy and the confusion matrix. This assessment helps to understand the sources of misclassification [9]. Additionally, model accuracy indicators including overall accuracy, Kappa coefficient, user's accuracy, and producer's accuracy were calculated from the confusion matrix obtained through cross-validation. This validation approach provides an unbiased estimate of the error rate when the model is applied to the entire study area [16].

2.5. Land-Use Change Analysis

Land-use change analysis was conducted using a transition matrix (in percentage) and the rate of change (in percentage) over the study period. The transition matrix highlights the conversions between land-use types between two dates and quantifies these changes [11] [17]. Annual rates of change were calculated using the standardized formula proposed by [18]:

$$Tv = -\frac{1}{t_2 - t_1}\ln\left(\frac{S_2}{S_1}\right)\times 100 \quad (1)$$

where S_1 and S_2 represent the areas of the land-use type at dates t_1 and t_2, respectively.

3. Results

3.1. Evaluation of Map Quality

The land-use maps for 1990, 2000, 2016, and 2025 achieved overall accuracies of 83.63%, 82.27%, 79.44%, and 84.53%, respectively, with all Kappa coefficients exceeding 0.70 (**Table 3**). The confusion matrices generated for each date indicate high user's accuracy values (PA > 75%) across all land-use categories (**Tables 4-7**). However, a notable confusion was observed between the forest class and other classes such as other crops and coconut groves across all dates. The resulting maps showed a similar magnitude of error (UA) per class, with an average difference of less than 3.5%.

Table 3. Overall accuracy and Kappa coefficient of the classified images.

Years	1990	2000	2016	2025
Overall Accuracy (%)	83.63	82.27	79.44	84.53
Kappa Coefficient	0.77	0.76	0.73	0.79

Table 4. Confusion matrices and accuracy metrics for 1990 land-use map (in number of pixels).

Reference/ Classified	Other crop	Forest	Food crop	Coconut grove	Water	Bare ground	Mangrove	Total	UA
Other crop	18,878	638	853	2771	0	4	5	23,149	0.82
Forest	1662	45,440	443	4972	0	5	1061	53,583	0.85
Food crop	646	111	8644	820	0	298	137	10,656	0.81
Coconut grove	2667	6712	1130	57,173	0	20	339	68,041	0.84
Water	0	5	3	0	3160	0	548	3716	0.85
Bare ground	3	2	278	16	0	2217	101	2617	0.85
Mangrove	1	802	279	384	64	73	7398	9001	0.82
Total	23,857	53,710	11,630	66,136	3224	2617	9589	170,763	
PA	0.79	0.85	0.74	0.86	0.98	0.85	0.77		

Note: UA—User accuracy; PA—Producer accuracy.

Table 5. Confusion matrices and accuracy metrics for 2000 land-use map (in number of pixels).

Reference/Classified	Other crop	Forest	Food crop	Coconut grove	Water	Bare ground	Mangrove	Total	UA
Other crop	20,873	1347	798	2093	5	1	6	25,123	0.83
Forest	1426	25,774	149	6208	3	1	366	33,927	0.76
Food crop	1182	198	17,316	3270	12	381	568	22,927	0.76
Coconut grove	1948	4835	2095	60,786	1	119	503	70,287	0.86
Water	0	0	0	0	2936	0	83	3019	0.97
Bare ground	2	3	424	147	1	3896	180	4653	0.84
Mangrove	22	332	587	784	543	45	8514	10,827	0.79
Total	25,453	32,489	21,369	73,288	3501	4443	10,220	170,763	
PA	0.82	0.79	0.81	0.83	0.84	0.88	0.83		

Note: UA—User accuracy; PA—Producer accuracy.

Table 6. Confusion matrices and accuracy metrics for 2016 land-use map (in number of pixels).

