Nigeria Cannabis Survey

2019 Baseline Assessment in Six States
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Acknowledgements

Delegation of the European Union to the Federal Republic of Nigeria and ECOWAS

We acknowledge, with thanks, the contribution of the European Union (EU) in funding this activity which is an essential part of the project “Response to Drugs and Related Organized Crime in Nigeria”. In particular, the interest shown by Ms. Eleni ZERZELIDOU, Project Officer Migration, Drugs and Organised Crime, EU Delegation to Nigeria & ECOWAS, throughout this activity was appreciated.

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Key Findings

In 2019, an estimated 8,900 hectares of cannabis were found in six Nigerian states.

- The 2019 cannabis survey covered six southwestern states, which are considered to have the highest concentrations of cannabis cultivation in the country: Edo, Ekiti, Ogun, Ondo, Osun and Oyo.

- In these states, an estimated 8,900 hectares of cannabis were found. The highest density of cannabis fields was found in the border area between Edo and Ondo states.

Cannabis was found in inaccessible areas with a low population density, a high forest cover, and a high deforestation rate.

- Cannabis fields detected in Nigeria were typically located deep inside dense forest, and away from urban settlements. They were not easily accessible by road. Based on the analysis of the detected fields, half of the fields were almost 6 km to the most proximate road, and 85% of the fields were more than 3 km away from the next road.

- There is a clear relationship between cannabis cultivation and deforestation; 39% of all cannabis fields detected in 2019, were cultivated on forest area cleared in the same year.

- Cultivating cannabis in forest areas provides protection from law enforcement since these fields are hard to detect or reach. The soil of freshly cleared forest land is comparatively more fertile during the first few years of cultivation.

Cannabis can be harvested two times a year, increasing potential production.

- In the survey area, the evidence collected points toward dominant cultivation in the rainy season and a less important dry season.

1 The figures represent a minimum estimate of cannabis cultivation in Nigeria, since the survey was restricted to six states only and covered only one crop season (rainy season). The survey instrument captured (mainly) mono-crop cultivation in outdoor field settings and did not cover cannabis grown in backyards, scattered cultivation in the form of standalone plants in forest areas, or greenhouse cultivation – all of which contributed to overall cannabis production in Nigeria.
Fields have been found with cannabis plants at different stages of growth, indicating staggered harvesting across the seasons.

Cannabis is cultivated as a standalone crop or in combination with other crops. The latter is done to hide the cannabis plants, to yield additional profits, and/or to grow food.

Cannabis products supply the large domestic market and reach countries outside the region, but there remain knowledge gaps on the size of the market.

The cannabis produced in Nigeria feeds its large domestic market (an estimated 10.6 million cannabis users in 2018) and there is evidence for trafficking to other countries in Africa, too. In the past decade, a number of countries outside of Africa also have mentioned Nigeria as source country of cannabis.

Between 2016 and 2018, an annual average of 1,600 hectares of cannabis were eradicated in Nigeria – almost 20% of the estimated area in the six states surveyed. This points towards a large “dark figure” (i.e., the amount of cannabis that is undetected and unreported).

Cannabis is grown in virtually all countries of the world, however, only for two other countries direct estimates for ‘area under cultivation’ are available: for Morocco (72,500 hectares in 2005) and Afghanistan (10,000 hectares in 2012), both of which are major producing and exporting countries of cannabis resin. A comparison of markets is not possible, though, since cannabis resin is a different product than what is produced in Nigeria.

In absence of a yield survey, there remain major knowledge gaps around the size and economic value of cannabis production in Nigeria, and the potential for exports, once domestic demand is met.
Cannabis in Nigeria, once harvested, is sun-dried before being compressed into a final product. The evidence available suggests a low THC content of the final products.

Cannabis sells for an average of 3,000 Naira per kilogram (7.25 USD/kg) at the wholesale level. In retail markets, cannabis is sold in wraps containing about 5 grams (enough for 3 cigarettes). In most states, the cost of a wrap is 100 Naira (20 Naira per gram) with some places quoting prices as low as 50 Naira per wrap (10 Naira per gram).

Reportedly, farmers are often organized in networks and cultivate cannabis close to each other. The aerial survey confirmed this finding from law enforcement interviews, as cannabis has been found to be frequently cultivated in clusters: 20% of the fields were directly adjacent to another cannabis field and 83% were cultivated within a distance of 100 metres from another cannabis field. In some areas, such clusters extended to some ten kilometres, forming a pattern together with fields with other crops, shrubs, and forest.

The key informants reported that commercial-scale production requires upfront financial capital, and that the main financers of illicit crop activities are large-scale drug traffickers. Moreover, organized crime groups have been found to be involved in trafficking cannabis from the farm onwards.

The survey also found that hired labour is key to cultivation, indicating commercial practices. These labourers, who are sometimes paid in the form of cannabis products, live on or close by the fields during the growing season. The presence of hired labour shows that the main beneficiaries of cultivation are not necessarily those working on the fields.

Implications for future research

Indirect indicators and a comparison with other producing countries point toward the potential international relevance of cannabis production in Nigeria – cannabis cultivation in Nigeria is of the same order of magnitude as in Afghanistan, the world’s second largest exporting country of cannabis resin. However, with 10.6 million cannabis users in Nigeria, more information on yields and production is needed to assess whether there are significant surpluses available once domestic demand is met. Such surpluses would be available for export to the region and beyond.

The survey found that cannabis is a rather low-cost product. However, the evidence collected indicated some degree of organization of cannabis farmers and a degree of organized crime involvement. More qualitative research on the modus operandi and value chains is needed to assess the extent to which cannabis cultivation poses a domestic or transnational organized crime threat.

