



Cocoa &
Forests
Initiative

CFI GHANA 2022 FOREST MONITORING REPORT

SEPTEMBER, 2023



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This report has been developed by RMSC and is published together with IDH and Cocoa & Forests Initiative National Secretariat. Annexes detailing land use change per year and per HIA are available upon request.

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Executive Summary

Deforestation of tropical rainforests is a major issue in Ghana, the second largest producer of the world's supply of cocoa, the main ingredient in chocolate. Ghana lost 9.3% of the humid primary forest between 2002 and 2020. A major driver of deforestation in the High Forest Zone which is also the cocoa production belt is agriculture with cocoa cultivation and expansion being the single most important commodity driver. This threat led to the formation of the Cocoa & Forests Initiative (CFI), an active commitment made between leading cocoa-producing countries and chocolate and cocoa companies. The aim of this initiative is to provide an enabling environment for cocoa sector players to positively contribute towards stopping further conversion of any forestland, zero production and sourcing of cocoa from protected areas. Key to the initiative is the ability to identify and map different landcover categories within the landscape and building on that to provide information on forests cover change, deforestation trends and forest conversion. In addition to these, identify deforestation hotspots, analyze the impact of deforestation on the landscape and provide risk maps which will guide the implementation of forest interventions. The CFI signatories need access to up to date landcover maps to be able to track cocoa lead deforestation. To that purpose, in June 2022, the Oversight Committee approved for CFI to adopt and work with the existing landcover maps produced by Resource Management Support Centre (RMSC) under the Forest 2020 project and available on [Ghana Forest Compliance](#). This system gives access to reliable landcover maps, protected areas boundary shapefiles as well as assist in monitoring deforestation trends in CFI priority areas.

In addition, for the purpose of tracking deforestation trends and develop meaningful periodic reporting, the CFI National Secretariat with funding through IDH, engaged the RMSC to develop landcover and landcover change maps for four epochs: 2019, 2020, 2021 and 2022 covering 6 Hotspot Intervention Areas

(HIA) in the CFI intervention areas. The aim of this engagement is to provide spatial data and information for all the CFI intervention areas to serve as basis to assess the performance of the intervention on the ground and report on them appropriately. In line with the aim the consultant was expected to deliver a first report on forest cover change covering from January 2019 – December 2022, develop a logfile / format for the underlying analyses, provide deforestation impact analysis and forest risk map, assess the impact of forest intervention undertaken within the project area.

Geographic Information System (GIS), remote sensing and image analysis, field data collection, review of existing maps and literature and participatory mapping were used to identify and map existing landuse / cover, determine landcover changes, deforestation rate, deforestation by cocoa, deforestation by other drivers, deforestation in and outside protected areas

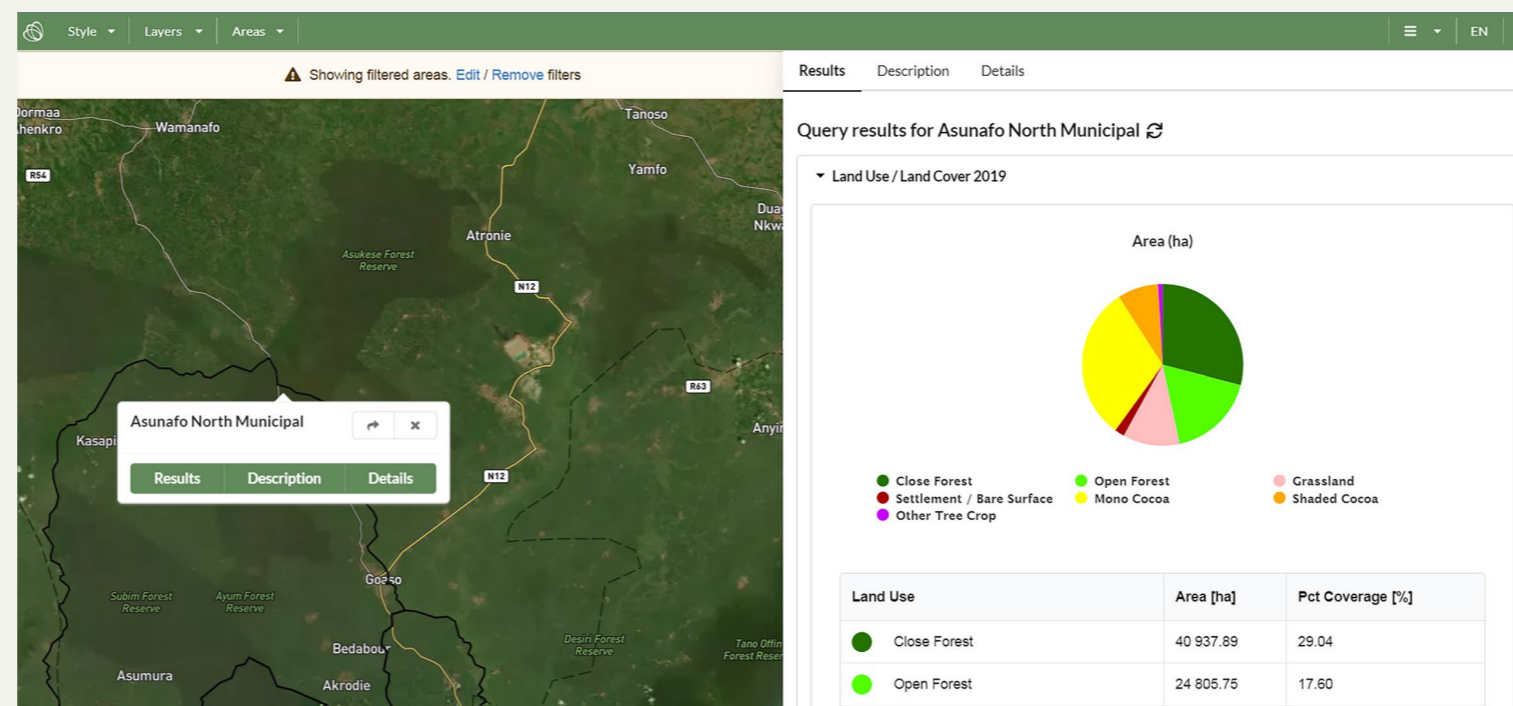
and forest reserve. The Hectare's indicator model (which applies GIS and remote sensing methods) was used to develop the forest risk map.

The landcover maps show that the dominant landcover within all the HIAs were cocoa plantation and forest. Whilst the forest cover is mostly found in the protected areas and forest reserve, cocoa plantation was dominant outside the protected areas and forest reserves.

In general, there was a net reduction in forest cover and a slight reduction in cocoa plantation across the HIAs. The annual deforestation rate for all the HIAs ranges from 0.006 to 0.064 with the highest rate recorded in Asunafo Asutifi and the lowest in Sefwi Wiawso, Bibiani and Anhwiaso. Deforestation in all the HIAs was higher in the off-reserve areas than the protected areas and forest reserves throughout

the study period. The only exception was the Sefwi Wiawso, Bibiani and Anhwiaso / Sefwi Wiawso HIA where deforestation was higher in the forest reserves than off-reserve areas in 2020 – 2021 and 2019 – 2022 epochs. For the HIAs that had both protected area and forest reserves, deforestation within the forest reserves was higher than deforestation within the protected areas. In general deforestation by cocoa plantation was lower than deforestation by the other drivers. The forest risk maps for each HIA showed that more than 70% of the forest cover were at low risk (very low and low risk categories). The forest at low risk were mostly found within the protected areas especially the national parks and conservation areas where entry is very restricted. The high-risk forest cover was found outside the protected areas and some few instances degraded portion within the protected areas.

The implications of the results of this work are that interventions to prevent further conversion of forest cover to cocoa plantation should focus more on the forest cover outside the protected areas and forest reserve. This is because deforestation is higher in this area and also the forest cover is at high risk. In designing interventions for the HIAs, the deforestation rate can be used as a guide to rank the HIAs and the level of interventions to be carry out for each. Conversion of forest cover to cocoa plantation is a process and takes time to be evident. The time period of this study was too short to detect cocoa led deforestation. This explains why other drivers of deforestation mostly conversion to food crop and settlement / bare surface was higher than cocoa plantation. These conversions are immediate and sometimes serve as transitional phase to cocoa plantation.



BACKGROUND

Deforestation of tropical rainforests is a major issue in Ghana, the second largest producers of the world's supply of cocoa, the main ingredient in chocolate. Ghana lost 9.3% of the humid primary forest between 2002 and 2020. Ghana's cocoa production belt serves as the main high forest repository of the country. Key drivers of deforestation and forest degradation in Ghana have been found to be agriculture, which includes cocoa farming.

The Cocoa & Forests Initiative (CFI) is an active commitment made between leading cocoa-producing countries and chocolate and cocoa companies. Central to the initiative is a commitment to stop further conversion of any forestland and zero production and sourcing of cocoa from protected areas. By signing a [Joint Framework for Actions \(JFA\)](#) in November 2017, companies and governments pledged to eliminate illegal cocoa production in national parks and forest reserves, in line with stronger enforcement of national forest policies and development of alternative livelihoods for affected farmers.

The CFI aims to provide an enabling environment for cocoa sector players to positively contribute to the preservation of forests in Ghana and the country's economy. The initiative takes a holistic approach to tackle the complex problem of deforestation in the cocoa value chain with a prime focus on three thematic areas: 1) sustainable production and farmers' livelihoods, 2) forest protection and restoration, and 3) community engagement and social inclusion. This is codified in an overarching Joint Framework for Action for Ghana and its [National Implementation Plan \(NIP\)](#).

The NIP hinged on enhancing and aligning with existing initiatives, ongoing projects with the basis for CFI interventions linked to a multi-stakeholder landscape approach. This should work to secure the remaining forests in Ghana in the immediate short-term as well

as restoration in the long-term. One of the overarching objectives is the monitoring & evaluation mechanism to track progress, help steer actions and transparently report and be accountable. A working M&E Framework was developed to track and evaluate key performance indicators in the implementation of CFI to show progress and identify gaps.

Monitoring and Mapping

Key to the initiative is the ability to identify and map different land use categories within the landscape and building on that to provide information on forests cover change, deforestation trends and forests conversion. In addition to these, identify deforestation hotspots, analyse the impact of deforestation on the landscape and provide risk map which will guide the implementation of forests interventions.

This will be delivered by the National Forest Monitoring System under Forestry Commission, which is work in progress. Meanwhile, CFI signatories need access to up to date landcover maps and the initiative needs to track deforestation and reforestation. To that purpose, in June 2022, the Oversight Committee approved for CFI to adopt and work with the existing land use maps produced

by Resource Management Support Centre (RMSC) under the Forest 2020 project and available on [Ghana Forest Compliance](#). This system gives access to reliable landcover maps, protected areas boundary shapefiles as well as assist in monitoring deforestation trends in CFI priority areas.

Access to Land Use Maps

Following the adoption of the RMSC produced maps by the Oversight Committee; the CFI National Secretariat organized a workshop bringing together CFI signatories to interact with the Mapping Unit of

RMSC. Subsequently an orientation was organized for the CFI signatories concerning the EOLAB system and explained how companies can gain access to the system. Thirteen company representatives in Ghana attended the program.

In addition, for the purpose of tracking, deforestation trends and progress reporting, CFI has identified the need to work closely with the Mapping Unit of RMSC. In the long-term, the CFI Oversight Committee should be provided with reliable and insightful reporting that can support decision making for investments and prioritization of actions in line with the JFA. To develop meaningful periodical reporting, the CFI National Secretariat, with funding through IDH, engaged the RMSC to develop landcover and landcover change maps for four epochs: 2019, 2020, 2021 and 2022 covering 6 Hotspot Intervention Areas (HIA) in the CFI intervention areas.

Cocoa Production in Ghana

Cocoa is the main cash crop in Ghana and occurs in the country's forested areas: Ashanti, Brong-Ahafo, Central Region, Eastern Region, Western Region, and Volta, where rainfall is 1,000-1,500 millimetres per year. These high rainfall areas cover the high tropical high forest zone where timber wildlife and other valuable natural resource occur. The crop year begins in October, when purchases of the main crop begin, with a smaller mid-crop cycle beginning in July. Cocoa has a long production cycle, far longer than many other tropical crops, and new hybrid varieties need over five years to come into production, and a further 10 to 15 years for the tree to reach its full bearing potential. Cocoa is planted either under forest trees or other crops which provide shade for the cocoa seedlings. It can be established under forests by thinning the forests to desirable shade levels this happens in the forest reserves. The common method for cocoa cultivation in Ghana outside the forest reserve is by interplanting the cocoa with plantain or any other crop that can provide shade at least for the first five to ten years until the cocoa attains height of about five meters. The early stages of cocoa growth are through agroforestry systems, therefore

to analysis the dynamics of cocoa growth through earth observation requires a period of not less than 10 years. This is the time the cocoa begins to form canopy which can be spectrally registered by the satellite image sensor.

Purpose of the Study

The study aims at providing spatial data and information for the all-CFI intervention to serve as basis to assess the performance of the intervention on the ground, and report on them appropriately. Conservation and sustainable use of forest resources in the high forests of Ghana to better balance increasing cocoa cultivation with forests protection is the primary aim of the CFI and to achieve this, data and information on the dynamic of the landscape is critical. Several cocoa management systems have been adopted to ensure cocoa is cultivated in an environmentally friendly manner. One of such initiatives is intercropping forest trees within cocoa farms to replace the monocrop (that is growing only cocoa) farming system. Furthermore, the study aims to identify gaps in terms of data, performance of the intervention and the appropriate remedial actions to ensure efficient use of resources under the CFI intervention which will feed into CFI monitoring and reporting starting with the 2022 annual report.

Scope of the Service

Develop landcover and landcover change map, change analysis from 2019 to 2022 deforestation rates for each HIA, landcover conversion, and transfers. Furthermore, analyse deforestation by drivers and location.