Reference/Classified	Other crop	Forest	Food crop	Coconut grove	Water	Bare ground	Mangrove	Cloud	Total	UA
Other crop	21,056	3583	770	2483	18	1	10	2	27,923	0.75
Forest	3396	38,001	735	5462	1	6	415	4	48,020	0.79
Food crop	474	494	28,024	2747	1	359	172	13	32,284	0.87
Coconut grove	2339	5016	3065	36,221	2	59	492	27	47,221	0.77
Water	2	1	0	0	940	52	58	0	1053	0.89
Bare ground	11	20	856	326	42	3912	176	40	5383	0.73
Mangrove	4	306	47	263	106	326	6964	9	8025	0.87
Cloud	44	53	93	160	0	19	25	460	854	-
Total	27,326	47,474	33,590	47,662	1110	4734	8312	555	170,763	
PA	0.77	0.80	0.83	0.76	0.85	0.83	0.84	-		

Note: UA—User accuracy; PA—Producer accuracy.

Table 7. Confusion matrices and accuracy metrics for 2025 land-use map (in number of pixels).

Reference/Classified	Other crop	Forest	Food crop	Coconut grove	Water	Bare ground	Mangrove	Total	UA
Other crop	39,399	4937	1653	1767	9	221	72	48,058	0.82
Forest	4989	33,490	1028	555	17	62	498	40,639	0.82
Food crop	1514	1232	53,226	2694	0	1341	29	60,036	0.89
Coconut grove	765	341	854	7070	0	211	0	9241	0.77
Water	48	45	4	0	994	14	50	1155	0.86
Bare ground	172	102	413	163	2	5603	1	6456	0.87
Mangrove	116	382	74	1	36	1	4568	5178	0.88
Total	47,003	40,529	57,252	12,250	1058	7453	5218	170,763	
PA	0.84	0.83	0.93	0.58	0.94	0.75	0.88		

Note: UA—User accuracy; PA—Producer accuracy.

3.2. Land-Use of Grand-Lahou Island from 1990 to 2025

The land-use maps from 1990 to 2025 generally show a decline in coconut groves and forests in favor of agricultural crops (Figure 2). The area of coconut groves initially increased from 1990 to 2000 before drastically decreasing through 2025. They covered 39.8% (6123.6 ha) in 1990, 42.9% (6595.9 ha) in 2000, 27.9% (4289.5 ha) in 2016, and only 5.4% (831.6 ha) in 2025 (Figure 3). Food crops, which accounted for only 6.2% of the study area in 1990, expanded to 12.5% in 2000, 19.6% in 2016, and 35.1% in 2025. Similarly, other perennial crops increased from 13.5% in 1990 to 14.9% in 2000, 16% in 2016, and 28.1% in 2025.