Deforestation is a major threat to sustainable development in Nigeria. Further research can shed light on the common drivers behind deforestation, cannabis cultivation and possibly illegal logging, and provide evidence for targeted development interventions.
Introduction

The 2019 Nigeria cannabis cultivation survey was jointly conducted by the National Drug Law Enforcement Agency (NDLEA), the UNODC Country Office in Nigeria (CONIG), and the UNODC Research and Trend Analysis Branch.

The survey was implemented within the technical framework of the UNODC Illicit Crop Monitoring Programme (ICMP) which was established in 1999 upon the request of the Commission on Narcotic Drugs in its resolution 42/3, Monitoring and verification of illicit cultivation. The objective of ICMP is to assist the international community in monitoring the extent and evolution of illicit crops, and to compile reliable and internationally comparable data. Currently, UNODC carries out monitoring activities in seven countries affected by illicit crop cultivation: coca surveys in Bolivia, Colombia and Peru; opium poppy surveys in Afghanistan, Mexico and Myanmar; and a cannabis survey in Nigeria.

The cannabis cultivation survey was implemented under the project “Response to Drugs and Related Organized Crime in Nigeria (FED/2012/306-744) (NGAV16)”, with financial contribution from the European Union. The project aims at supporting Nigeria’s efforts in fighting drug production, trafficking and use, and in curbing related organized crime including in relation to counterfeit narcotics and psychotropic substances. The project proposes a balanced approach to drug control, with equal attention being paid to drug interdiction, and drug demand reduction, including drug prevention, treatment, and care.

One of the key aims of the project is to strengthen the evidence base on drug use and drug-related crime in an effort to inform policy planning and implementation. An integral part of the project has been to provide a baseline on cannabis cultivation in the country and to provide information on production patterns of this activity. UNODC has partnered with government agencies, in particular the National Drug Law Enforcement Agency, to carry out a cannabis cultivation survey. This survey was designed to determine the extent of cannabis cultivation in targeted areas in the country, and to map potential cannabis-growing areas.

The survey provides a cultivation area baseline for the year 2019 and reports figures on eradication and seizures over the last years, as well as information on cannabis cultivation practices, prices, and policy implications. The project activities continue to facilitate and enable the building of capacity of national counterparts in managing and analysing geospatial remote sensing data for illicit crop monitoring purposes, as well as deriving a range of geospatial products such as density maps and subnational estimates. Such activities are key to guiding the implementation of alternative development and drug supply eradication efforts.

Cannabis is cultivated and produced in Nigeria for both domestic consumption and export. Between 2017 and 2019, Nigeria seized the second highest quantity of cannabis herb in Africa at an annual average of some 260 tons, surpassed only by Morocco which had an annual average of 280 tons. Local use of cannabis is widespread, and the drug is available in all parts of the country. According to the 2018 Drug Use Survey, cannabis is the most commonly used drug in Nigeria, with more than 10 per cent or 10.6 million adults of the adult population reporting use in the past year. Over half of those admitted to treatment for illegal drug use in 2018 were admitted for cannabis use.

The present survey is the first systematic survey on areas under cannabis cultivation in Nigeria and thus presents a baseline estimate on which future assessments can build.

2 “...[A]lternative development is predominantly aimed at small-scale farmers. Alternative development is aimed at identifying and helping to address not only the driving factors, but also the underlying root causes of the cultivation of illicit crops — lack of development, marginalization, poverty and, thus, overall human insecurity — and to do so in a sustainable way.” (UNODC, World Drug Report 2015).
3 UNODC Response to the Annual Report Questionnaires (ARQs)
4 Prevalence of cannabis use is thus higher than at the regional average: in 2019, annual prevalence of cannabis use in Africa was estimated at 6.3 per cent, see https://dataunodc.un.org/data/drugs/Prevalence-general.
Cannabis cultivation and production in Nigeria

In 2019, 8,900 hectares of cannabis were found in six surveyed states in south-west Nigeria.

In 2019, the overall area under cannabis cultivation was estimated at 8,900 (5,300 to 18,200) hectares in the six states covered by the survey: Edo, Ekiti, Ogun, Ondo, Osun and Oyo. The states with the highest density of cannabis cultivation were Edo and Ondo, followed by Ekiti and Ogun. In Osun and Oyo, the survey did not yield an area estimate since no fields were detected in the sampled area.

The highest density of cannabis fields was found in the border between Edo and Ondo states, in areas signified by a low population density, remoteness, a high forest cover and a high deforestation rate.

Cannabis cultivation may be more widespread in the country.

The estimated area under cultivation is a minimum estimate: firstly, there is evidence of at least some degree of cannabis cultivation outside of the surveyed area. Cannabis can be cultivated in all states of Nigeria, and eradication data and accounts from key informant interviews provided evidence of some degree of cultivation in several states outside the surveyed ones.

Secondly, on the aerial imagery a number of suspected cannabis fields were identified (about 5 per cent when compared to fields clearly classified as cannabis), in addition to those fields that were classified as being under active cannabis cultivation. Given the lack of certainty of the cultivation of cannabis in suspected fields, such fields were not included in the estimate. These fields were, for example, isolated fields with scarce vegetation (sporadic cannabis), or possible cannabis fields that have not been counted towards the area under cannabis cultivation but could have been fields harvested earlier in the year or culti-
Cannabis density was calculated based on detected fields during the aerial survey. Densities are calculated as the relative number of fields found located within a radius of 40 kilometres around a location. “High density” represents areas with the highest observed concentration of cannabis fields per unit area, “low density” with at least a single field within the radius. The map is based on the fields found in the observed area. The presence of cannabis fields outside of this area cannot be ruled out.