The study covered the six (6) Hotspot Intervention Areas (HIAs) in Ghana namely:

APPROACH



- | | |
|--|---|
| 1. Ahafo Ano South / Atwima Mponua / Atwima Nwabiagya (Ashanti Region) | 4. Bibiani / Anhwiaso / Sefwi Wiawso (Western North Region) |
| 2. Asunafo / Asutifi (Ahafo Region) | 5. Juabeso Bia (Western North Region) |
| 3. Atiwa / Denkyembour / East Akim (Eastern Region) | 6. Kakum (Central Region) |

Figure 1: Project Area (HIAs) Map

A desk review of existing data was carried out to assess the gaps in the data, this was followed up by satellite image download, processing and classification and analysis for the six (6) HIAs to generate land cover maps, which succinctly isolated the landcover categories and the respective coverage and extent for the four epochs. 2019, 2020, 2021 and 2022. The four epoch maps were subjected to change detection analysis to determine the landcover conversions and drivers of deforestation for all the 6 HIAs. Shapefiles (polygons) of protected areas and forest reserves were overlaid on the change maps for all the 6 HIAs to measure deforestation in and outside the forest reserve and protected areas as well as relate the deforestation to cocoa farming both within and outside protected (forest reserves and National parks). From the change detection analysis, the deforestation rates, degradation status and areas of carbon enhancement (forest gain) were identified and quantified both in terms of area and location. The dynamics of the cocoa management system i.e., to determine within the period the coverage of mono-cocoa and cocoa agroforestry system in other words the impact of CFI indicators on the cocoa management system. Using the outputs, a template/Logfile for reporting forest change has been developed to enhance reporting of CFI indicators and other relevant information for the Monitoring and Evaluation framework.

Forest risk map

The risk maps for all the HIAs were developed using the Hectare's Indicator Model. Drivers or factors of deforestation for the Ghana Cocoa Forest REDD+ Program (GCFRP) area that could be spatially mapped were identified and used for the forest risk mapping. These factors were accessibility, population dynamics, slope, history of deforestation and forest management practices. The factors were grouped into four categories namely, accessibility (A), cultivable value (C), extractable value (E) and protection status (U). All the risk factors were classified on a scale of 1 – 5 (risk levels) with low values representing areas with least vulnerability to forest loss due to cocoa cultivation and other human interventions. For the accessibility, 5 km buffer was created around all roads, footpaths, and logging trails. The forest within this buffer was classified as very high risk (5). Population density was developed using the clustering of community as a proxy. A higher community clustering represented dense population

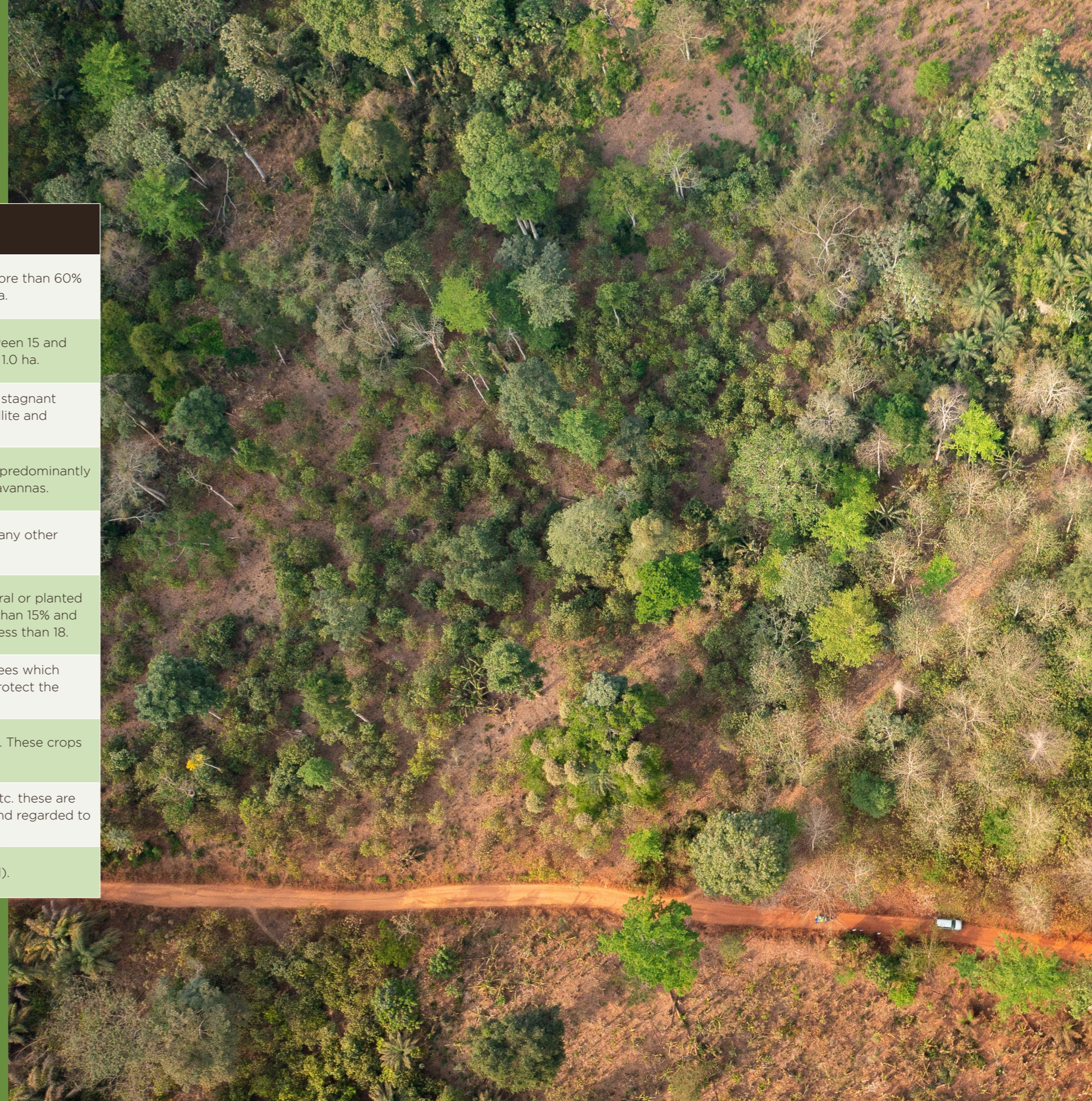
and vice versa. Forest at a high population density area was more vulnerable to deforestation than forest at low population area. The slope was developed using the contour map of the area and guided by policies on forest encroachment and watershed management. The slope map was classified to the 5 risk levels with slope greater than 30% as low risk (1). Deforestation hotspot map (history of deforestation) was developed from the change maps for each HIA for the period of this study. The deforested areas for each HIA throughout the study period was used to generate a deforestation hotspot map and classified into the 5 risk levels. Forest at high risk means that the forest cover meets all or most of the risk factors above. The forest management practices were grouped into on-reserve, off-reserve and river buffer. These were mapped using the protected areas and forest reserve boundaries, buffer of 30m and 50m around waterbodies and off-reserve areas. The river buffer, national and conservation areas were rated as very low risk (1), the forest reserve as low risk (2) and the off-reserve area as medium risk (3). The cultivate value (C) risk factors included conversion of forest to agriculture land whilst the extractable value (E) included forest conversion to mining and logging. The C and E risk factors were captured in the deforestation hotspot map. The risk map was produced by adding all the factors that lead to deforestation and subtracting the factors that enhance forest protection (Risk (R)=[A + C + E] - U). The output from this operation was reclassified to the 5 risk factors. The output from this was masked out using the forest class from the 2022 landcover map to get the forest risk map for each HIA.

Classification Scheme

The classification scheme (Table 1) used for this study was adopted from the United Nations Convention Framework on Climate Change (UNFCCC) based on Good Practice Guide (GPG 2003) and the Guidelines for Agriculture, Land Use and Forestry (GL-AFOLU 2006). The scheme was modified using the national definition of forest as basis by the RMSC of the Forestry Commission and the Faculty of Renewable Natural Resources (FRNR) of the Kwame Nkrumah University of Science and Technology (KNUST) to suit local condition. The forests / vegetation condition scoring developed by RMSC to measure the quality of forest was integrated in the classification.

Landcover	Description
Closed forest	Woody vegetation with canopy cover of more than 60% and minimum mapping unit (MMU) of 1.0 ha.
Open forest	Woody vegetation with canopy cover between 15 and 60% and minimum mapping unit (MMU) of 1.0 ha.
Water	River, stream, lake and pond and any other stagnant water large enough to be captured by satellite and mapped.
Grassland	Grass, bush, bamboo and shrubs these are predominantly found in fallow agriculture lands, and the savannas.
Settlement / Bare Surface	Built-up areas, mining sites gravel pits and any other surface without vegetation.
Full sun cocoa	Cocoa plantation with no or very little natural or planted trees. The trees do not form canopy more than 15% and the number of stems /trees per hectare is less than 18.
Shaded Cocoa	Cocoa plantation with natural or planted trees which form canopy of 15% and above. Shade to protect the plantation from direct sunlight.
Other Tree Crops	Oil palm, cashew, rubber, mango and citrus. These crops are regarded as agricultural crops.
Food Crops	Rice, maize, plantain, cassava, vegetables etc. these are crops grown and harvested within a year and regarded to provide food local consumption.
Mangrove	Mangrove stands (both natural and planted).

Table 1: Classification Scheme



Recommendations Ahafo Ano South, Atwima Mponua and Atwima Nwabiagya HIA

A significant portion of forest cover in the Ahafo Ano South, Atwima Mponua and Atwima Nwabiagya HIA are occur in forest and wildlife reserves. In the off-reserve areas of the HIA, remnant forest cover mainly occurs in the Ahafo Ano South District. The highest forest cover loss (deforestation rate of 0.08) was recorded from 2021 to 2022. Food crop cultivation is major driver of deforestation (63%) in the HIA. Bare areas have increased in the HIA and it is attributed to increase surface mining in the area. In view of this findings the following conservation measures are recommended in the HIA:

- Given that significant portion of forest cover in the Ahafo Ano South, Atwima Mponua and Atwima Nwabiagya HIA are found in forest and wildlife reserves. It is important to protect the conservation areas from activities contribute to forest degradation and deforestation.
- Conscious efforts are required conservate remaining forest cover in off reserve areas particularly in Ahafo Ano South District.
- Most croplands in most cases have low productivity. Given that conversion of large areas for food crop cultivation remains a challenge, it is important that agriculture technologies that improve productivity per unit need to promoted in the landscape to ensure there reduce the rate of conversion of forest lands to agriculture.
- Livelihood programme that will provide alternative income to the communities should be introduce to reduce the pressure on the forest.

Landcover Maps for Ahafo Ano South, Atwima Mponua and Atwima Nwabiagya HIA

This HIA covers a total area of 365,188.88 ha. The HIA is made up of the Ahafo Ano South, Atwima Mponua and Atwima Nwabiagya political districts in the Ashanti region of Ghana. The cocoa and forest classes were the dominant landcover classes in this HIA throughout the study period. As expected, the forest cover dominated the forest and wildlife reserves whilst cocoa and other tree crop plantation dominated off-reserve areas. Forest cover at the off-reserve areas were concentrated at the northern part of this HIA (Ahafo Ano South District). The forest cover at the off-reserve areas were mostly open forest resulting from forest plantation and fallow areas. The other tree crops were mostly found at the eastern part of the HIA (mostly the border between Ahafo Ano South and Atwima Nwabiagya). Closed forest, mono cocoa and shaded cocoa reduced throughout the study period whilst food crop and settlement / bare surface increased (Figure 2). Open forest decreased for greater part of the study period but increased in the last year (2022).

In terms of landcover change and transfers (Table 2), the diagonal figures highlighted yellow represents the area in the landscape which remained unchanged. All figures above the diagonal represents loss and the figures below gain of one landcover to another. The area of closed forest converted to open forest was 1,882.77 ha which constitute forest degradation (cell highlighted red in Table 2). On the other hand, the cells highlight in green are areas closed forest gained (10,034.93 ha) constituting forest enhancement. Deforested areas are the cells shaded brown and these sum up to 16,581.78 ha. The deforestation rate for the study period was 0.04 annum or 4% with conversion to food crop being the major driver contributing 63% of the forest loss. It is important to state that bare surface increased throughout the study period. This could be attributed to increase surface mining in the area. Timber harvesting within the Tano Offin forest reserve and its environs might have accounted for the loss of forest cover for the period. The highest forest cover loss (deforestation rate of 0.08) was recorded from 2021 to 2022 with conversion to food crop being the major driver (80% of the forest conversion). The conversion of forest to food crops occurred mostly in the forest reserves.

Furthermore, the admitted settlement in Tano Offin has become a sprawling township with high population and commensurate high demand for land for agriculture leading to the implementation of the Modified Taungya System (MTS). The MTS is an agroforestry system where degraded portion of the forest reserve are given to individuals, group or community to cultivate food crop mainly plantain and integrate timber species into it. The forest conversion to food crop can also be early stage of cocoa plantation development where the cocoa seedlings are intercropped with plantain to provide shade for the seedlings. This early stage of cocoa plantation development is difficult to detect using earth observation approach since what will be captured by the satellite sensors will be the plantain and not the cocoa seedling. The highest conversion of forest cover to food crop was part of the reasons why other drivers of deforestation was higher than cocoa led deforestation throughout the study period. Another reason was that, with the exception of conversion to other tree crop, the rest of the conversion (food crop, settlement / bare surface, water and grassland) were immediate and did not take time to be detected by satellite sensors as it occurs in cocoa plantation. Deforestation at the off-reserve areas was higher than deforestation within the protected areas and forest reserves throughout the study period. This is expected because the forest cover within the protected areas and forest reserves is managed by state institution and therefore access and extraction of resources are regulated to ensure sustainable use of the resources. The forests at off-reserve areas are on lands belonging to individuals or communities who may decide to convert it at their convenience. This conversion results from the cocoa rehabilitation program (where the old cocoa is cut down for more improved and climate smart cocoa) or to actual food crop. This gain in open forest was from existing MTS. Grassland represented 1.28% in 2019 and increased to 2.29% in 2022. For the four-year period grassland appreciated by 1.01%. The increase is attributed to surface mining which denuded cover types to bear surface. The landcover type that suffered most conversion was mono cocoa and food crop.