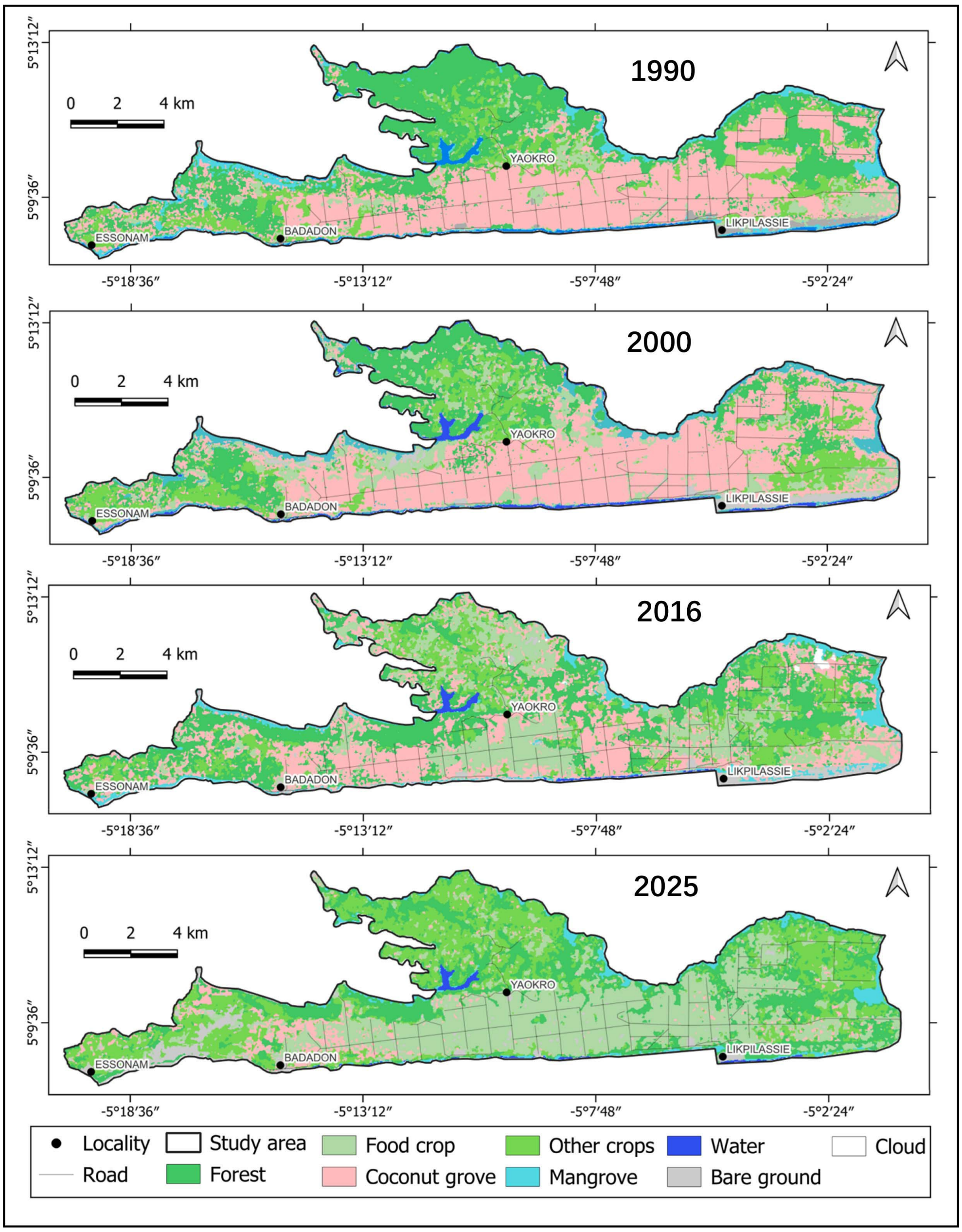

Figure 2. Land-use maps of Grand-Lahou Island in 1990, 2000, 2016, and 2025.

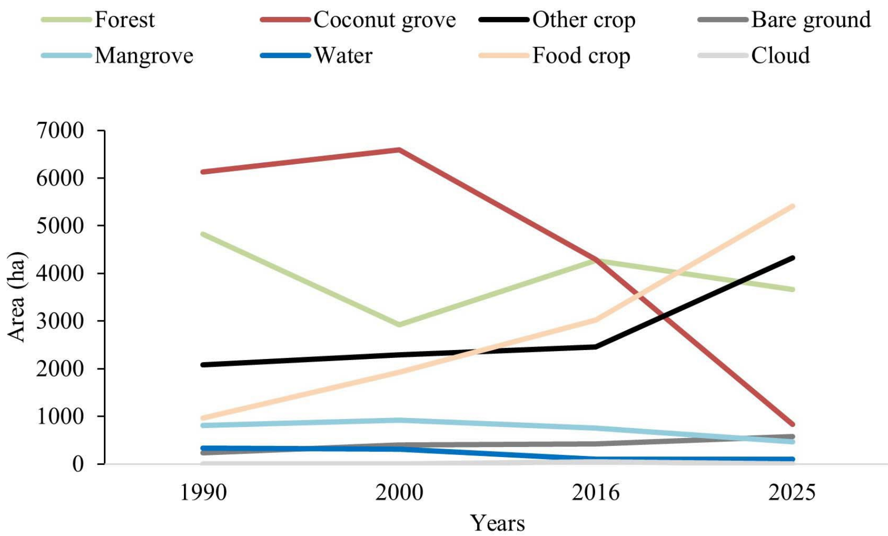

Figure 3. Area of land-use types.