Cannabis cultivation and production in Nigeria

Climatic conditions favour cultivation in the south-west

Cannabis is a rain-fed crop in Nigeria, grown mainly during the rainy season of the year. Cannabis requires a balanced water supply. It needs abundant water throughout the growing season, particularly while young plants are becoming established during the first six weeks of growth. The climatic conditions of the tropical rainforest in the southwestern regions of Nigeria together with the prevailing precipitation patterns favour the cultivation of cannabis in the region. The north-central and northern regions in Nigeria present less favourable conditions in terms of water supply and due to the warm and semi-arid climate of the area.

The south-west of Nigeria, where the survey area is located, exhibits the following seasonal patterns: (i) The long, wet season starts in mid-March and lasts until July, characterized by heavy rains and high humidity; (ii) The short, dry season normally starts at the end

Cannabis is a unique plant. It has been cultivated for centuries, although it is only fairly recently that its use as a drug has outpaced its other applications such as hemp production.

As evidenced by its geographic range – cannabis is cultivated in almost all regions of the world – the plant is hardy and adaptable, leading to the oft-repeated quip “cannabis can grow anywhere”.

However, it can only reach its full potential, and thus be of practical use, under certain conditions. The cannabis plant thrives in temperatures of 14°–27° Celsius, but can withstand freezing temperatures for brief periods of time. While it can grow in difficult soil types, such as sand, it fares better in loam that is rich in nitrogen.

Scientific literature on cannabis indicates that the cannabis plant is a “heavy feeder”, drawing lots of nutrients (especially nitrogen) from the soil, and that feeding is most intense immediately before and during flowering. It fares better in direct sunlight, as much as it can get. After the first six weeks, it can grow with little water, as it possesses a powerful taproot, but it only flourishes with regular moisture. For drug purposes, however, arid climates seem to favour the production of resin and thus active ingredients like THC (the main psychoactive compound in cannabis), and reduce the risk of fungus and moulds.

In addition, the cannabis plant requires well-drained soil, or its roots will rot, so it does not grow well in clay. It can be grown in slightly alkaline soil, but fares better in a fairly neutral pH of between 6 and 7. It is resistant to many predatory insects and has even been used as a hedge to protect other crops from insects, but it is vulnerable to spider mites, aphids and other pests.

Cannabis plants are annual, completing their life cycle in a single season and dying after reproduction. When cultivated outdoors in the temperate climates of the northern hemisphere, seeds are usually planted between March and May and the plant flowers between September and November, representing about a six-month growth cycle, with only one crop possible. Closer to the equator, however, it is possible to manage two annual crops from the same plot and it has been claimed that some tropical varieties will experience up to four growth seasons a year. Plants harvested for drug use are generally destroyed and would normally die soon after harvest time.

The cannabis plant is “dioecious”, which signifies that each individual plant is either male or female. Males fertilize females by means of wind-borne pollen.

The cannabis plant flowers over time or when darkness exceeds 12 hours per day (due to the shortening of the days in autumn). This allows plants that germinated late to complete their life cycle in an accelerated manner. The exact photoperiod required to induce flowering, however, varies by variety.

Cannabis contains over 400 chemicals, of which more than 60 are chemically unique and are collectively referred to as cannabinoids. Delta-9 THC is believed to be responsible for most of the psychoactive effects of cannabis, although related chemicals also play a role. The flowers of the plant are harvested when resin secretion and associated cannabinoid levels are at their peak which is just after the pistils have begun to turn brown but before the calyx stops growing. The floral clusters of the plant are responsible for the production of seeds, psychoactive components, and aromatic resins.

Cannabis yield varies across different regions, cultivation practices and harvesting practices. Given the variability of the plant and the range of cultivation techniques employed, coming up with yield to plot area ratios can be difficult, and comparability across countries and even regions is challenging. Poorly cultivated or feral plants may produce small buds, while those with the benefit of the best genetics, high maintenance and the latest growing technology can produce very large ones.

The surveyed area was constructed based on an analysis of crop suitability considering the geographic and climatic conditions of Nigeria, complemented with georeferenced historical records of cannabis eradication and seizures reported by NDLEA. Key geographic variables were the distance to large cities and settlements, terrain topography, favourable weather, rainfall distribution and proximity to the rainforest.

Some areas in Nigeria are more affected by cannabis cultivation than others

Cannabis can be cultivated in all 36 states in Nigeria, but cannabis cultivation occurs at varying levels.

of July with a peak in August; (iii) The short, wet season follows the August break and lasts from September to October; and (iv) the long, dry or harmattan season continues from the end of November to mid-March.

Source: Bulletin on Narcotics Volume LVIII, Nos. 1 and 2, 2006 Review of the world cannabis situation

10 See methodology section on the definition of the cannabis risk map used for sampling, surveying and cultivation inference.
FIG. 2  Long-term average monthly precipitation in the survey area, 2010–2021

Source: Precipitation data obtained from the GPM IMERG NASA service.

MAP. 2  Average monthly precipitation over Nigeria (2015–2021) and land cover

Source: GPM IMERG NASA services and Esri 2020
The regional scope of the survey area (area of interest) was defined in collaboration with the NDLEA, which provided accounts and evidence of cannabis seizures and cannabis farming in the country over the last decade. On this basis, the area of interest was restricted to six states in the south-west and south-central regions of the country, namely Edo, Ekiti, Ogun, Ondo, Osun, and Oyo.

The area of interest was further reduced by removing areas deemed unsuitable for cannabis cultivation. For example, swampy and marshy land located in the low-lying riverine areas of Ogun, Ondo and Edo are often flooded and hence present a low to very low risk of cannabis cultivation. Lastly, large cities and their immediate surroundings were removed from the risk area.

The risk area was further stratified, being composed of two classes, “high-risk” and “low-risk”, to represent the probability of risk, given the land cover. Using tree cover and forest loss data,[11] areas of forest or areas of close proximity to the forest that were suitable for cannabis cultivation were designated as “high risk”; the remaining areas were determined to be “low risk”. [12]

On the area of interest, a spatial frame was defined from where systematic random samples (flight lines) were drawn that have been surveyed.