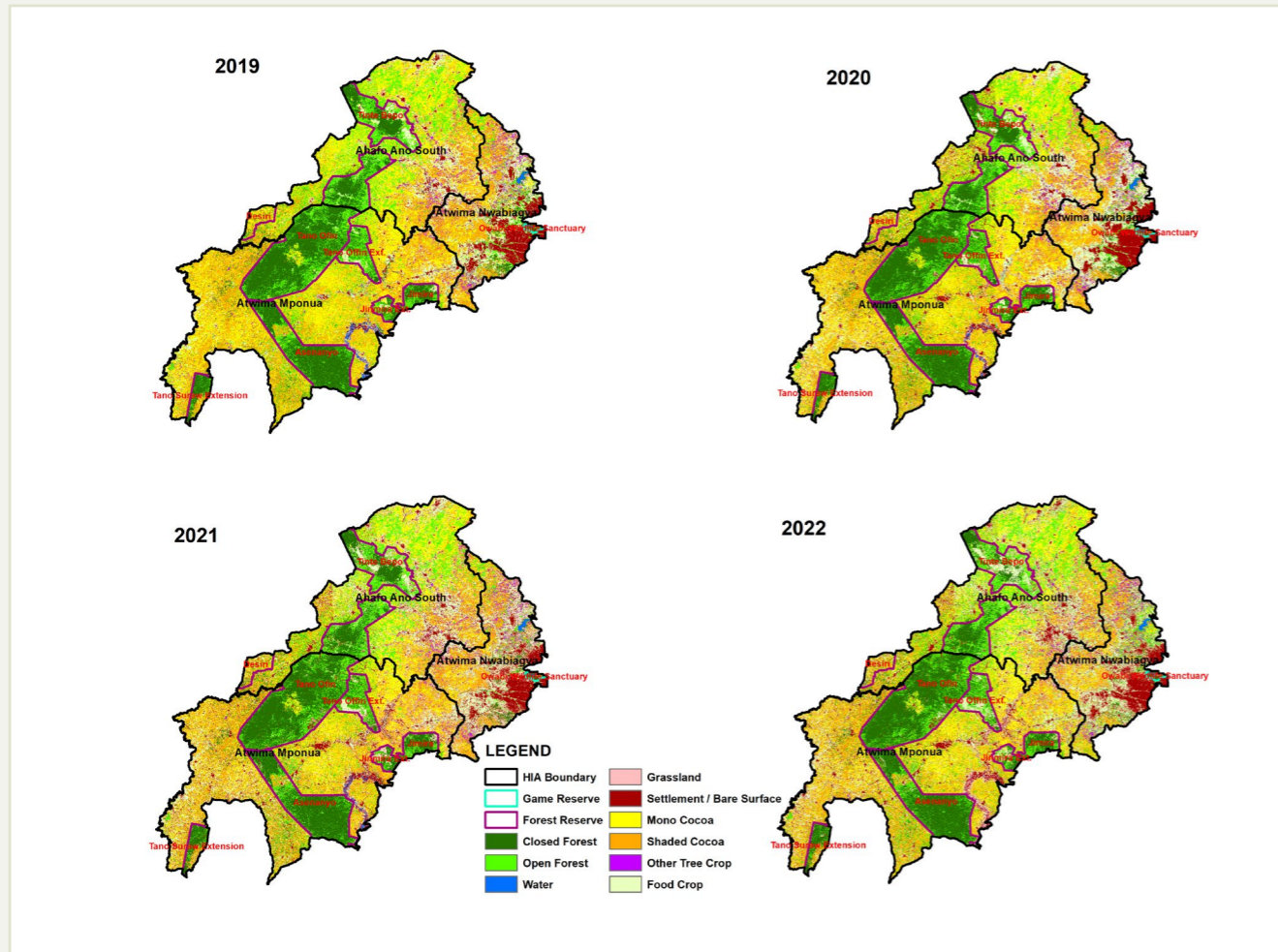


Figure 2: Landcover Maps for 2019, 2020, 2021 and 2022 Ahafo Ano South / Atwima Mponua / Atwima Nwabiagya

Drivers of deforestation



Deforestation location

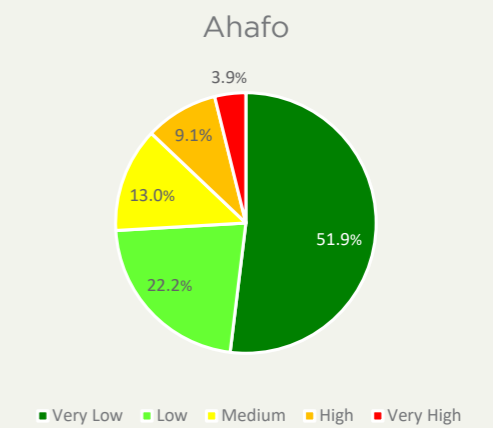
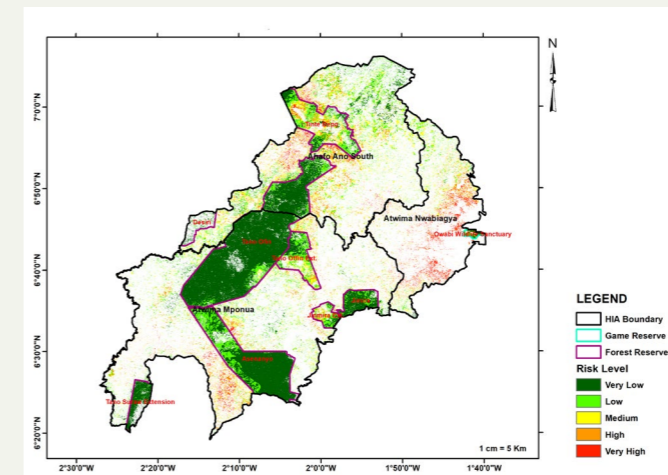
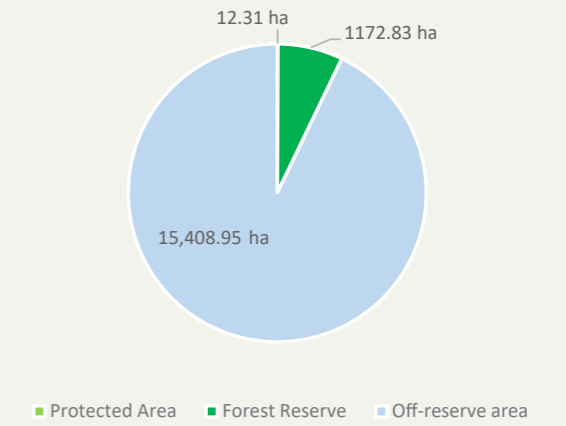


Figure 3: Risk map for Ahafo Ano South, Atwima Mponua and Atwima Nwabiagya HIA

Table 2: Landcover change Matrix for Ahafo Ano South HIA for 2019-2022

		Area (ha)									
		2022									
	Landcover	Closed Forest	Open Forest	Water	Grassland	Settlement / Bare Surface	Mono Cocoa	Shaded Cocoa	Other Tree Crop	Food Crop	Total
2019	Closed Forest	54,853.49	1,882.77	3.89	364.62	1,034.60	7.12	13.35	36.73	3,655.07	61,851.64
	Open Forest	607.43	51,946.99	15.47	618.8	3,541.07	112.89	349.01	30.55	6,798.61	64,020.82
	Water	1.01	1.38	371.12	376.88	644.21	1.23	5.49	0.15	75.72	1,477.19
	Grassland	24.1	242.61	15.37	648.29	2,642.42	61.8	31.25	13.16	1,002.74	4,681.74
	Settlement / Bare Surface	8.77	94.51	36.83	1,138.06	11,326.26	128.67	47.42	18.11	2,652.15	15,450.78
	Mono Cocoa	63.12	34.75	5.64	1,304.06	6,006.12	56,664.53	4,047.61	32.54	20,941.58	89,099.95
	Shaded Cocoa	20.02	1,383.92	15.43	1,298.95	2,280.48	1,996.43	62,962.80	29.1	11,082.21	81,069.34
	Other Tree Crop	60.52	46.34	0.75	123.27	478.4	14.74	17.01	8,147.09	1,377.24	10,265.36
	Food Crop	51.94	7,394.51	16.74	2,479.78	6,078.11	641.82	251.08	161.34	20,196.74	37,272.06
		Total	55,690.40	63,027.78	481.24	8,352.71	34,031.67	59,629.23	67,725.02	8,468.77	67,782.06

Recommendations Atiwa HIA

The HIA is dominated by forest and cocoa plantation. In this HIA, closed forest was more than open forest whilst in the cocoa plantation, agroforestry cocoa system was more than monoculture cocoa system. The forest cover dominated the forest reserves whilst the cocoa plantation, other tree crops and the rest of the landcover classes dominated the off-reserve areas. forest cover outside the protected areas is mainly open forest and occur at the edges of the HIA. The forest cover dominated the forest reserves whilst the cocoa plantation, other tree crops and the rest of the landcover classes dominated the off-reserve areas. Closed forest and other tree crops were fairly stable throughout the study period whilst open forest fluctuated. Agroforestry cocoa and monoculture cocoa were also fairly stable except 2021 where it reduced significantly. Food crop and cocoa plantation were the major drivers of deforestation contributing 39% and 29% respectively. The deforestation rate for the study period for this HIA was 2%. Settlement / bare surface increased from 9,298.73 ha to 13,603.20 ha. This could be attributed to settlement expansion resulting from population increase and surface mining. The rate of deforestation should be addressed in the landscape through various conservation strategies including:

- The remaining forest cover especially in conservation areas should be protected from conversion to cropland and other landcover by the Forestry Commission in collaboration with other stakeholders.
- Shaded cocoa is dominant in the HIA, however there are still remnant monoculture cocoa farmers, these farms should be encouraged to adopt agroforestry practices through incorporation of trees on their farms to make system more resilient and adaptive to the effects of climate change.
- Since most areas under food crop production in off reserve areas are in the long-term designed for cocoa and other tree crop production, it important these are targeted for climate smart agriculture.
- Settlement / bare surface increased from 9,298.73 ha to 13,603.20 ha. This was attributed to settlement expansion resulting from population increase and surface mining. Proper land use zoning could ensure that future demand for shelter due increased population are catered. There is the urgent need to facilitate a discussion to regularize and control small scale mining within the HIAs through the chiefs and the district assemblies.
- There is the need to address deforestation due to surface mining through law enforcement and rehabilitation of degraded areas. Areas within protected could be reforested while agricultural lands in off reserve areas could be rehabilitated using best practices for crop cultivation.

Landcover Maps for Atiwa HIA

This HIA is made up of the Atiwa, Denkyembour, and East Akim districts in the Eastern Region of Ghana. It covers an area of 211,161.99 ha. The HIA encompasses the Atiwa Range and Extension Forest reserves and parts of Esukawkaw, Ayiola Nsuanza and Worobong South (Ashanti Akim portion) forest reserves. From the landcover map (Figure 5) and associated area attribute, the forest cover and cocoa plantation dominated this HIA throughout the study period. In this HIA, closed forest was more than open forest throughout the study period whilst for the cocoa plantation, agroforestry cocoa system was more than monoculture cocoa system in the same period. The forest cover dominated the forest reserves whilst the cocoa plantation, other tree crops and the rest of the landcover classes dominated the off-reserve areas. The forest cover at the off-reserve areas was mainly open forest and found at the edges of the HIA (Figure 5). The other tree crops mainly oil palm resulted from large scale plantation as observed in Figure 5. Closed forest and other tree crops were fairly stable throughout the study period whilst open forest fluctuated. Agroforestry cocoa and monoculture cocoa were also fairly stable except 2021 where it reduced significantly. The food crop increased significantly in 2021 but was relatively stable for the rest of the years.

The landcover conversion for 2019 and 2022 (Table 3). The diagonal figures highlighted yellow represents the area in the landscape which remained unchanged. All figures above the diagonal represents loss and the figures below gain of one landcover to another. The area of closed forest converted to open forest was 1,572.79 ha which constitute forest degradation (cell highlighted red, Table 3). The cells highlighted green represent forest gained (forest enhancement) which was 2,856.30ha. Deforested areas are the cells shaded brown and these sum up to 4,233.40 ha. Throughout the study period, food crop and cocoa plantation were the major drivers of deforestation contributing 39% and 29% respectively. The deforestation rate for the study period for this HIA was 0.02 ha / annum or 2%. The highest deforestation rate was recorded from 2020 to 2021 (0.09) with cocoa plantation being

the major driver (40% by agroforestry cocoa and 21% by monoculture cocoa). This conversion was caused by tree removal (pruning and logging) from highly shaded agroforestry cocoa leading to canopy openings. As indicated earlier, the dominant landcover in this HIA is agroforestry cocoa. The highly shaded cocoa areas appear as open forest and to some extent closed forest. Tree removal from these farms lead to significant canopy opening exposing the cocoa tree beneath. The satellite sensor capturing this change led to conversion of forest cover to agroforestry cocoa. The cocoa led deforestation dominated the drivers of deforestation for the early part (2019 to 2021) of the study period. This was taken over by other drivers (surface mining and conversion to other tree crops) for the remaining part of the study period (2021–2022). Deforestation in the Atiwa HIA was higher in the protected areas than the forest reserves. It is important to note that Atiwa Range and Apedwa which constituted protected areas for this HIA are forest reserves under protection and not national parks where entering restricted. Deforestation within the off-reserve areas was higher than both the protected areas and forest reserve. This means that there was more forest loss outside protected areas and forest reserves throughout the study period. This was attributed to private ownership of lands outside the protected areas which makes it difficult to control the use of the land.

Throughout the study period 13% of the cocoa plantation was converted (Table 3). The major driver for this conversion was food crop contributing 49% (Table 3). This conversion resulted from the cocoa rehabilitation program (where the old cocoa is cut down for more improved and climate smart cocoa), food crop or other tree crops. Settlement / bare surface increased from 9,298.73 ha to 13,603.20 ha. This could be attributed to settlement expansion resulting from population increase and surface mining. Grassland represented 1.63% in 2019, reduced to 1.11% in 2022 for the four years. Food crops cultivation increased from 4,128.57 ha representing 1.96% to 13,305.31 ha representing 6.30%.