3.3. Evolution of Land-Use Class Areas from 1990 to 2025

During 1990-2000, forests and water bodies declined annually by 3.9% and 0.5%, respectively (Figure 4). In contrast, coconut groves, other perennial crops, bare soil, mangroves, and food crops increased at annual rates of 0.7%, 0.9%, 6.9%, 1.3%, and 10%, respectively. The period 2000-2016 appeared favorable for forests, which recorded an annual reforestation rate of 2.8%. Food crops, other perennial crops, and bare soil also expanded, with annual gains of 3.5%, 0.5%, and 0.4%, respectively. Over the same period, coconut groves, mangroves, and water bodies declined, with annual losses of 2.1%, 1.1%, and 4.1%, respectively. Between 2016 and 2025, the regression of coconut groves continued at a rate of 8.9% per year, while mangroves also kept decreasing. Conversely, food crops and other perennial crops expanded significantly, with annual increases of 8.4% and 8.7%, respectively.

3.4. Conversion between Land-Use Classes

Land-use changes on Grand-Lahou Island between 1990 and 2025 were highlighted through transition matrices (Table 8). Values along the diagonal represent the stability rate of each land-use type for the respective periods. Between 1990 and 2000, forest (21.55%), food crops (24.02%), and other perennial crops (22.70%) were converted into coconut groves. The period 2000-2016 was marked by the transformation of coconut groves into food crops and forest, with conversion rates of 23.24% and 25.35%, respectively. The largest forest conversions were toward coconut groves (22.40%), food crops (19.16%), and other perennial crops (19.43%). From 2016 to 2025, the most significant conversion of coconut groves was into food crops, which gained 43.91% of their area, followed by other perennial crops (25.57%). Only 8.78% of coconut groves remained stable. Forests were also converted into other perennial crops at a rate of 27.44%.