**Overflights have provided the basis of data for the estimates**

The area estimates are based on the results of imagery collected during an aerial mission (overflights) in September and October, 2019. During that mission, more than 30,000 images covering an area of 5,000 km² were collected, in a total of 55 hours of flights. To define the survey area, a risk assessment of cannabis cultivation in Nigeria was conducted that identified the states, and geographical areas within the states, that were at highest risk for cannabis cultivation.[13]

The survey methodology, its timing and the amount of data collected was determined by the prevailing weather conditions in the survey area. The weather conditions in Nigeria during the main cannabis growing season are characterized by two distinct wet seasons, the first from April to May and the second from July to October. The dry season lasts from November to March.

These seasons were considered to be the best for cannabis cultivation due to the availability of water and suitable growing conditions. The survey was conducted during these wet seasons to ensure accurate representation of cannabis cultivation areas.

In addition to the overflights, on-the-ground assessments were conducted to validate the data collected from the imagery. This dual approach ensured that the survey provided a comprehensive understanding of cannabis cultivation in the area of interest.

12 Forest areas suitable for cannabis cultivation were considered as areas with tree cover between 20 per cent and 80 per cent. The values below 20 per cent were not considered as forests and the pixels above 80 per cent were assumed to have too dense a canopy for cannabis cultivation.
13 See Methodology section for more details.
season are mostly cloudy and rainy and it is almost impossible to collect cloud free satellite imagery which is needed to detect cannabis cultivation. Therefore, overflights were conducted to collect very high-resolution aerial photographs. During the mission, 127 out of 151 planned flight trips were successfully concluded. In the remaining 24 trips, no data could be collected, mostly due to adverse weather conditions, a low cloud ceiling and heavy rain. The flight height was established at around 750–800m above ground, which was below the cloud ceiling. Storms and heavy rain resulted in a delay or a cancellation of the flights. Data was collected at the end of the rainy season, which is considered to be the peak period for the cultivation of cannabis.14

The importance of Nigerian cannabis production in the region

Estimating the quantities of cannabis herb that a hectare can yield is challenging, as many factors influence yields. Some fields receive a lot of attention, including irrigation, while many appear to be low-investment operations, where seeds are dropped, and the proceeds collected months later. Plants can grow to great heights in low-density fields (up to four or five meters), or remain relatively short when planted more densely. Such planting decisions affect the number of plants per hectare and the average amounts of herb that can be collected from a plant.

The survey did not collect data on cannabis yields per hectare in Nigeria. Data collected in other countries provided evidence of a huge variability in average yields of cannabis herb per hectare, ranging from some 470 kilograms per hectare in feral cannabis in Central Asia, to some 1.8 tons per hectare in Morocco.15 Differences in climatic conditions, agricultural practices and crop varieties make a transferability of yield estimates of other countries to Nigeria impossible. A dedicated yield survey would therefore be needed to provide an estimate of quantities of cannabis produced in the country. Cannabis fields in Nigeria had a large variability in quality. The cultivation patterns of the fields varied from very organized planting in rows, to more irregular or random plantings. Larger fields, or fields located in larger clusters, tended to have more organized plantings than smaller fields where plants tended to be more

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14 See Methodology section for more details.

**MAP. 5** Surveyed area in south-west and south-south regions of Nigeria

Source: UNODC

**MAP. 6** Randomly selected flight strips used for collecting imagery to estimate the area under cannabis cultivation, 2019

Green strips – successfully conducted flight trips; Red strips – areas where data could not be collected due to challenging weather conditions.
PIC. 1  A well-organized cannabis field (left) and a field with more irregular planting patterns (right)

PIC. 2  Densely planted (left) and sparsely planted (right) cannabis fields

PIC. 3  Young and mature cannabis cultivated in the same field (left) and a partially harvested field with nurseries and a shelter (right)
Cannabis is grown in virtually all countries of the world, however, only for two other countries direct estimates for ‘area under cultivation’ that use a similar methodology are available: for Morocco (72,500 hectares in 2005) and Afghanistan (10,000 hectares in 2012), both of which are major producing and exporting countries of cannabis resin. Since cannabis resin is a different product than what is produced in Nigeria, a comparability across markets is not possible.

Nigeria reported the second largest quantity of cannabis herb seized in Africa in recent years (after Morocco), and seized on average 260 tons each year, except for 2015, when seizures spiked with some 800 tons. Eradication data reported by Nigeria to the UNODC also points towards significant cultivation. While highly volatile, in 2018 the Government of Nigeria reported that more than 3,600 hectares were eradicated – more than a third of the estimated area in the six states surveyed.

Indirect measures allow for assessing the role of Nigerian cannabis in the region and beyond

In the absence of direct estimates of cannabis production, indirect indicators of cultivation and/or production (including “hectares of cannabis eradicated”, “number of cannabis sites eradicated”, “number of cannabis plants seized” and “origin of cannabis seized”) have been used to identify countries likely to have significant cannabis production in a region or subregion. In Africa, Morocco (mostly cannabis resin or ‘hashish’), as well as Nigeria, Eswatini and the Sudan have been identified, amidst widespread cultivation in most other African countries. In the past decade, a number of countries, including Niger, Qatar and China, reported Nigeria as a source country for cannabis herb.

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17 World Drug Report 2020, booklet 3, p 68.
Cannabis fields are mostly located in remote forest areas, often on newly cleared fields

The cannabis fields detected in Nigeria were typically located deep inside dense forest, away from urban settlements, and were not easily accessible by road. Several NDLEA officers reported long travelling times from the closest main road to cannabis fields, as well as difficult terrain which makes access challenging. Indeed, based on a geospatial analysis of the detected fields, the distance to the most proximate road was about 6 km for half of the cannabis fields, and more than 3 km for 85 percent of the fields.