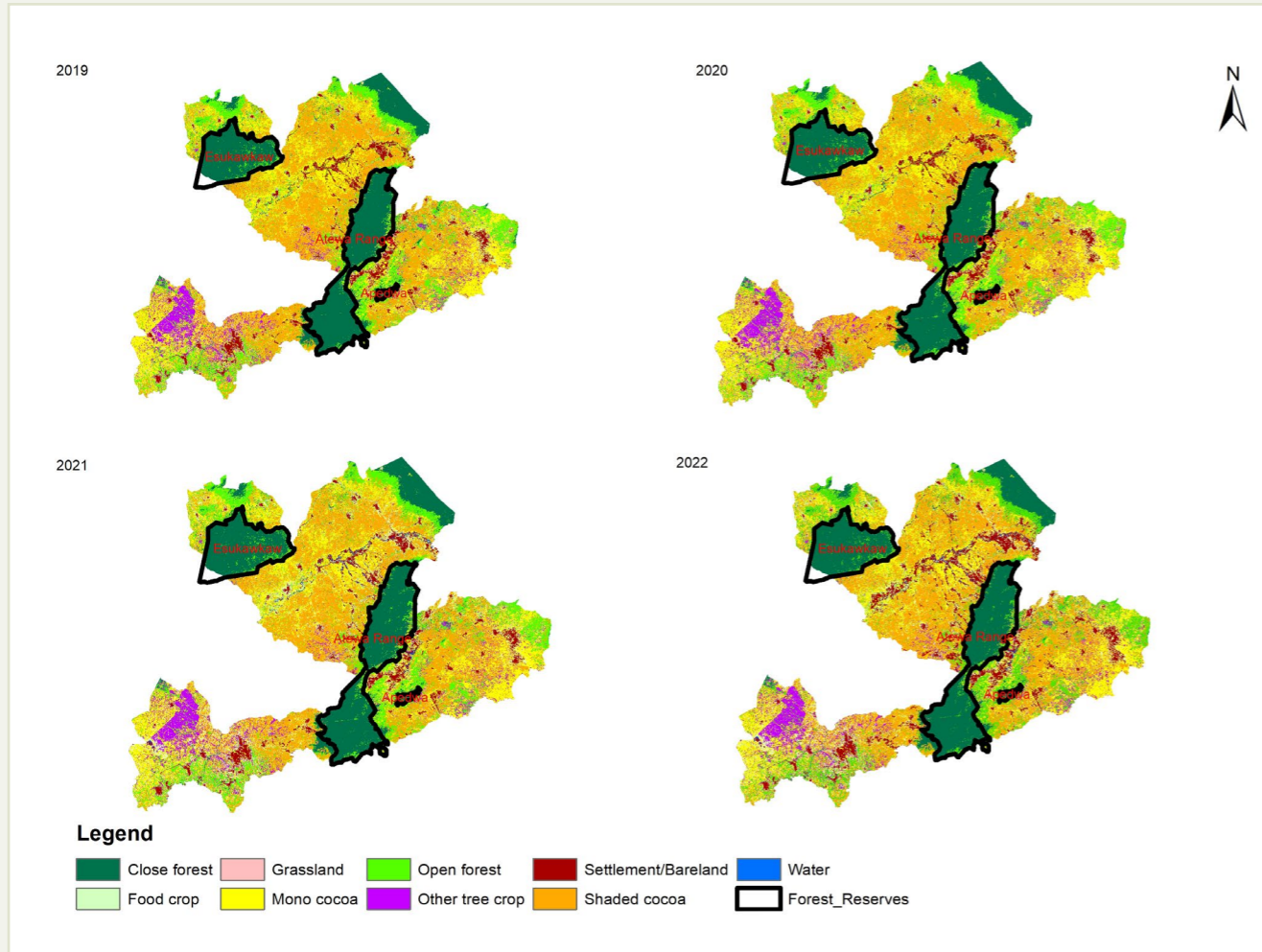


Figure 4: Landcover maps for 2019, 2020, 2021 and 2022 - Atiwa / Denkyembour / East Akim

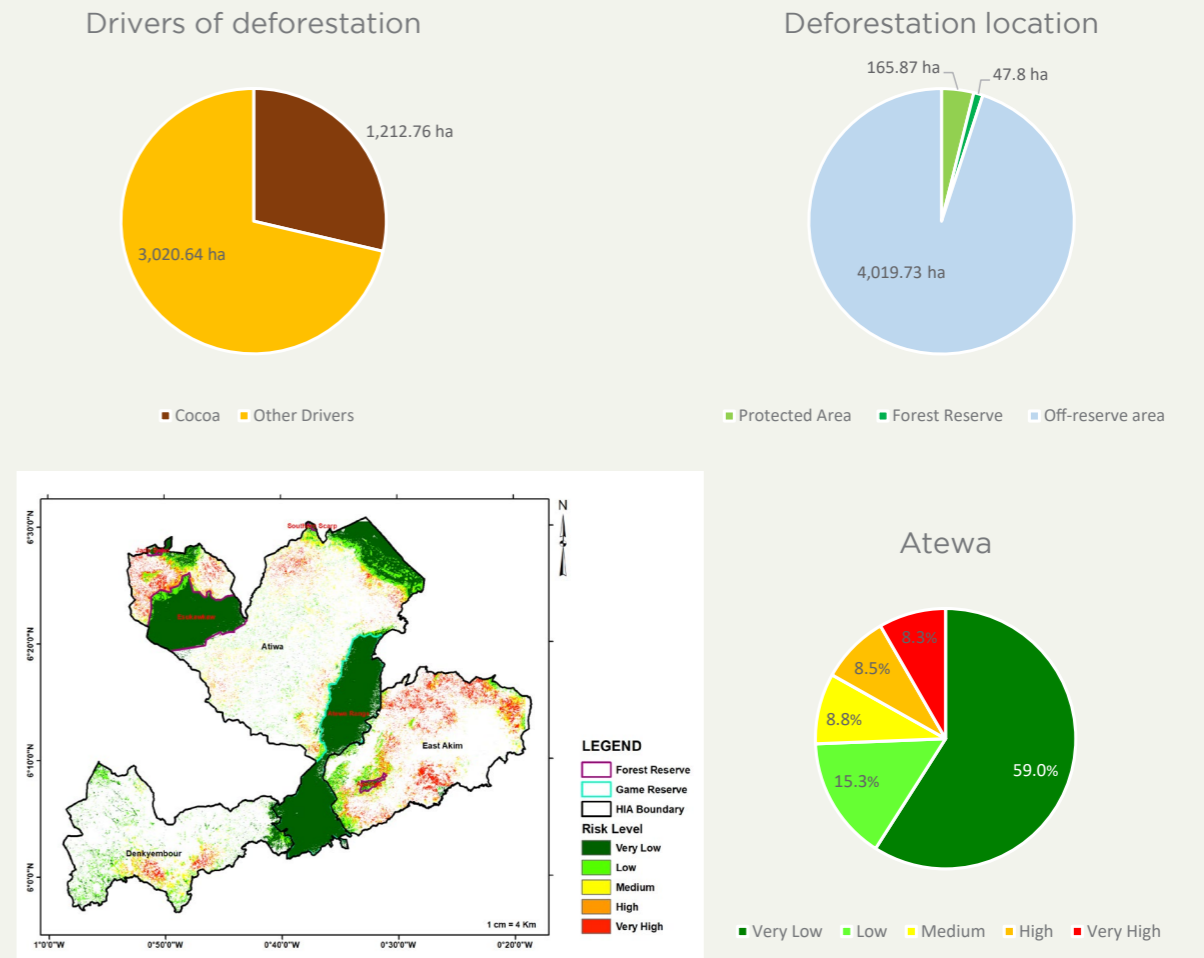


Figure 5: Forest risk map for Atiwa HIA

Table 3: Landcover change Matrix for Atiwa / Denkyembour / East HIA for 2019-2022

		Area (ha)									
		2022									
	Landcover	Closed Forest	Open Forest	Water	Grassland	Settlement / Bare land	Mono Cocoa	Shaded Cocoa	Other Tree Crops	Food crops	Total
2019	Closed Forest	38,026.37	1,572.79	1.53	28.09	17.43	242.59	359.53	89.96	30.49	40,368.78
	Open Forest	729.8	28,227.33	81.61	119.39	602.31	214.57	396.07	443.46	1,606.37	32,420.91
	Water	1.11	17.65	196.94	10.77	90.3	38.24	24.63	15.02	40.88	435.54
	Grassland	26.61	124.92	19.36	1,572.09	316.24	213.68	140.75	88.91	946.62	3,449.18
	Settlement/Barelands	1.73	43.96	435.3	57.61	8,147.62	174.06	50.05	26.18	362.22	9,298.73
	Mono Cocoa	219	232.2	86.67	205.73	1,886.57	38,741.90	727.08	850.45	3,787.75	46,737.35
	Shaded Cocoa	243.93	586.77	58.83	168.61	1,869.30	586.75	55,290.69	720.85	2,997.72	62,523.45
	Other Tree Crops	56.28	410.97	25.59	88.55	145.02	764.6	596.76	8,878.49	833.22	11,799.48
	Food crops	18.24	143.13	16.4	92.75	528.41	358.41	174.17	97.02	2,700.04	4,128.57
		Total	39,323.07	31,359.72	922.23	2,343.59	13,603.20	41,334.80	57,759.73	11,210.34	13,305.31

Recommendations Bibiani / Anhwiaso / Sefwi Wiawso HIA

The HIA is covered by closed forest, open forest grassland, water, settlement / bare surface mono cocoa, shaded Cocoa, other tree crops and food crops. The dominant landcovers in HIA is cocoa plantation especially the monoculture cocoa (41.97%). Shaded cocoa or climate smart cocoa is however, increasing within the HIA. With the exception of food crop, the rest of the landcover classes were relatively stable with very marginal increase or decrease. Conversion to food crop was the major driver contributing to deforestation.

- The remaining closed forest cover particularly in conservation areas should be protected against encroachment by the Forestry Commission in collaboration with other stakeholders.
- Degraded areas in forest reserves and protected areas should be reforested using various restoration method depending on the level of degradation.
- Mono crop cocoa is dominant in the HIA and shaded cocoa remained fairly stable throughout the study period. Farmers be educated on the importance of the adoption of agroforestry practices through incorporation of trees on their farms to make such systems more resilient and adaptive to the effects of climate change.
- Since a significant portion of the HIA is under food crop production in the off reserve areas and are in the long-term designed for cocoa and other tree crop production, it important these are targeted for the promotion of agroforestry and conservation agricultures practices.
- The deforestation rate for this HIA was low, however, there still the need step-up efforts to bring the rate lower than the current rate.

Landcover Maps for Bibiani / Anhwiaso / Sefwi Wiawso HIA

The Bibiani / Anhwiaso / Sefwi Wiawso HIA covers an area of 184,337.40 ha and is located in the Western North Region of Ghana. This HIA is made up of the Bibiani Anhwiaso Sefwi Bekwai and Sefwi Wiawso political districts. The HIA encompasses the Muru, part of Sui River, Tano Suraw, Tano Suraw Extension, Anhwiaso West, Anhwiaso East, Upper Wassaw and part of Suhuma forest reserves. From the image analysis, (Figure 7) closed forest, open forest grassland, water, settlement/bare surface mono cocoa, shaded cocoa, other tree crops and food crops were identified and mapped for the 2019 and 2022 epochs. With the exception of the food crop class, the rest of the landcover classes were relatively stable with very marginal increase or decrease throughout the study period. The dominant landcovers in HIA throughout the study period were cocoa plantation especially the monoculture cocoa (41.97%) and forest. Shaded cocoa had a spatial extent of 26,588.6 ha representing 14.42% in 2019. In 2022 the mono cocoa decreased in extent to 74,137.91 ha representing 40.22% of the landscape. Similarly, the shaded cocoa decreased marginally to 26,567.61 ha representing 14.41%, The net decrease in the mono cocoa and shaded cocoa were 1.75% and 0.01% respectively.

With respect to the forest class, the open forest was dominant over the closed forest. Whereas, the open forest represented 21.38% of the landscape, the closed forest was 11.64% in 2019. In 2022, the open forest increased marginally to 39,925.81 ha. Conversely, the closed forest decreased marginally to 21,063.27 representing 11.43%. The net change in closed and open forest were 0.21 decrease for closed forest and 0.28 increase in open forest. Food crops as usual increased significantly from 3,564.34 ha representing 1.93% to 7,300.71 ha representing 3.96%. As indicated above, the early stages of cocoa cultivation are registered as food crops because of the intercropping of food crops to provide shade to the cocoa seedlings. The study has further revealed another driver of deforestation which is surface mining which has gained prominence in the landscape and this is likely going to change the narrative for drivers of deforestation in the near future.

In terms of landcover change, conversions and transfers (Table 4), the diagonal figure highlighted yellow represents the area in the landscape which remained unchanged. All the figures above the diagonal are represents losses from their original cover types and those below the diagonal represents gains. The area of closed forest converted to open forest 349.56 ha which is shown in the cell marked red, constituted forest degradation based on forest canopy closure. It is instructive to state that because forest degradation is a complex phenomenon which is difficult to quantify, in this study only canopy closure was used as a proxy to measure forest degradation. On the other hand, the cells highlighted green are areas where forest gained which is 1,519.64 ha constituting forest enhancement. Deforested areas are the cells shaded brown and these sum up to 1,058.99 ha. The deforestation rate for this HIA was 0.006 / annum or 0.6% for the period under consideration. Conversion to food crop was the major driver contributing 65% of deforestation within the study period (2019–2022). This is attributed to the fact that food crop is the immediate conversion of forest cover. This was followed by conversion to cocoa plantation which contributed 24% of the forest loss in this HIA. Conversions from closed forest to mono cocoa was 61.24 ha and to shaded cocoa was 19.97 ha. Open forest to mono cocoa was 23.35 ha and 144.38 ha for shaded cocoa. The relative stability of the forest cover was the reason why the lowest deforestation rate was recorded in this HIA. In this HIA, cocoa led deforestation was relatively high as compared to other HIA (Ahafo and Asunafo). With the exception of the 2020–2021 and 2019–2022 epochs, cocoa led deforestation was higher than the other drivers put together in the remaining epochs. Deforestation in this HIA was higher in the forest reserves than off-reserve areas in 2020–2021 and 2019–2022 epochs. Other conversion are the cells shaded pink and they add up to 5,639.64 ha.