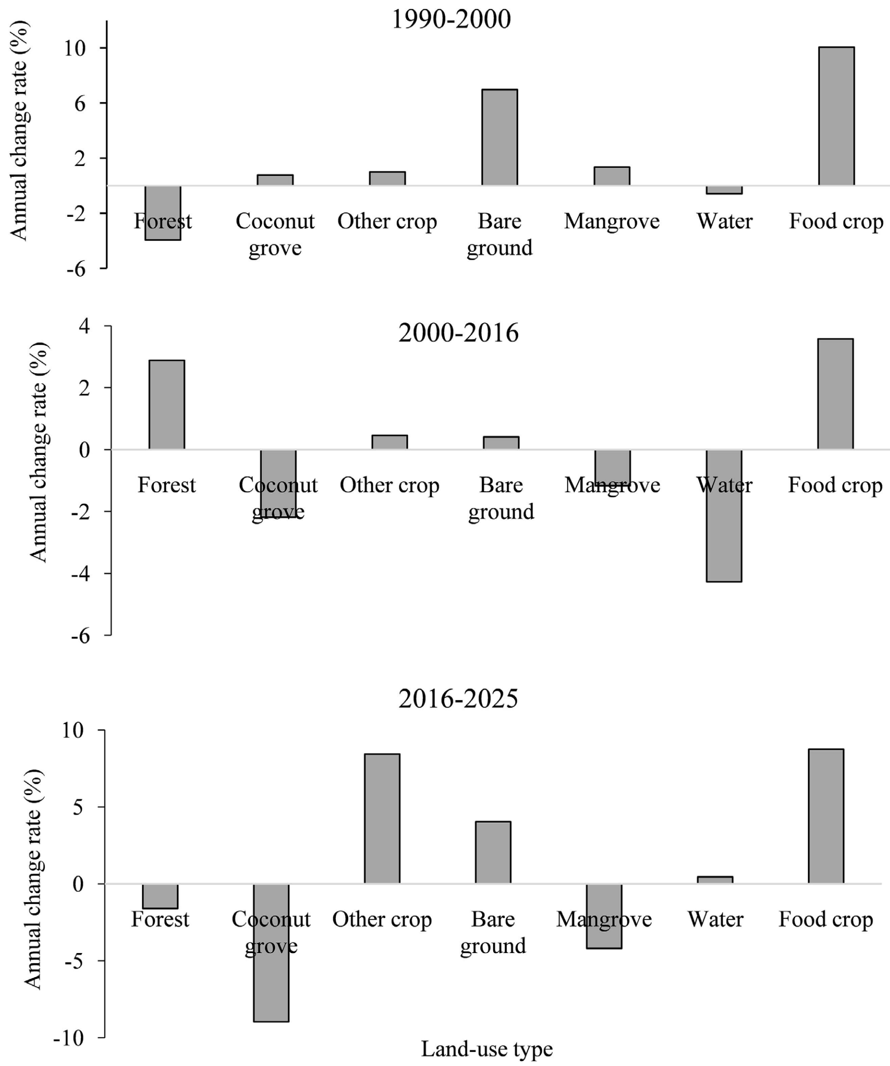

Figure 4. Rates of change in land-use classes from 1990 to 2025.

4. Discussion

4.1. Evaluation of Map Quality

Validation of the classified images revealed overall accuracies consistently above 79%, with Kappa coefficients exceeding 0.70. These values indicate a good quality of the produced land-use maps [19]. Similarly, user's accuracy values were

Table 8. Land-use transition matrix.

	Bare ground	Coconut grove	Food crop	Forest	Mangrove	Other crop	Water	Cloud
1990-2000								
Bare ground	92.47	0.38	6.32	1.03	4.80	0.44	0.13	-
Coconut grove	1.76	78.07	24.02	21.55	8.32	22.70	0.38	-
Food crop	3.97	7.75	42.30	12.92	7.12	16.91	0.13	-
Forest	0.19	5.41	3.25	48.33	5.01	9.07	0.19	-

Continued

Mangrove	1.38	1.12	1.14	4.26	69.27	0.29	19.27	-
Other crop	0.08	7.25	22.97	11.80	0.38	50.60	0.00	-
Water	0.15	0.02	0.00	0.10	5.10	0.00	79.90	-
2000-2016								
Bare ground	43.37	0.59	1.57	0.68	6.30	0.38	30.91	-
Coconut grove	10.56	36.72	29.13	22.40	12.97	21.13	2.06	-
Food crop	10.20	23.24	21.75	19.16	3.79	18.98	0.29	-
Forest	19.42	25.35	31.71	37.76	26.47	24.15	3.86	-
Mangrove	15.87	1.26	1.90	0.23	49.76	0.29	29.79	-
Other crop	0.59	12.38	13.78	19.43	0.43	34.76	2.20	-
Water	0.00	0.00	0.00	0.00	0.26	0.00	30.91	-
Cloud	0.00	0.46	0.15	0.33	0.02	0.31	0.00	
2016-2025								
Bare ground	25.86	3.55	2.73	2.43	9.29	2.51	0.81	0.72
Coconut grove	1.29	8.78	3.09	5.34	1.73	4.68	0.00	0.00
Food crop	20.64	43.91	55.60	22.21	4.27	31.19	0.09	5.77
Forest	19.60	17.43	11.63	41.21	36.51	16.83	17.12	19.28
Mangrove	12.91	0.75	0.15	1.36	40.17	0.06	14.32	0.00
Other crop	12.80	25.57	26.80	27.44	7.21	44.73	0.18	74.23
Water	6.91	0.00	0.00	0.02	0.82	0.00	67.48	0.00