There is a clear relationship between cannabis cultivation and deforestation. Cannabis fields are established in dense, tropical forest away from major roads and urban areas, most often by burning the wood in the area. Remote locations offer protection from law enforcement since these fields are hard to detect or reach. Moreover, freshly cleared forest land offers fertile soil for the first years of cultivation. According to the interviews conducted, these fertile lands are used for a few years before being abandoned when cultivation moves to new areas.

Source: UNODC
Of all detected cannabis fields, 39% were cleared in 2019

The year of clearance of the cannabis fields observed in the survey could be estimated using information on tree cover loss:\(^{21}\) in 2019, 39 per cent of the detected fields were cleared and 77 per cent of cannabis fields were younger than 4 years (established between 2016–2019).\(^{22}\) As such, cannabis cultivation is certainly contributing to the ongoing deforestation in the country, although deforestation due to cannabis cultivation seems to be limited when juxtaposed against overall forest loss: in 2019, Nigeria lost 86,700 hectares of forest, mostly due to licit agriculture.\(^{23}\)

The practice of using newly cleared fields for cannabis cultivation was also evidenced by aerial imagery. In many fields, and not only cannabis fields, charcoal was present, possibly coming from the practice of using forest fires to create fields and trails in dense forest areas.

**FIG. 5** Year of forest-clearing of the cannabis fields detected in the survey

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\(^{21}\) Data on tree cover loss obtained through the University of Maryland

\(^{22}\) Tree cover and tree cover loss cannot be interpreted as forest and deforestation in all cases, since plantations or changes in woody crops and tree plantations are captured as tree cover and tree cover loss, respectively. However, in the study area, most of the tree cover and change of tree cover loss refers to natural forest and deforestation, respectively. Source: University of Maryland

\(^{23}\) https://www.globalforestwatch.org/ Last accessed March 2021
MAP. 7  Detected cannabis fields, density of cannabis fields, roads and urban areas and settlements

MAP. 8  Tree cover loss and cannabis cultivation in the survey area, 2019

The map illustrates the spatial connection between cannabis fields and the forest. In Nigeria, cannabis is planted in remote locations inside of forest areas and in recently cleared areas. The largest share of the cannabis fields (>77%) are located in areas deforested in or after 2016. The detected cannabis fields are also in areas of medium and high deforestation activity as shown by the green coloured areas on the map.
How cannabis is cultivated in Nigeria

Cannabis cultivation involves a series of activities, which begin with the clearing of a field (e.g., by removing trees and other vegetation in the forest), followed by ploughing and tillage, the preparation of nursery beds, sowing, growing seedlings, transplanting, and weeding. The harvesting of the cannabis is the final stage of cannabis cultivation.

Nurseries, where cannabis seeds are germinated, are often established in the vicinity of the cannabis fields. Here, small plants (seedlings) develop and are then transplanted to the main fields after a few weeks. Seedlings are frequently planted in a staggered manner, which results in different growth stages on the same field and a staggered harvest. Staggering the harvest can have advantages, as it reduces the amount of labour needed at a certain point in time. It may also contribute to the general maintenance of the field.

Ploughing and tillage is done before transplanting the cannabis plants and it is a labour-intensive activity. As revealed from key informant interviews, other maintenance activities, such as thinning and pruning of the cannabis plants, are not a common practice. However, the weeding of unwanted grass in early growth stages was reported. Informants also reported the use of organic and inorganic pesticides and herbicides.

In the study area, rainwater reportedly serves as the sole source of water during the rainy season. In contrast, during the dry season the fields are irrigated using water pumps, hoses, and pipes, as well as watering cans and buckets which use water from nearby streams and rivers. Crops are also planted in riverine areas or nearby forest streams that provide better conditions for farming in dry season.

Hired labour is key for the management of cannabis cultivation

According to the interviewed informants, the activities necessary for farming cannabis are (mostly) done by hired workers. Hired labour is key in managing the entire production chain, including activities such as clearing, ploughing, planting, weeding, harvesting, packing, and ensuring security of the fields. In some cases, labourers are employed (at low costs) to fetch water and irrigate the crops, and/or to dig wells on the farms to procure water. One informant indicated that some of those who manage the farming operations (the main beneficiaries of the sales) do not know the location of their farms since they only operate through hired workers and intermediaries.

The interviews revealed that several criteria are considered when hiring labourers. These include the size of the farm, and whether the person is a cannabis user and/or is unemployed. Cannabis users are preferred, as being a user is deemed an incentive for performing and operating clandestinely. Some farmers hire workers on the pretence that they would be working in a legitimate farm and later use them for cannabis cultivation. In contrast, other farmers are upfront about the nature of work and look specifically for workers who are willing to work in menial jobs to survive.

24 In the survey area, cannabis was present in all growth stages – from young cannabis to far-grown, mature and harvested cannabis. A single field could contain cannabis plants that are at different stages of growth. This indicates that, firstly, cannabis is indeed cultivated in a staggered manner in the surveyed area and, secondly, that the continuous growing of cannabis throughout the year is possible in Nigeria.
Farmers may or may not live on or nearby the farms, while hired workers predominantly stay in the field or in nearby shelters during the harvest season. Local farmers may provide food and shelters or tents to workers that relocate temporarily to the fields. Such rudimentary shelters and huts were frequently observed in, or in the vicinity of some cannabis fields based on the aerial imagery. One informant revealed that in some cases, the labourers cook by themselves in the forest. Workers are reportedly paid after the harvest. Such payments can take the form of cash, bags of cannabis or both, depending on the conditions of their engagement. One informant revealed that it is a common practice to pay workers in two instalments – one upfront and one after the work is carried out.