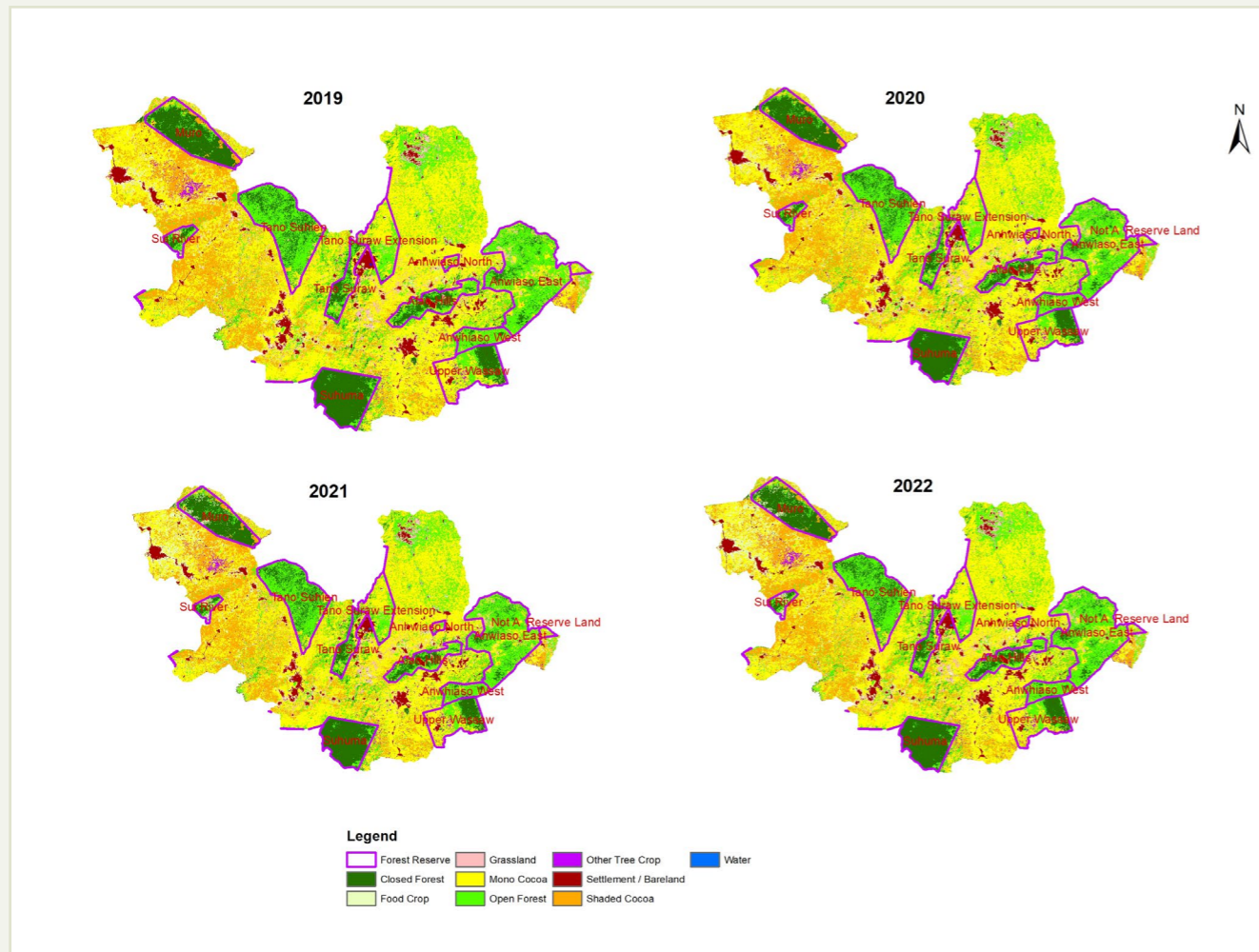
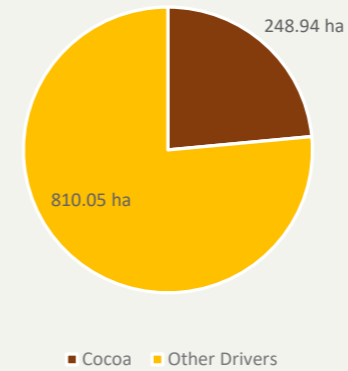


Figure 6: Landcover aps for 2019, 2020, 2021 and 2022 - Bibiani / Anhwiaso / Sefwi Wiawso - HIA

Drivers of deforestation



Deforestation location

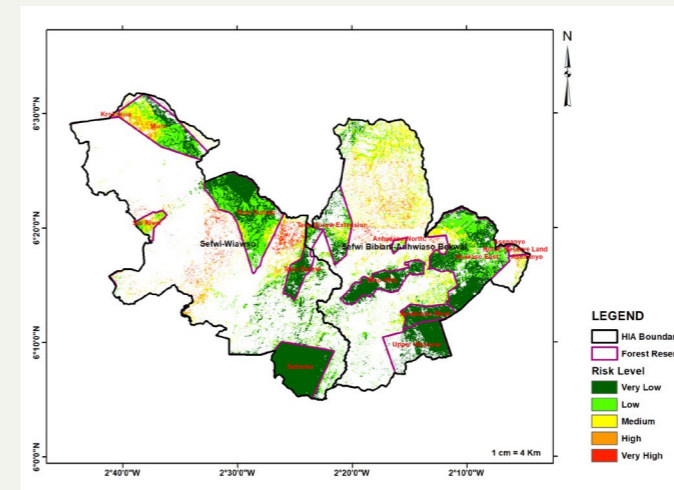
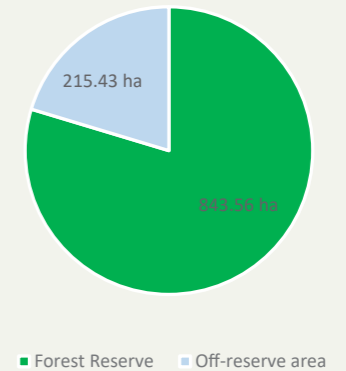


Figure 7: Forest Risk Map for Bibiani / Anhwiaso / Sefwi Wiawso HIA

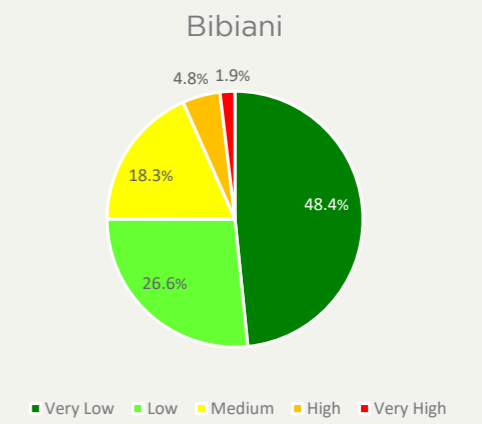


Table 4: Landcover change Matrix for Bibiani / Anhwiaso / Sefwi Wiawso HIA for 2019-2022

		Area (ha)									
		2022									
	Landcover	Closed Forest	Open Forest	Water	Grassland	Settlement/Bare land	Mono Cocoa	Shaded Cocoa	Other Tree Crops	Food crops	Total
2019	Closed Forest	20,603.81	349.56	0.06	25.70	4.64	61.24	19.97	0.06	389.50	21,454.54
	Open Forest	341.88	38,516.07	0.10	92.85	3.87	23.35	144.38	0.69	292.58	39,415.77
	Water	0.10	0.23	33.42	2.34	5.17	1.38	0.14		0.57	43.35
	Grassland	33.05	99.40	2.24	7,297.81	44.12	261.63	59.17	0.22	671.06	8,468.70
	Settlement/Barelands	3.22	5.35	4.71	38.49	6,121.48	30.03	5.22		13.69	6,222.19
	Mono Cocoa	58.67	794.03	3.28	264.91	104.48	73,023.04	714.55	2.06	2,399.50	77,364.52
	Shaded Cocoa	19.44	143.97	0.24	61.38	23.17	669.70	25,600.26	4.78	65.66	26,588.60
	Other Tree Crops	0.42	0.78		0.05	0.41	2.23	4.21	1,156.44	50.88	1,215.42
	Food crops	2.68	16.42	0.35	35.78	6.79	65.31	19.71	0.03	3,417.27	3,564.34
		Total	21,063.27	39,925.81	44.40	7,819.31	6,314.13	74,137.91	26,567.61	1,164.28	7,300.71

Recommendations Juabeso-Bia HIA

The HIA is covered by closed forest, open forest grassland, water, settlement / bare surface mono cocoa, shaded Cocoa, other tree crops and food crops. The dominant landcovers in HIA is cocoa plantation especially the monoculture cocoa compared to shaded cocoa. There has been a decline in the area under monoculture cocoa and climate smart cocoa. The deforestation rate for the period for the HIA is 3% with food crop being a major driver (84%) of deforestation. The following actions are recommended:

- The remaining closed forest cover particularly in conservation areas should be safeguarded encroachment by the Forestry Commission in collaboration with other stakeholders. Forest cover including other areas of conservation value including sacred grove could be conserved through strengthening traditional conservation measures.
- The degraded areas in forest reserves and protected areas should be reforested using accepted restoration method depending on the level degradation.
- Mono crop cocoa is very dominant in the HIA. It is also obvious that areas under shaded cocoa and mono crop cocoa are both declining in the landscape. Future efforts should strengthen existing programmes aimed increasing shaded cocoa in the landscape relative to cocoa monocrop production. For such efforts to yield a positive result. Farmers be educated on the importance of the adoption of agroforestry practices through incorporation of trees on their farms to make such systems more resilient and adaptive to the effects of climate change.
- Since a significant in the HIA is under food crop production in off reserve areas and are in the long-term designed for cocoa and other tree crop production, it important these are targeted for the promotion of agroforestry and conservation agricultures practices. It is also important to indicate that some of the areas are under MTS and therefore could contribute reforestation in conservation areas.

Landcover Maps for Juabeso - Bia West HIA

The Juabeso Bia West HIA has a total area of 265,334.62 ha and is made up of the Juabeso and Bia West political districts of the Western North Region of Ghana. The HIA includes the Bia North, Krokosua Hills forest reserves and Bia National Park. Spatial and temporal image analysis for the 2019 and 2022 epochs (Table 11) showed that the landcover is made up of Closed Forest, Open Forest, Grassland, Water, Settlement / Bare surface, Mono Cocoa, Shaded Cocoa, Other Tree crops and Food crops. The dominant landcover in the HIA was mono cocoa which covered an area of 106,369.6 ha representing 40.1% in 2019 and reduced to 86,579.91 ha representing 32.6% in 2022. Shaded cocoa which covered 25,786.22 ha representing 9.7% in 2019 reduced to 18,772.42 ha representing 7.1%. The net loss in mono and shaded cocoa for the period were 7.5% and 2.6% respectively. Closed forest was 92,291.7 ha representing 34.78% in 2019 and reduced to 83,132.06 ha representing 31.3% of the landscape. Open forest had spatial extent of 28,763.31 ha representing 10.80% in 2019 and decreased to 27,471.39 ha representing 10.35%. The net decrease in the closed and open forest categories were 3.45 and 0.49% respectively. Food crops increased significantly from 6,479.93 ha (2.4%) in 2019 to 42,111.22 ha representing 15.87%. The drastic increase in food crop within the study period was due to the fact it was the major driver of landcover conversion especially cocoa plantation and forest.

This reflects the methods of cocoa cultivation in Ghana where the cocoa is interplanted with food crops in the early stages to provide shade as a result it is being captured as food crops.

For the landcover change, conversions and transfers (Table 5), the diagonal figures shaded yellow signifies the areas in the landscape which remained unchanged. All the figures above the diagonal are denote losses from their original cover types and those below the diagonal indicate gains. The area of closed forest converted to open forest was 8,749.27 ha which is shown in the cell marked red, constitutes forest degradation based on forest canopy closure. On the other hand, the cells highlight in green are areas closed forest gained which constitute forest enhancement. Deforested areas are the cells shaded brown and these sum up to 11,074.29 ha. The deforestation rate for the period for the HIA was 0.03 / annum or 3%. As in the previous HIA, food crop was the major driver (84%) of deforestation for this HIA within the study period. For the short period food crop is the immediate conversion either for cocoa plantation or MTS. Conversions from closed forest to mono cocoa was 75.32 ha and to shaded cocoa was 51.37 ha and open forest to mono cocoa 116.33 ha and 836.03 ha to shaded cocoa. Other conversion are the cells shaded pink and they add up to 33,928.35 ha.