satisfactory (PA > 75%). Such performances can be explained by the good knowledge of the study area and the limited number of land-use classes considered [20]. Across all dates, the main confusion occurred between forests and other classes, notably other crops and coconut groves. This reflects the complexity and high heterogeneity of perennial crop formations observed during our field surveys. Indeed, the "other perennial crops" class encompasses very old plantations of rubber (*Hevea brasiliensis* Muell Arg.) and cocoa (*Theobroma cacao* L.) intercropped with trees, which are difficult to distinguish from forests on LANDSAT imagery. This source of confusion has also been reported by [9] [20] using Sentinel-2 imagery with 10 m spatial resolution in southern Côte d'Ivoire.

4.2. Land-Use Dynamics of Grand-Lahou Island (1990-2025)

Our results indicate an increase in coconut grove areas between 1990 and 2000, followed by a sharp decline up to 2025. The initial expansion can be attributed to the absence of the Lethal Yellowing Disease, which encouraged the establishment of new plantations by the *Société Ivoirienne de Coco Râpé* (SICOR) on Grand-Lahou Island [6]. The first symptoms of the disease were observed from 1992 in the Grand-Lahou department, without causing massive plantation losses at that time [5]. Concurrently, forests declined during the 1990-2000 period, with an estimated annual deforestation rate of 3.9%, likely due to the expansion of coconut groves [10].

Between 2000 and 2016, coconut groves experienced an annual decline of 2.1%, which sharply increased to 8.9% between 2016 and 2025. This trend reflects the massive destruction of coconut groves on Grand-Lahou Island since 2000, directly linked to the spread of lethal yellowing. The disease caused a significant loss in coconut and copra production, estimated at over two billion CFA francs in Côte d'Ivoire [21] [22]. Indeed, the coconut lethal yellowing disease has caused the destruction of numerous coconut plantations over the past decades, including about 350 hectares within the large Ivorian plantation located in the Grand-Lahou district. These findings corroborate [23], which reported a dramatic increase in disease incidence after 2000, with up to 70% of coconut trees lost by 2012 in the study area.

In parallel, food crop areas expanded considerably between 2016 and 2025, largely due to the conversion of former coconut groves, representing 43.91% of the lost coconut area. The death of coconut trees created fallow lands suitable for agriculture, which local communities used for subsistence crops, such as cassava [6]. Additionally, [22] reported that in 2016, SICOR returned 2,500 ha of coconut plantations to local communities for agricultural use.

4.3. Coconut Cultivation on Grand-Lahou Island in the Context of Lethal Yellowing Disease

The conversion of coconut groves into other perennial crops between 2016 and 2025 reflects the abandonment of coconut cultivation in favor of alternative crops, driven by the devastating effects of lethal yellowing disease. During our field surveys, we observed the establishment of new plantations, including rubber, cocoa, and oil palm. The introduction of these crops appears to represent an adaptive strategy by local communities in response to the disease. However, the profitability and vulnerability of these newly established crops remain largely unknown.

5. Conclusion

This article provides an assessment of land-use dynamics on Grand-Lahou Island between 1990 and 2025. Analysis of Landsat satellite imagery indicates that the landscape, initially dominated by coconut plantations in 1990, has progressively shifted towards food crop cultivation. Land-use trajectories reveal an expansion of coconut plantations between 1990 and 2000, followed by a pronounced decline from 2000 to 2025. Between 2016 and 2025, 43.91% of coconut plantations were converted into food crops. The substantial conversion of coconut stands into other perennial crops, largely attributable to the devastating impact of coconut lethal yellowing disease, reflects a broader process of agricultural transition and the abandonment of coconut cultivation in favor of alternative crops within the study area. Considering the magnitude of coconut plantation losses, the establishment of an early detection system based on drone imagery for the identification of infected palms appears critical to mitigating the spread of lethal yellowing disease.