Cannabis is also planted together with other crops to conceal it, and for growing food

Key informants report that it is a common practice to cultivate other crops mixed with, or in close proximity to cannabis plants. This practice applies to both small and large cannabis fields. Crops such as cassava, banana, cocoa, maize, pepper and yam are cultivated together with cannabis.

This agricultural practice takes place mainly for the purpose of concealing the cannabis plants and avoiding detection by law enforcement. Farmers also take advantage of the relatively fertile soils where cannabis is planted, which yield additional profits. The produce from planted crops provides food to farmers and field workers, thereby reducing the costs for providing food to the hired labour who have relocated and live close to the fields during the harvest season.

In the aerial survey, however, cannabis that was intercropped with other crops was rarely found. This does not signify that these fields rarely exist; heavily mixed fields may not have been detectable on the aerial photos if the canopy and foliage of other crops hid the cannabis plants. The imagery also revealed that cannabis may be followed by other crops on the same field.

Cannabis tends to be cultivated on comparatively small fields

Average cannabis fields are small when compared to fields cultivated with other crops. Based on the 711 detected fields, the median size of a cannabis field was 0.33 hectares with a minimum area of 0.02 hectares and a maximum area of 6.9 hectares. In comparison, average fields with licit crops held by smallholders are an average of 0.5 hectares; almost two-thirds of the cannabis fields were smaller than that. In Nigeria, more than 80 per cent of farmers are considered smallholders, with access to less than 5 hectares of land.

Across states within Nigeria, Ogun had a higher median field size (about one hectare) than other states. In contrast, Edo had the smallest median field size (0.24 hectares). This may be due to different cropping practices or other conditions. More research is needed to shed light on the implications of different field sizes.

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FIG. 6  Distribution of field area of detected cannabis fields, 2019

FIG. 7  Histogram of distance between fields
Cannabis is frequently cultivated in clusters of fields, possibly indicating that farmers are organized in networks. Even though the size of the individual cannabis fields was found to be small, field reports and the aerial survey confirmed that cannabis is frequently cultivated on large tracts of land, with several adjacent fields clustering within a relatively short distance from each other. In some areas, such tracts were as long as ten kilometres, forming a pattern together with fields with other crops, shrubs, and forest.

Of the 711 detected fields, 142 (20 per cent) were directly adjacent to another field (e.g., only separated by shrubs or a row of licit crops such as maize, yam or cassava), and 83 per cent (592) of the fields had at least one other cannabis field within a distance of 100 metres. Only 3 per cent of the detected fields were isolated fields, and were located further than 1 km away from another cannabis field.

This may provide an indication of how frequently cannabis farmers organize themselves in networks. According to the interviews conducted, farmers are often organized in networks and cultivate crops close to each other; three to five of them set up their farms about 500m apart from each other. The same informants reported that some farmers sell to the same traders. This can serve as an indication of farmers gaining a potential advantage in price negotiations, through collaboration.

Cannabis cultivation needs upfront capital, indicating a certain degree of commercialization. Respondents in Oyo and Ondo states mentioned some requirements for entering cannabis farming. These include the availability of adequate upfront funds, a certain socio-economic status, and having connections to actors in the relevant markets.

According to the respondents, commercial-scale production requires substantive financial capital. In Oyo, for instance, it was reported that farmers take loans from cooperatives and banks under the pretence of cultivating licit crops. The main financers of illicit crop activities, however, are reportedly large-scale drug traffickers. The respondents considered dry-season cannabis farming as an enabler for farmers to raise enough capital to fund their activities during the wet season. Narratives from some of the respondents indicate that farmers cultivate cannabis as a means of making money opportunistically, purely for business, and upon the request of buyers or traders. Some farmers cultivate cannabis exclusively to gain more profit than with licit crops, while others combine cannabis with licit crops to make additional income.
In Nigeria, cannabis cultivation does not follow a strict crop calendar and fields can be found in multiple stages throughout the year. There is however more cultivation in the rainy season.

Since cannabis is a rain-fed crop, its cultivation is largely associated with the seasonal rainfall distribution. Therefore, the timing of the crop stages differs between regions and across years, according to the onset of the rainy season.

A generalization of the patterns of large-scale cannabis cultivation in the six surveyed states indicates that cannabis farming begins with the installation of seedling nurseries in February. After about 3 to 4 weeks, when cannabis shoots are ready, the planting phase begins, taking place from the beginning of April to late June. It then takes 3 to 4 months for the plants to mature; plants reach a height of 2.5 to 3 meters. Harvest begins in August, peaks in September and October, and ends in November when the last mature fields are harvested at the onset of the dry season.

A dry-season harvest has been reported from all states covered by the survey: Oyo, Ondo, Ekiti, Osun, Ogun and Edo. The dry season crop calendar starts in October/November with the installation of nurseries. It is then followed by a harvest period that goes from March to July, depending on planting time. The water-logged marshy soils of the south facilitate the irrigation of nurseries along the riverbanks of the area. For instance, in Edo state, reported areas of dry-season cultivation are the banks of the Owan and Osun rivers.

Remote sensing data reflects the crop calendar

Remote sensing data reflects the findings on the crop calendar. The NDVI (Normalized Difference Vegetation Index) quantifies vegetation based on reflectance patterns obtained from satellite data. The NDVI data collected using the 711 cannabis fields identified during the aerial survey in 2019 shows minimum vegetation in August and increasing vegetation after that time, with a peak reached in November. After November the vegetation index declines again, for example caused by the drastically reduced presence of vegetation in the fields after the harvest.

In addition to the November peak, there is a smaller one between April and July, indicating that at least some of the cannabis fields studied had a second vegetation peak earlier in the year. This type of data does not allow for the identification of cannabis, but the peak substantiates the qualitative information on a possible second harvest. Further investigations are needed to determine if cannabis is indeed grown twice a year on the same fields.