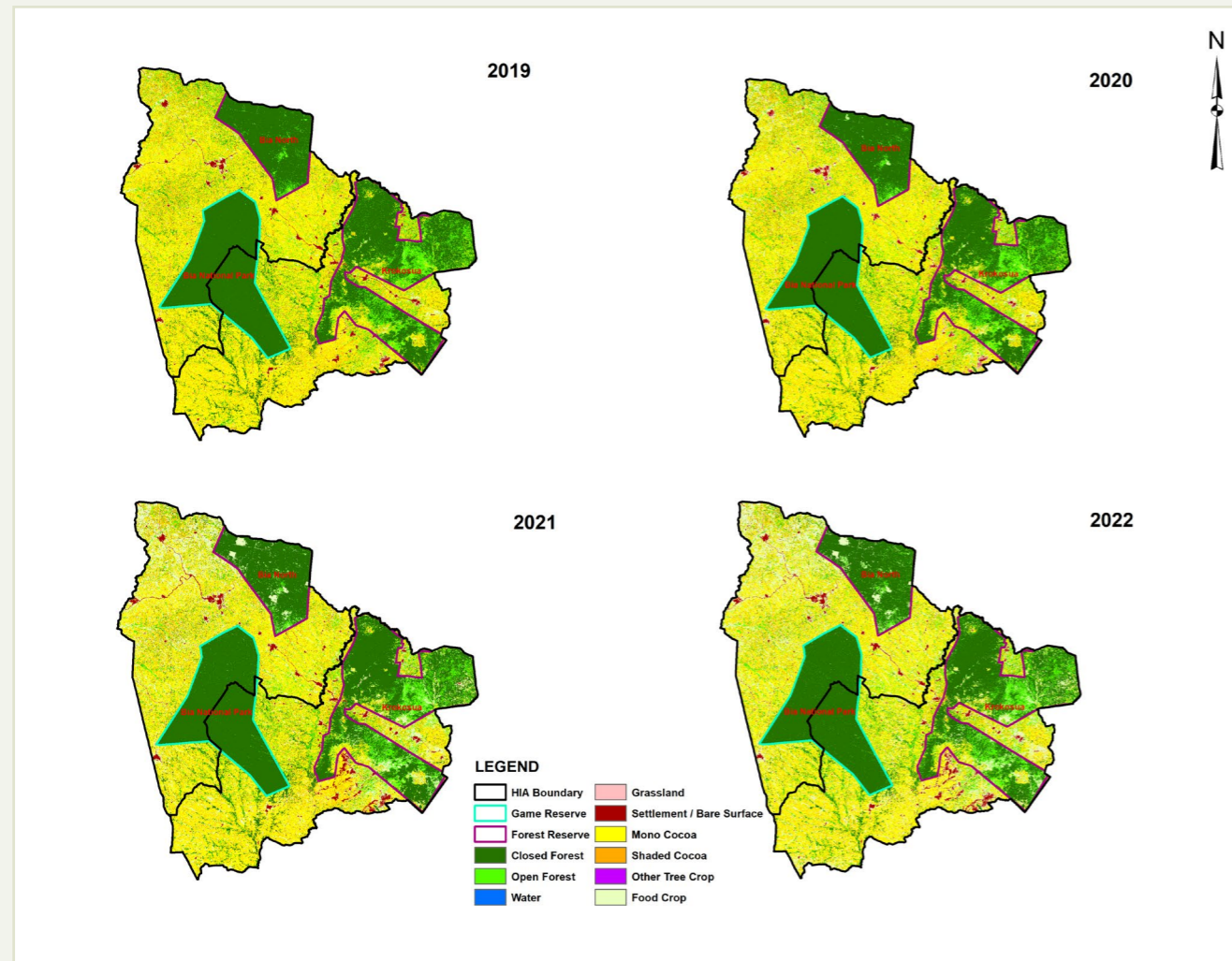


Figure 8: Landcover Maps for 2019, 2020, 2021 and 2022 - Juabeso Bia West HIA

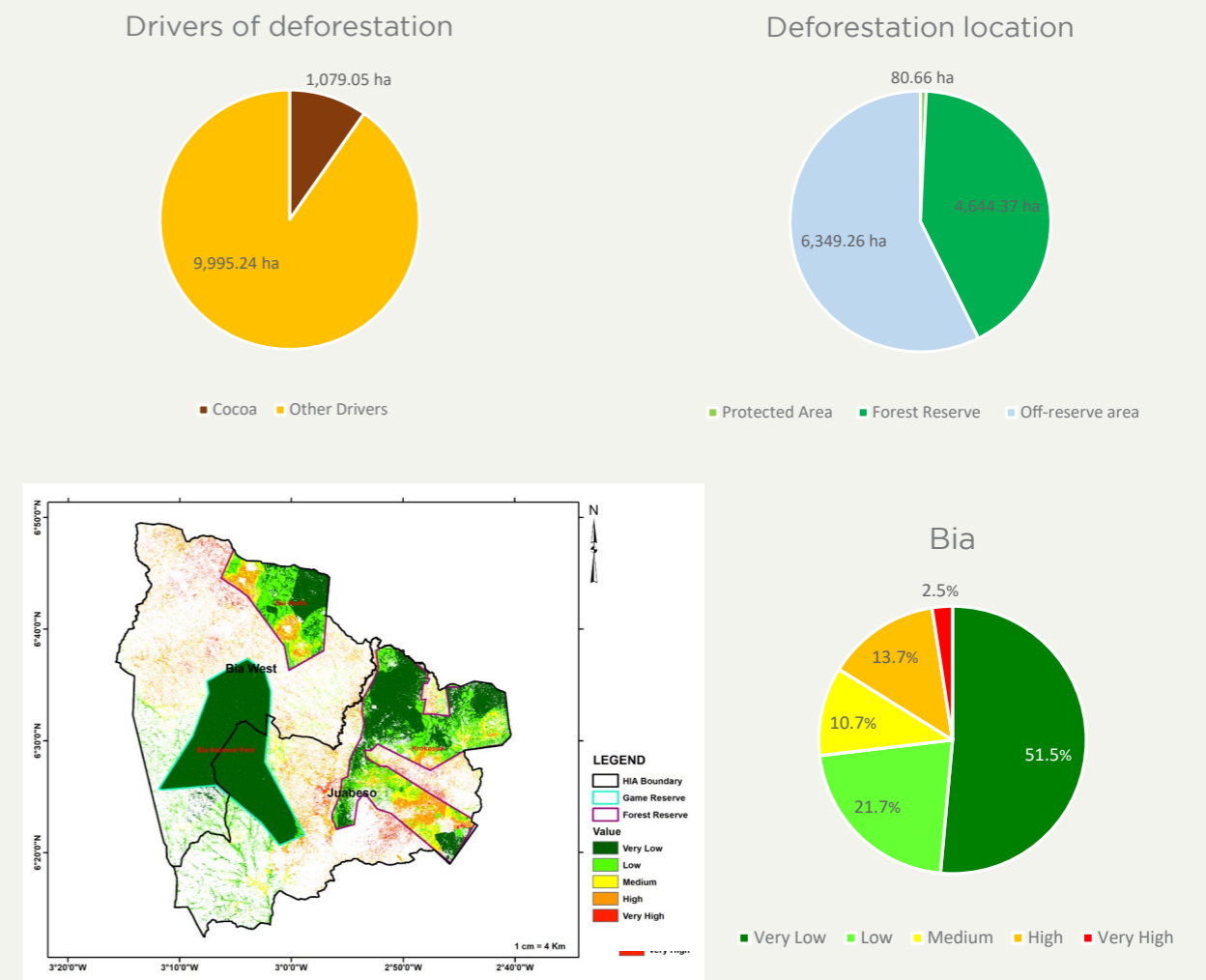


Figure 9: Forest Risk Map for Juabeso Bia West HIA

Table 5: Landcover conversion matrix for 2019-2022 for Juabeso Bia West HIA

		Area (ha)									
		2022									
	Landcover	Closed Forest	Open Forest	Water	Grassland	Settlement / Bare Surface	Mono Cocoa	Shaded Cocoa	Other Tree Crop	Food Crop	Total
2019	Closed Forest	80,750.11	8,749.27	-	43.59	37.70	75.32	51.37	26.64	2,557.70	92,291.70
	Open Forest	2,358.06	18,123.28	0.03	397.57	156.47	116.33	836.03	69.26	6,706.28	28,763.31
	Water	0.04	1.35	22.59	2.21	8.68	0.55	0.01	-	0.62	36.05
	Grassland	1.14	11.90	-	172.00	70.82	4.77	37.97	27.96	1,203.98	1,530.54
	Settlement / Bare Surface	6.22	9.95	0.04	239.84	2,656.88	2.14	7.70	4.65	702.53	3,629.95
	Mono Cocoa	3.86	177.29	-	576.35	564.81	83,706.38	453.57	13.30	20,873.99	106,369.55
	Shaded Cocoa	11.39	378.06	0.06	499.42	130.33	2,659.45	17,378.92	26.92	4,701.67	25,786.22
	Other Tree Crop	0.29	6.98	-	1.71	0.67	1.47	2.06	430.75	3.44	447.37
	Food Crop	0.95	13.31	0.01	544.13	493.50	13.50	4.79	48.73	5,361.01	6,479.93
		Total	83,132.06	27,471.39	22.73	2,476.82	4,119.86	86,579.91	18,772.42	648.21	42,111.22

Recommendations Kakum HIA

The HIA is covered by closed forest, open forest grassland, water, settlement / bare surface mono cocoa, shaded Cocoa, other tree crops and food crops. The dominant landcovers in HIA is cocoa plantation especially the monoculture cocoa (27%) compared shaded to cocoa. However, shaded cocoa is increasing in HIA. The deforestation rate for the period for the HIA is 2% with food crop being a major driver of deforestation. The following actions are recommended. The rate of deforestation should be addressed in the landscape through various conservation strategies including:

- The remaining closed forest cover particularly in conservation areas should be safeguarded encroachment by the Forestry Commission in collaboration with other stakeholders. Forest cover including other areas of conservation value including sacred grove could be conserved through strengthening traditional conservation measures.
- Degraded areas in forest reserves and protected areas should be reforested using various restoration method depending on the level degradation.
- Mono crop cocoa is very dominant in the HIA. It is also obvious that shaded cocoa is gaining grounds in the landscape. Future efforts should strengthen existing programmes aimed increasing shaded cocoa in the landscape relative to cocoa monocrop production. Farmers be educated on the importance of the adoption of agroforestry practices through incorporation of trees on their farms to make such systems more resilient and adaptive to the effects of climate change.
- Since a significant in the HIA is under food crop production in off reserve areas and are in the long-term designed for cocoa and other tree crop production, it important these are targeted for the promotion of agroforestry and conservation agricultures practices.
- There is the need to address deforestation due to surface mining through law enforcement and rehabilitation of degraded areas. Areas within protected could be reforested whiles agricultural lands in off reserve areas could be rehabilitated using best practices for crop cultivation.
- There is the need to address deforestation due to surface mining through law enforcement and rehabilitation of degraded areas. Areas within protected could be reforested whiles agricultural lands in off reserve areas could be rehabilitated using best practices for crop cultivation.

Landcover Maps for Kakum HIA

The Kakum HIA which covers a total area of 210,622.16 ha is located in the Central Region of Ghana. It is made up of Assin North and South districts. It has a project in place running which is known as Kakum Cocoa Agroforestry Project which is under the GCFRP. The HIA encompasses the Kakum National Park, Ajenjua, Krochua, Bimpong, Ochi Head Waters and Assin Atandaso forest reserves. From the analysis for the 2019 and 2022 epochs, Closed Forest, Open Forest Grassland Water, Settlement/Bare surface Mono Cocoa, Shaded Cocoa, Other Tree crops and Food crops were mapped. The dominant landcover in the HIA is Mono cocoa covering 56,594.69 ha representing 26.87% of landscape. Shaded cocoa followed with spatial extent of 50,674.27 ha representing 24.1%, in 2019. In 2022, the mono cocoa decreased in extent to 52,654.37 ha representing 25% of the landscape. Likewise, the shaded cocoa also decreased to 47,868.46 ha representing 22.7%. The net decrease in the mono cocoa and shaded cocoa were 1.87% and 1.3% respectively. The forest class within this HIA remained fairly stable in the study period with slight reduction.

Between the forest class, closed forest was dominant compared to the open forest. Whereas, the closed forest covered 36,767.12 ha representing 17.5% of the landscape in 2019 it reduced to 36,106.2 ha (17.14% of the landscape) in 2022. Open Forest covered 17,256.64 ha representing 8.19% of the total area in 2019 and reduced to 16,697.29 (7.93%) ha in 2022. The net change (reduction) in closed and open forest were 0.31% and 0.27% respectively.

Food crops increased significantly from 12,582.51ha representing 5.97% to 20,703.98 ha representing 9.83% within the study period. About 66% of the gain in food crop were conversions of cocoa plantation (Table 6). As explained, these areas represent cocoa growing areas under rehabilitation. The study further revealed that other drivers including surface mining are becoming very prominent and this is likely going to change the narrative for drivers of deforestation in the near future. Concerning the landcover change, conversions and transfers (Table 6), the figures in the diagonal highlighted yellow represents the area in the landscape which remained unchanged. All the figures above the diagonal are representing losses from their original cover types and those below the diagonal representing gains. The area of closed forest converted to open forest of 896.48 ha shown in the cell marked red, constitutes forest degradation based on forest canopy closure. This could be attributed to timber harvesting. On the other hand, the cells highlight in green are areas closed forest gained which was 1,304.37 ha constituting forest enhancement. Deforested areas are the cells shaded brown and these sum up to 2,453.72 ha. The deforestation rate for the period for the HIA is 0.02 or 2%. Food crop remained the major driver contributing 55% of forest loss in this HIA within the study period. Cocoa plantation also contributed significantly by 21% to forest loss. Conversions from closed forest to mono cocoa was 8.50 and to shaded cocoa was 28.94. Other the hand open forest to mono cocoa was 497.16 ha and to shaded cocoa 116.51 ha. Other conversions are the cells shaded pink and they add up to 12,762.87 ha.