Authors' Contributions

Conceptualization, K.J.M.K., A.T.M.K. and K.S.B.N.; methodology, K.J.M.K., A.T.M.K. and B.M.D.; validation, Y.S.S.B.; formal analysis, K.J.M.K. and B.M.D.; investigation, K.J.M.K., A.T.M.K. and B.M.D.; data curation, K.J.M.K. and B.M.D.; writing—original draft preparation, K.J.M.K.; writing-review and editing, K.J.M.K., A.T.M.K. and K.S.B.N.; visualization, Y.S.S.B.; supervision, M.S.T.; project administration, K.S.B.N.; funding acquisition, K.S.B.N.

All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Bene, S., Courbet, P., Dziwormu, A., Salinier, J. and Mensah-Bonsu, A. (2009) La filière du cocotier au Ghana et au Nigéria. *Oilseeds and Fats*, *Crops and Lipids*, **16**, 87-96. http://dx.doi.org/10.1051/ocl.2009.0251

[2] Assa, R.R., Konan, J.L., Nemlin, J., Prades, A., Agbo N'zi, G. and Sié, R.S. (2006) Diagnostic de la cocoteraie paysanne du littoral ivoirien. *Sciences & Nature*, **3**, 113-120.

[3] Legoupil, J.C. and Courbet, P. (2008) Worldwide Coconut Production. Importance and Impact of the Lethal Yellowing Disease. Justification and Objectives of the International Workshop. 24. https://agritrop.cirad.fr/548439/1/document_548439.pdf

[4] Beugré, N.I., Doh, F., Djiwha Danon, A.S., Allou, K. and Dagnogo, M. (2022) Dynamique Saisonnière de Nedotepa curta (Homoptera, Cicadellidae) et Proutista fritillaris (Homoptera, Derbidae), Potentiels Vecteurs du Phytoplasme de la Maladie du Jaunissement Mortel du Cocotier de Grand-Lahou (Côte d'Ivoire). *European Scientific Journal*, *ESJ*, **18**, 351. https://doi.org/10.19044/esj.2022.v18n27p351

[5] CNRA (2012) Comment Freiner La Propagation de l'Affection provoquant la mortalité du cocotier dans le Département de Grand-Lahou. Direction de la recherche scientifique et de l'appui au développement, 2.

[6] N'guessan, T.S., Kra Kouame, D., Jonas Ibo, G. and Diallo Taky, H.A. (2019) Jaunissement Mortel du Cocotier et Mutations Sociales à Grand-Lahou, Côte d'Ivoire. *European Scientific Journal ESJ*, **15**, 130-142. https://doi.org/10.19044/esj.2019.v15n25p130

[7] Myrie, W., Oropeza, C. and Saenz, L. (2011) Reliable Improved Molecular Detection of Coconut Lethal Yellowing Phytoplasma and Reduction of Associated Disease through Field Management Strategies. *Bulletin of Insectology*, **64**, 203-303.

[8] Bonnot, F., de Franqueville, H. and Lourenço, E. (2010) Spatial and Spatiotemporal Pattern Analysis of Coconut Lethal Yellowing in Mozambique. *Phytopathology*, **100**, 300-312. https://doi.org/10.1094/phyto-100-4-0300

[9] Ouattara, T. (2022) Suivi des terres et de la déforestation par télédetection spatiale et aérienne à l'Est et au Sud-Est de la Côte d'Ivoire. Ph.D. Thesis, University of Cocody-Abidjan.