Crop calendar in states outside of the survey area

Qualitative information collected from other states, that have not been surveyed in the aerial mission, indicated that cannabis is harvested once a year in Anambra, Kaduna, Birnin Kebbi, Akwa Ibom, Nasarawa, Cross River (mostly once), and twice a year in Kwara and Delta states. According to climatic and local conditions, the crop calendars can vary substantially.
FIG. 9  NDVI index as observed on the detected fields, by month, 2019

Source: Google Earth Engine, Sentinel-2 surface reflectance product (ESA). Data has been compiled by intersecting the centroids of the fields with the Sentinel-2 data. The box contains 50 per cent of the values; the upper and lower whiskers 25 per cent each. The horizontal bar indicates the median and the ‘x’, the average values.

TABLE 1  Crop calendar in states outside of the survey area

<table>
<thead>
<tr>
<th>Nursery</th>
<th>Sowing</th>
<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>February – March (Cross River)</td>
<td>April (transplanting) (Cross River)</td>
<td>July – August – November (Akwa Ibom)</td>
</tr>
<tr>
<td>March (Anambra, Akwa Ibom)</td>
<td>April – May (Nasarawa, Akwa Ibom)</td>
<td>August – September (Cross River)</td>
</tr>
<tr>
<td>March – August (Kaduna)</td>
<td>April – June (Plateau, Kwara)</td>
<td>September (Delta)</td>
</tr>
<tr>
<td>June (Delta), June – July (Birnin Kebbi)</td>
<td>September – October (Birnin Kebbi, Kaduna, Kwara, Nasarawa),</td>
<td>October – December (Anambra, Plateau)</td>
</tr>
<tr>
<td>To some extent January (Plateau)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cannabis can be harvested two times a year, increasing potential production.
After being harvested, cannabis is processed into its final form for selling (e.g., compressed leaves). The farmers then sell the product either directly at the farm (to intermediaries from either close-by or different states, and/or directly to end-consumers) or transport them to a designated warehouse. These warehouses are reportedly located in secluded, hard-to-reach places, and are used by wholesalers to compile larger consignments consisting of products from several farmers. Wholesalers organize further trafficking to end-consumers, frequently by using lower-level traffickers, e.g., retailers.

There are certain mechanisms in place to ensure the security of the buyer and the seller. For example, the location of the cannabis is only disclosed after negotiations on the sales conditions have been concluded by both the buyer and the seller. Moreover, cannabis trafficking appears to be built on trust. Newcomers to the business need to have established contacts with members of trafficking networks. Cannabis is usually moved at nightfall to avoid detection.

Processing of cannabis after the harvest

Once the cannabis plants are mature and harvested, the plant material is further processed for trafficking and selling. The main commercial products of the cannabis plant in Nigeria are its leaves and seeds. However, some informants also said that dried buds, stems and flowers are sold by the farmers. The local names of cannabis products mentioned by the informants are as follows: ganja, igbo, gbana, colorado, skunk, wee wee, and taba.

Most farmers process the plants on the farm or close to the farm. The plants are cut from the stocks and then spread in an open space in the open air and under direct sunlight to be sun-dried. The materials used for processing the plants are large, flexible plastic sheets, or cement bags sewn into a large sheet for spreading and drying the cannabis plant. After drying, the cannabis is cleaned and sieved to separate good leaves and seeds. Seeds are also sold to other farmers for the next planting cycle.

Cannabis plants cultivated in traditional settings are usually fertilized, as male pollen almost always reaches the female plants which then produce seeds. The resin of seed-producing cannabis plants contains fewer active ingredients and is thus less potent than the resin of non-fertilized female plants in controlled conditions.
(e.g., in greenhouses) where pollination is prevented. The practice of drying the plants in sunlight further reduces their potency.

The harvested leaves are compressed to reduce volume and packed in non-standard-sized bags for further distribution. The weight of bags range from a few grams to about 10 kilograms; the typical weight reported by each participant varied. For example, in Oyo the typical weight and size of the package ranged from 15 grams to 100 kilograms and in Ondo, from 500 grams to 13 kilograms. One informant indicated that compressing is done at the warehouses, and another one that compressing is done with machines. The dried, compressed cannabis is packed in bags for storage either at the farm, in close vicinity to the farm, or in warehouses far away from the farm.

Participants gave varying records of the average size of consignments (consisting of several bags), and both kilograms and bags were used as units. The reported average sizes varied between 6 and 20 kilograms, while one respondent described the range as from 25 to 350 bags. This variation may reflect different trade levels, e.g., wholesale trafficking for local distribution, in contrast to interstate or cross-border trafficking.

Means of transportation and concealment

Depending on the location and the terrain, traffickers choose different means of transportation, which can involve two-, three- or four-wheelers and animals. They move at night or during heavy rainfall when the roads are less policed.

Different methods of concealing cannabis were highlighted. The methods ranged from concealing in vehicle compartments (fake compartments) to concealing (covering) with groceries, fruits and vegetables (e.g., maize, yam, pepper, banana, cocoa, or pineapple), and other commodities (e.g., cassava, bags of grain, cement, palm oil, or coal). Informants highlighted that warehouses are used for compiling larger consignments. In Ogun, an informant indicated that other domestic cannabis farmers are responsible for compiling larger consignments.

Some participants revealed that organized crime networks play a role in helping to secretly transport the cannabis products from the farm directly to the buyers or to dealers and warehouses in villages and large cities. From there, the products are distributed to intermediaries and local dealers who retail the product to the final consumers. One informant indicated that farmers are not a part of the network but that they work independently.

Market prices

The respondents indicated that, in general, prices vary regionally and also depend on the availability of cannabis during the year. Wholesale prices were, on average, 3,000 Naira per kilogram (7.25 USD/kilogram) or 3 Naira per gram for a standard bag of 10–11 kilograms of dried leaves. In Ondo, the price per kilogram went from 1,500 Naira per kilogram during the harvest season to 2,500 Naira per kilogram in the off season.