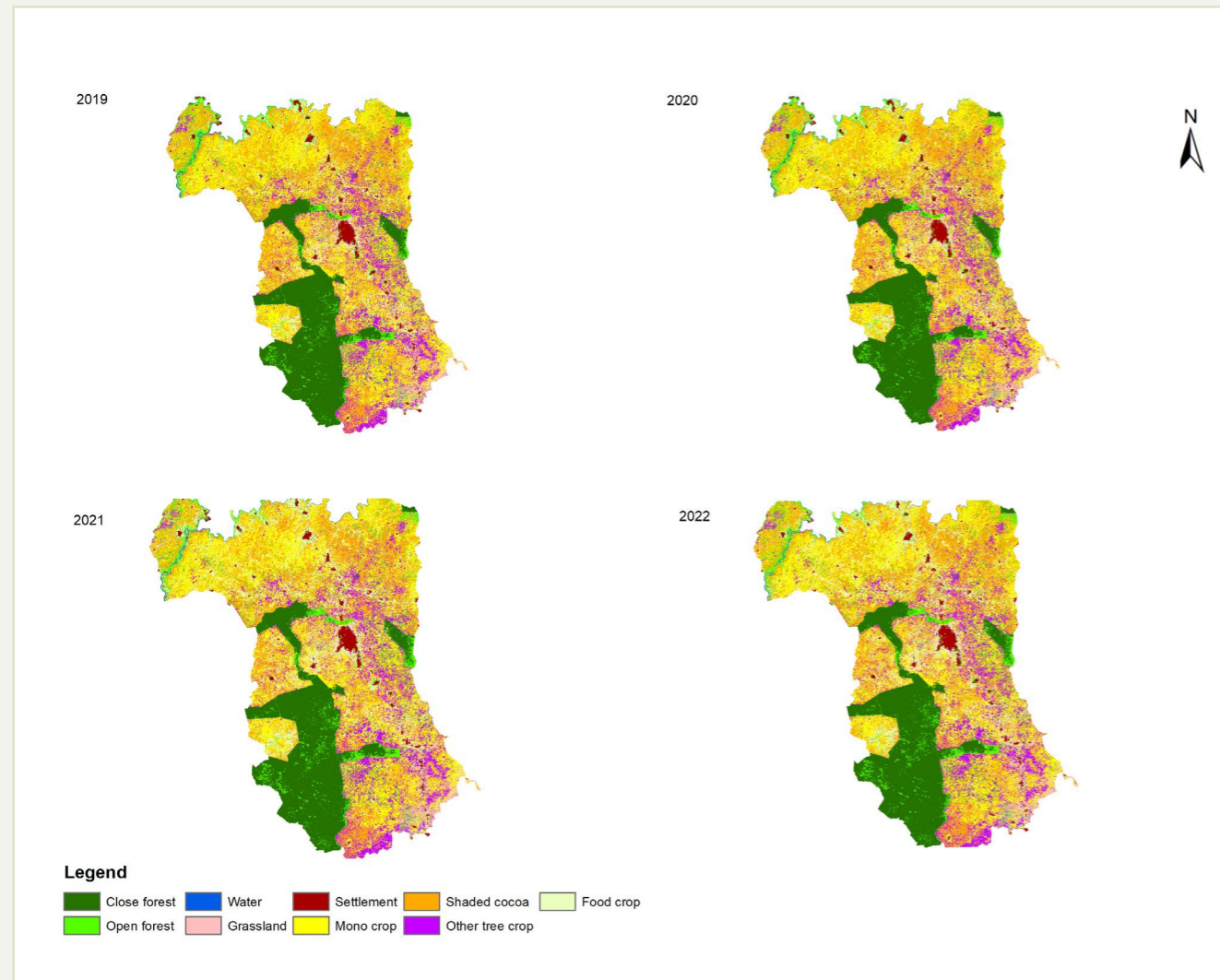


Figure 10: Landcover Maps for 2019, 2020, 2021 and 2022 - Kakum HIA

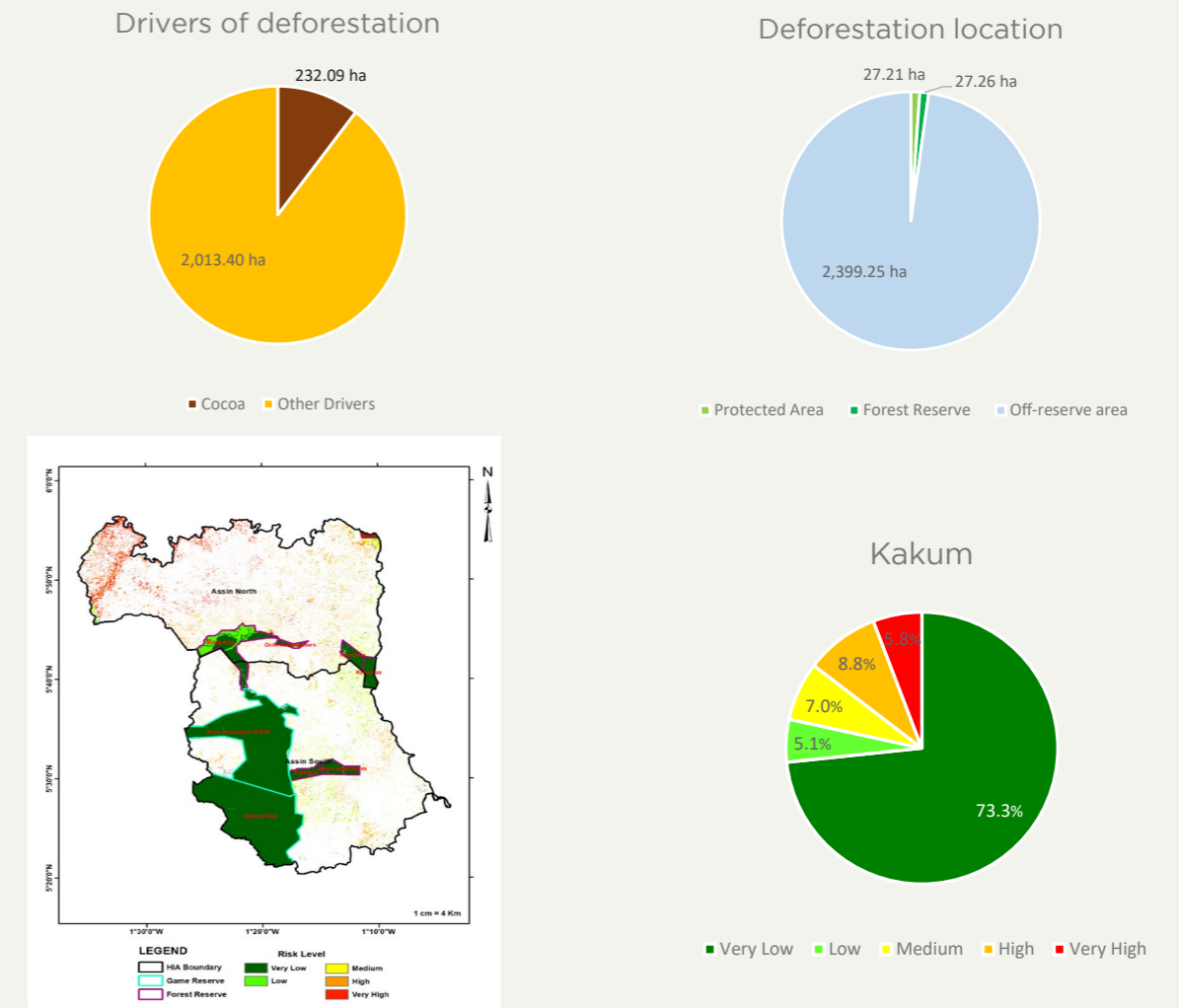


Figure 11: Forest Risk Map for Kakum HIA

Table 6: Landcover conversion matrix for 2019-2022 for Kakum HIA

		Area (ha)									
		2022									
		Closed Forest	Open Forest	Water	Grassland	Settlement/ Bare land	Mono Cocoa	Shaded Cocoa	Other Tree Crops	Food crops	Total
2019	Closed Forest	35,800.72	896.48	6.00	6.00	0.07	8.50	28.94	18.64	1.77	36,767.12
	Open Forest	70.92	14,801.92	23.59	215.89	47.14	497.16	116.51	141.12	1,342.39	17,256.64
	Water	0.07	39.00	376.02	2.53	12.64	25.39	15.05		5.13	475.83
	Grassland	17.71	131.78	1.25	5,187.89	22.49	138.95	132.78	79.25	917.75	6,629.85
	Settlement/ Bare land	16.64	72.55	62.86	67.38	3,517.23	80.36	24.94	14.08	206.40	4,062.44
	Mono Cocoa	27.70	231.65	7.36	967.77	17.04	51,279.91	206.84	80.62	3,775.80	56,594.69
	Shaded Cocoa	28.05	328.13	0.85	300.84	6.89	255.03	47,015.75	267.91	2,470.82	50,674.27
	Other Tree Crops	25.32	138.99	0.14	283.74	9.51	116.98	178.75	24,033.37	792.01	25,578.81
	Food crops	119.07	56.79	1.39	644.56	83.38	252.09	148.90	84.42	11,191.91	12,582.51
	Total	36,106.20	16,697.29	479.46	7,676.60	3,716.39	52,654.37	47,868.46	24,719.41	20,703.98	210,622.16

Recommendations Asunafo /Asutifi HIA

The HIA is covered by closed forest, open forest grassland, water, settlement / bare surface mono cocoa, shaded Cocoa, other tree crops and food crops. The dominant landcovers in HIA is cocoa plantation especially the shaded cocoa (27%) compared to monoculture cocoa. However, shaded cocoa is increasing in HIA. The deforestation rate for the period for the HIA is 6% (the highest among the HIAs) with food crop being a major driver of deforestation. The following actions are recommended. The rate of deforestation should be addressed in the landscape through various conservation strategies including:

- The forest cover in conservation areas (forest reserves and protected areas) should be safeguarded encroachment by the Forestry Commission in collaboration with other stakeholders. Forest cover including other areas of conservation value including sacred grove could be conserved through strengthening traditional conservation measures.
- The degraded areas that have been identified particularly in forest reserves and protected areas should be targeted for reforestation or restoration using various restoration method depending on the level degradation.
- Shaded cocoa is very dominant in the HIA. It is also obvious that shaded cocoa is gaining grounds in the landscape. Future efforts should strengthen existing programmes aimed increasing shaded cocoa in the landscape relative to cocoa monocrop production. Farmers should be educated on the importance of the adoption of agroforestry practices through incorporation of trees on their farms to make such systems more resilient and adaptive to the effects of climate change.
- Since a significant in the HIA is under food crop production in off reserve areas and are in the long-term designed for cocoa and other tree crop production, it important these are targeted for the promotion of agroforestry and conservation agricultures practices.
- There is the need to address deforestation due to surface mining which becoming very prominent in the HIA through law enforcement and rehabilitation of degraded areas. Areas within protected could be reforested whiles agricultural lands in off reserve areas could be rehabilitated using best practices for crop cultivation.

Landcover Maps for Asunafo /Asutifi HIA

The Asunafo/Asutifi HIA covers 386,547.90 ha and is made up of Asunafo and Asutifi districts located in the Ahafo Region of Ghana. The HIA comprises of the Abonyire, Asukese, Bia sheltabelt, Bia Tano, Goa shelterbelt, Ayum and Bomsa Bepo forest reserves. From the image analysis, (Figure 13) Closed Forest, Open Forest Grassland Water Settlement /Bare surface Mono Cocoa, Shaded Cocoa, other tree crops and Food crops were identified and mapped for the 2019 and 2022 epochs. The dominant landcover in HIA is shaded cocoa covering 91,316.11 ha representing 23.62% of the landscape. This was followed by closed forest with spatial extent of 90,837.68 ha representing 23.50%, in 2019. In 2022, the shaded cocoa decreased in coverage to 76,961.86 ha representing 19.91% of the landscape. Similarly the mono cocoa decreased from 74,719.6 ha representing 19.33% in 2019 to 69,116.59 ha representing 17.9% in 2022. The net decrease in the mono cocoa and shaded cocoa were 1.45% and 4.50% respectively.

With respect to the forest class the closed forest was dominant over the open forest. Whereas, the closed forest represented 23.50% of the landscape, the open forest represented 16.02% in 2019. The net change (reduction) in closed and open forest were 3.59% and 3.64% respectively. Food crops as usual increased significantly from 41,301.95 ha representing 10.68% to 88,445.5 ha representing 22.88%. As it was observed in the Juabeso Bia West HIA, food crop gain was mainly from the conversion of cocoa plantation and forest. Cocoa plantation and forest cover conversions together contributed 81% of the gain in food crop (Table 7). As indicated, early stage of cocoa cultivation is dominated by food crops because of the intercropping of food crops to provide shade to the young cocoa

seedlings. The MTS was the major source of conversion of forest to food crop. As explained earlier, the MTS is means to restore degraded areas within the forest reserves where vast of the forest cover exist. The study has further revealed other driver such as surface mining has become very prominent, and this is likely going to change the narrative for drivers of deforestation in the near future.

In terms of landcover change, conversions and transfers (Table 7), the diagonal figures highlighted yellow represents the area in the landscape which remained unchanged. All the figures above the diagonal are represents losses from their original cover types and those below the diagonal represents gains. The area of closed forest converted to open forest of 13,257.20 ha is shown in the cell marked red, constitutes forest degradation based on forest canopy closure. On the other hand, the cells highlight in green are areas closed forest gained which is 3,995.09 ha constituting forest enhancement. Deforested areas are the cells shaded brown and these sum up to 29,471.67 ha. The deforestation rate for the period for the HIA is 0.06 / annum or 6% and this was the highest among the HIAs. Conversion to food crop remained the dominant driver of deforestation contributing 78% in this HIA within the study period. It is important to note that in this HIA conversion to bare surface which includes mining recorded significantly (13%) to forest loss. Conversions from closed forest to mono cocoa was 188.41 ha and to shaded cocoa was 203.68. Open forest to mono cocoa was 399.79 ha and to shaded cocoa was 607.81 ha..

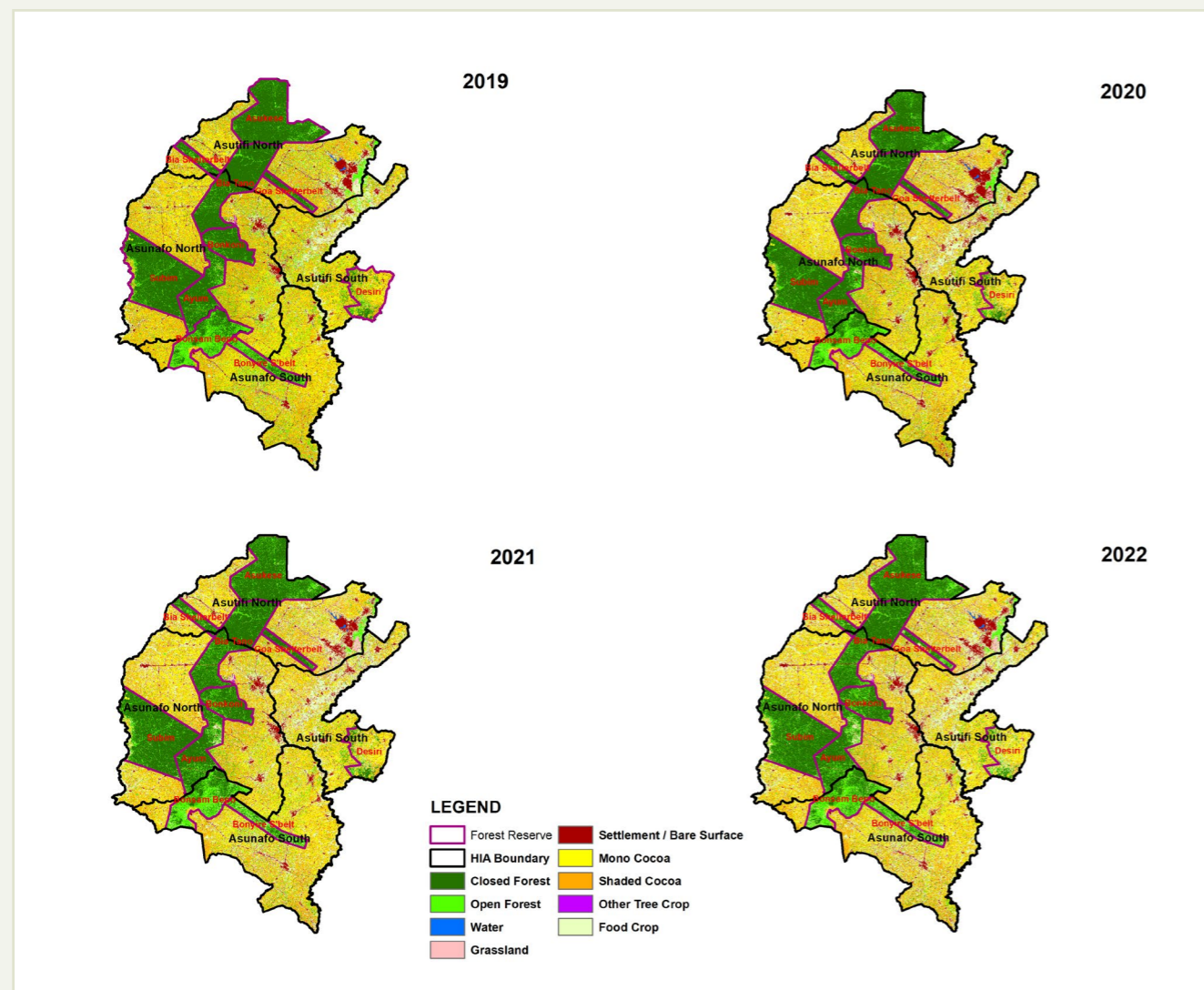
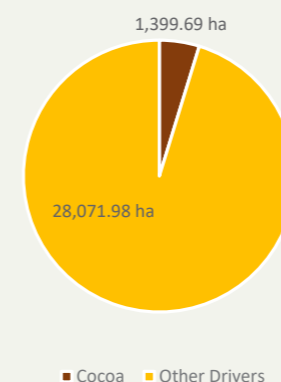