[10] Amenan, Y., Atcham, A., Pohe, J., D'Almeida, M. and Zama, P. (2012) Association d'organismes de type mycoplasmes avec le dépérissement mortel des cocotiers de Grand-Lahou en Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, **6**, 959-984. https://doi.org/10.4314/ijbcs.v6i3.5

[11] Barima, Y.S.S., Kouakou, A.T.M., Bamba, I., Sangne, Y.C., Godron, M., Andrieu, J., et al. (2016) Cocoa Crops Are Destroying the Forest Reserves of the Classified Forest of Haut-Sassandra (Ivory Coast). *Global Ecology and Conservation*, **8**, 85-98. https://doi.org/10.1016/j.gecco.2016.08.009

[12] Kouakou, A.T.M. (2019) Dynamiques spatio-temporelles du couvert végétal et diversité floristique de quelques parcs nationaux et forêts classées de côte d'Ivoire dans un contexte de crises politico-militaire. Ph.D. Thesis, University of Jean Lorougnon Guédé.

[13] Kouakou, A.T.M., Barima, Y.S.S., Konate, S., Bamba, I., Kouadio, J.Y. and Bogaert, J. (2017) Gestion des forêts domaniales en période de conflits: Cas de la forêt classée du Haut-Sassandra, Centre-Ouest de la Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, **11**, 333-349. https://doi.org/10.4314/ijbcs.v11i1.26

[14] Zammit, O. (2008) Détection de Zones Brûlées Après Un Feu de Forêt à Partir d'une Seule Image Satellitaire SPOT 5 Par Techniques SVM. Ph.D. Thesis, University of Nice-Sophia Antipolis.

[15] Bylander, T. (2002) Estimating Generalization Error on Two-Class Datasets Using Out-Of-Bag Estimates. *Machine Learning*, **48**, 287-297. https://doi.org/10.1023/a:1013964023376

[16] Chatelain, C. (1996) Possibilités d'application de l'imagerie Satellitaire à Haute Résolution Pour l'étude Des Transformations de La Végétation En Côte d'Ivoire Forestière, Ph.D. Thesis, University of Genève.

[17] Kadio, A.N.K., Kouassi, B.K. and Yao, S.S.B. (2020) Impact of Cocoa Cultivation in the Forest-Savannah Transition Zone of Western Côte d'Ivoire. *International Journal of Biodiversity and Conservation*, **12**, 291-304. https://doi.org/10.5897/ijbc2020.1430

[18] Puyravaud, J. (2003) Standardizing the Calculation of the Annual Rate of Deforestation. *Forest Ecology and Management*, **177**, 593-596. https://doi.org/10.1016/s0378-1127(02)00335-3

[19] Pontius, R.G. (2000) Quantification Error versus Location Error in Comparison of Categorical Maps. *Photogrammetric Engineering & Remote Sensing*, **66**, 1011-1016.

[20] Caloz, R. and Collet, C. (2002) Précis de Télédétection. Presses de l'Université du Québec.

[21] Jofack Sokeng, V., Akpa, Y.L., Assoma, T.V., Kouame, F., Corgne, S., Rudant, J.P., Ouattara, T., Sorho, F., Yao, N. and Kouame, P. (2019) Suivi par télédétection des affectations des terres pour la promotion d'une agriculture intégrée au dé-veloppement forestier en Côte d'Ivoire. In: Mertens, B. and Orekan, V., Eds., *Proceedings of the Actes de la Conférence OSFACO: Des images satellites pour la gestion durable des territoires en Afrique*, OSFACO, 17p.

[22] Irie, B.V.G. and Lida, D.S. (2019) Acteurs Immatériels et Solidarité Intra-Lignagère Dans La Représentation Sociale Du Foncier à Grand-Lahou. Étude de Cas. *Revue Sociétés & Economies*, **2019**, 59-74. https://shs.hal.science/halshs-03744470v1

[23] Kouadjo-Zeze, C., Konan, K.J.L. and Daramcoum, V.M.P. (2020) Comment faire le diagnostic précoce de la maladie du jaunissement mortel du cocotier en côte d'Ivoire. *Direction des Programmes de Recherche et de l'Appui au Développement* , CNRA, 2 p. https://cnra.ci/download/comment-faire-le-diagnostic-precoce-de-la-maladie-du-jaunissement-mortel-du-cocotier-en-cote-divoire/