Figure 12: Landcover Maps for 2019, 2020, 2021 and 2022 -Asunafo Assutifi

Drivers of deforestation



Deforestation location

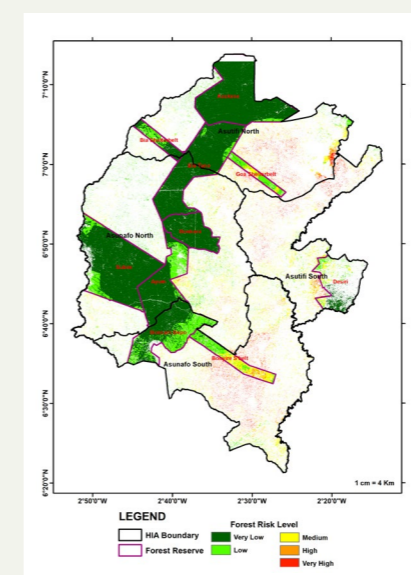
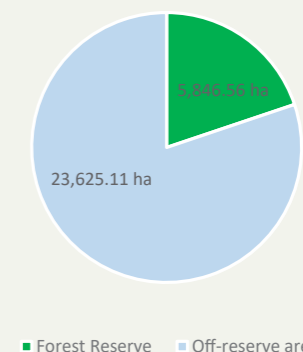


Figure 13: Forest Risk Map Asunafo Asutifi HIA

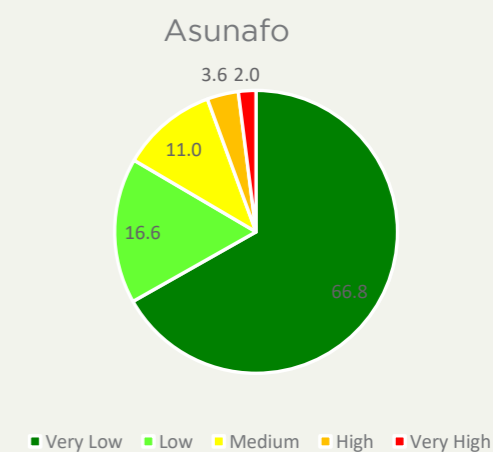


Table 7: Landcover conversion matrix for 2019-2022 for Asunafo/Asutifi HIA

		Area (ha)									
		2022									
	Landcover	Closed Forest	Open Forest	Water	Grassland	Settlement / Bare Surface	Mono Cocoa	Shaded Cocoa	Other Tree Crop	Food Crop	Total
2019	Closed Forest	74,193.58	13,257.20	5.63	114.70	560.57	188.41	203.68	58.36	2,255.55	90,837.68
	Open Forest	2,474.05	33,383.78	7.15	942.34	3,224.81	399.79	607.81	125.31	20,777.56	61,942.60
	Water	12.23	3.47	196.42	2.53	18.79	10.15	8.71	0.61	40.71	293.62
	Grassland	3.54	22.26	1.78	326.36	319.74	29.71	17.80	12.60	1,595.70	2,329.49
	Settlement / Bare Surface	11.51	49.99	8.95	659.47	9,408.70	60.28	14.56	60.64	7,781.01	18,055.11
	Mono Cocoa	34.64	103.72	5.54	169.43	465.21	65,960.63	669.20	86.49	7,224.80	74,719.66
	Shaded Cocoa	171.35	848.79	14.43	480.86	1,642.71	2,135.06	72,310.14	125.82	13,586.95	91,316.11
	Other Tree Crop	43.43	52.41	0.36	49.78	65.70	60.83	69.67	4,613.60	795.86	5,751.64
	Food Crop	17.53	146.17	7.42	1,689.67	4,629.31	271.73	22.40	130.36	34,387.36	41,301.95
	Total		76,961.86	47,867.79	247.68	4,435.14	20,335.54	69,116.59	73,923.97	5,213.79	88,445.50

Remarkable, in Bibiani HIA deforestation in forest reserves was higher than the off-reserve areas, in the Atiwa HIA deforestation in protected areas was higher than within forest reserves.

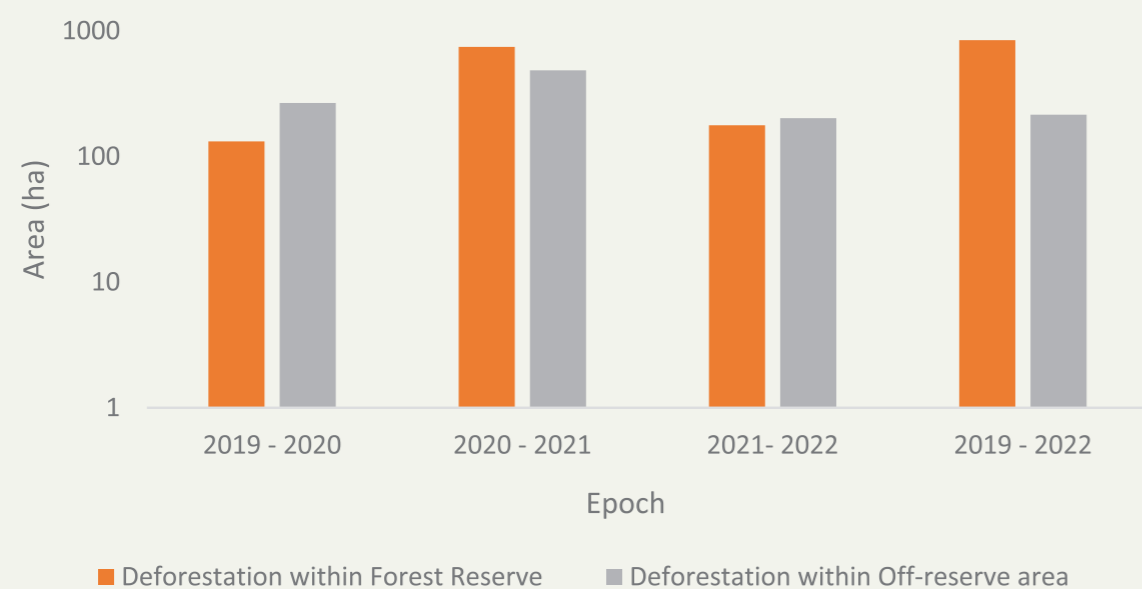


Figure 14: Deforestation by Location - Bibiani

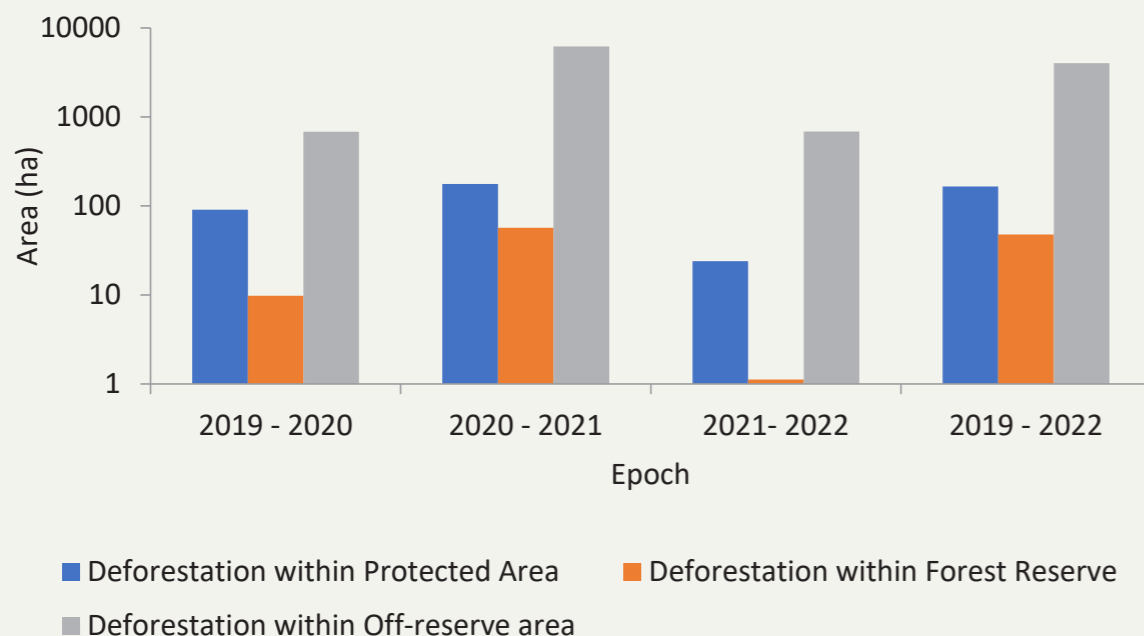


Figure 15: Deforestation by Location - Atiwa

CONCLUSION AND RECOMMENDATION

The deforestation trend by drivers and location shows the deforestation spikes throughout the study period. The deforestation by cocoa is defined as conversion of forest cover either close or open to either mono or shaded cocoa. This was extracted from the deforestation cells in the change matrices under the two cocoa classes. The rest of the deforestation cells make up the deforestation by other drivers. **Generally, deforestation by other drivers was higher than deforestation by cocoa in all the HIAs. This is because cocoa led deforestation is difficult to detect in a short period.** Conversion of forest to cocoa plantation is a process which involves the clearing of the forest, preparation of the land and the actual planting. The cocoa seedlings are interplanted with plantain to provide shade. These factors together with the time for the newly planted cocoa trees to mature and gain canopy cover, it will be difficult to detect them by satellite sensor.

Deforestation by location, that is forest reserve, protected areas and off-reserve areas were estimated. For protected and forest reserves the boundaries of these areas were used to extract deforested cells from the change maps. The deforested areas within the protected areas and forest reserves were subtracted from the total area deforested to get area of deforestation outside protected areas. **In all the HIAs deforestation within the off-reserve areas was higher than deforestation in both the protected area and forest reserves throughout the study period.** However, Bibiani HIA deforestation was higher in the forest reserves than off-reserve areas in 2020-2021 and 2019-2022 epochs. In HIAs where protected areas and forest reserves exist, deforestation was higher in forest reserves than the protected areas. The only exception was in the Atiwa HIA where the protected areas recorded higher deforestation. It is important to

note that Atiwa Range and Apedwa are forest reserves under protection. The high deforestation within forest reserves and off-reserve areas were expected because the forest cover within the protected areas is strictly under conservation and entry or access to these areas is highly restricted. The deforestation in the forest reserves was lower than the off-reserve areas because the forest cover within the forest reserves are managed by state institution and therefore access and extraction of resources are regulated to ensure sustainable use of the resources. Conversely, the forest outside the protected areas are on lands belonging to individuals and or communities and may decide to convert it at their convenience. The figures (deforested areas) were scaled up using the logarithm scale to ensure all the bars in the graphs were visible.

From the forest risk maps, the forest cover at high and very high risk were mostly found at the off-reserve areas whilst those at very low and low risk were found within the protected areas and forest reserves. Protected areas that had experienced high level of deforestation or forest degradation (e.g. Bia North and Krokosua Hills in the Bia West Juabeso HIA, Tinte Bepo and Offin Shelterbelt in the Ahafo HIA) had portions of the forest cover falling under the medium to high risk. The forest cover at these risks are close to previously deforested areas. The forest at very low risk dominated all the HIAs. They ranged from 48% to 73% in all the HIAs. This trend is attributed to the fact that majority of the forest cover in all the HIAs are still within the protected areas and forest reserves where they are managed. As indicated earlier, **deforestation is higher in off-reserve areas than the protected area. This is because the forest cover at the off-reserve areas is not managed and this is where cocoa plantation dominates.**

The six HIAs are very dynamic landscapes with changing landcover over time. **The mapping of the various landcover and forest risk model could be a useful baseline for long-term monitoring of the spatial and temporal changes in the HIAs as well as the drivers of these changes.** These landscapes include protected areas and other systems that are key refuge areas for biodiversity conservation and carbon sequestration. Enrichment planting and tree on farms remain important activities that should be explored in future projects to restore degraded areas. The commonly planted tree species which also contribute most carbon stocks need to be considered in future restoration programmes. Also, the inclusion of threatened tree species in the restoration programmes need to be sustained to increase the population of such species of conservation concern. It is also important source of livelihood for local people through the cultivation of cocoa which is a major export commodity for Ghana. The cocoa rehabilitation program by the COCOBOD is a laudable initiative that should be sustained to ensure sustainable cocoa production within the HIAs.

Monitoring of spatial and temporal changes in the 6 HIAs needs to be carried out and standardized protocol and tools at the landscape level are developed. An effective monitoring system may be useful for decision-making and conservation planning. Cultivation of food crops in the landscape remains a major driver of deforestation. However, as indicated in the results most of the areas under food crop cultivation are transitional. It is important that agroforestry practices are encouraged in these to ensure incorporation of trees on farms.



TABLE 8: REPORTING PERIOD - 2022										
DEFORESTATION BY LOCATION										
Hotspot Intervention Area (HIA)	Forest Cover (ha)	Forest Loss (ha)	Deforestation Rate	Forest Enhancement (ha)	Net Forest Gain / Loss (ha)	Forest Risk (Medium to Very High) %	Major Drivers of Deforestation	Cocoa Led Deforestation (%)	Protected Area	Off-reserve
Ahafo Ano South / Atwima Mponua / Atwima Nwabiagya	118,718.18	16,581.78	0.04	10,034.93	-17,915.70	25.92	Food Crop	3	7%	93%
Atiwa / Denkyembaour / East Akim	70,682.79	4,233.40	0.02	2,856.30	-1,377.10	25.63	Food Crop and Cocoa Plantation	29	31%	69%
Bibiani / Anhwiaso / Sefwi Wiawso	60,989.08	1,058.99	0.006	1,519.64	460.65	24.98	Food Crop	24	19%	81%
Juabeso Bia	110,603.45	11,074.29	0.03	2,980.79	-8,093.50	26.87	Food Crop	10	43%	57%
Kakum	36,106.20	2,453.72	0.02	1,304.37	-1,149.35	21.58	Food Crop	27	39%	61%
Asunafo / Asutifi	124,829.65	29,471.67	0.06	3,995.09	-25,476.58	16.55	Food Crop	5	20%	80%



Cocoa & Forests Initiative



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MINISTRY OF FOREIGN AFFAIRS OF DENMARK
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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Swiss Confederation

Federal Department of Economic Affairs,
Education and Research: EAER
State Secretariat for Economic Affairs SECO

Report prepared by the CFI National Secretariat of the Ministry of Lands and Natural Resources, IDH and the World Cocoa Foundation