In retail markets, prices were mainly quoted in terms of conventional cannabis wraps that get to the hands of the final consumer. One wrap contains about 5 grams of cannabis with enough content to produce 3 cigarettes. In most states, the cost of a wrap is 100 Naira (20 Naira per gram) with some places quoting prices as low as 50 Naira per wrap (10 Naira per gram).

The NDLEA reports that cannabis is sold for between 40,000 and 50,000 Naira for a 50-kilogram bag,\(^{28}\) or 25,000 Naira for a 25-kilogram bag,\(^{29}\) although there is considerable seasonal variation. This amounts to about US$100 for 50 kilograms, or one-fifth of one US cent per gram, suggesting a low-quality, low-investment bulk product. Data on THC levels was not available at the time of publication.

In Ogun, cannabis is more expensive in urban centres than in rural areas. One of the answers from a respondent revealed that in the north, the price can be double if it is coming from the southern part of the country.

As disclosed by different interview participants, the Nigerian Naira is the currency with which cannabis is traded. The Nigerian Naira is also the only currency used in transactions involving cannabis.

\(^{28}\) UNODC, responses to the ARQ 2015
\(^{29}\) UNODC, responses to the ARQ 2016
Mostly hired labourers are arrested

The circumstances leading to an arrest can be quite different, but the most-named circumstances were information leakage and intelligence gathering. Information leakage can occur through aggrieved hired labourers, farm managers, hunters, aggrieved farmer network members, forest guards, the general public, etc. Also, a land dispute among the farmers and landowners can lead to intelligence gathering, arrest, and the eradication of cannabis fields.

When an intelligence report is received about the illegal cultivation of cannabis at a particular location, surveillance will be conducted to ascertain the authenticity of the information, with consideration being given to the risk assessment of the intended operation and the logistics required. A team of operatives will then scatter themselves around the farm and raid it at night.

There is no constant location for arrests, according to the reports, but most times the arrest takes place in the cannabis farm. Because it is the labourers who sleep on the farms (e.g., in tents), rather than the main beneficiaries of the sales, workers are the ones who are most often arrested. In most cases, farm managers or hired labourers will be arrested and only when they divulge information would the farmers be arrested.
Methodology

Study Design

This chapter discusses methodological aspects of the survey design and the area estimation procedure applied in this survey.

The 2019 Nigeria cannabis cultivation survey had two main components:

- A remote sensing survey as a primary source of data for assessing the area under cannabis cultivation, during which aerial photographs were obtained from an overflight mission conducted in 2019; and

- Structured key informant interviews with NDLEA experts in the six states that were surveyed, and in an additional 17 states for the purpose of collecting information on common agricultural practices of cannabis cultivation and production, the organization of cannabis trafficking, common cannabis products trafficked, and information on prices in the region.

The information from the two main survey components was complemented by eradication data provided by NDLEA, open source geospatial remote sensing datasets, and seizure data from UNODC’s Drugs Monitoring Platform.

The methodology applied for the area estimation of the Nigeria cannabis survey followed the standard practices developed under UNODC’s illicit crop monitoring programme and were tailored to the Nigerian context to overcome country-specific challenges.

Cannabis cultivation in Nigeria has particular features that make its detection through remote sensing difficult:

- The agricultural practices have the peculiarity of the slash-and-burn, a form of shifting cultivation where the woody vegetation of forested areas is cut down and burned as a method of clearing and enriching the land for cultivation. The same farming method is applied in the same areas to other herbaceous crops (e.g., cassava). In remote sensing data, unless they are of very high quality, cannabis plants can be easily confused with other crops, as well as with the surrounding vegetation.

- The large (92,000 km2) survey area is covered by clouds for most of the year and the amount of rainfall is very high even during the “dry” season. Due to the high level of humidity, the occurrence of haze and fog is also very frequent. Those weather conditions make the use of optical satellite imagery infeasible.

Ground truthing activities were logistically very difficult to implement; baseline information about the location of the cannabis fields was relatively scarce, coming mostly from eradication sites reported by NDLEA.

In view of these challenges, the approach and the design of the survey were required to consider the following:

**Primary data source:** The persistent occurrence of clouds and haze over the study area made the use of satellite imagery impossible. Therefore, professional aerial photos, taken from an aircraft that was capable of flying below the cloud ceiling, were a primary data source used to implement the survey.

**Data quality:** To serve their purpose, the professional aerial photos needed to have a very high spatial resolution of 25cm/pixel or better, with a level of overlapping that allows for processing into orthophotos and georeferencing. This type of image can only be acquired by operators specialized in aerial surveys, with significant cost consequences; the price for such services results from the combination of processed imagery (area covered) and the aircraft service (flight time).

**Flight lines:** A sample approach was required because of budget implications. Covering the entire survey area with orthophotos was not a sustainable option. To maximize the efficiency of the flight time assigned to the campaign, it was decided to use north-south flight lines as sample units instead of squares. Thus, distance flown for transfers from one sample to the other was decreased.
Risk map and sampling frame

The regional scope of the survey area (area of interest) was defined in collaboration with the NDLEA, which provided accounts and evidence of cannabis seizures and cannabis farming in the country over the last decade. The area of interest (AOI) was restricted to six states in the south-west and south-central regions of the country, namely Edo, Ekiti, Ogun, Ondo, Osun, and Oyo, covering a total area of 92,000 km².

The study area was classified based on an analysis of crop suitability with consideration being given to the geographic and climatic conditions of Nigeria, complemented with georeferenced historical records of cannabis eradication and seizures reported by NDLEA. Key geographic variables were the favourable weather, rainfall distribution, proximity to forest, the distance to large cities and settlements, and the elevation above the sea level.

A risk map was created, which represented the likelihood of finding cannabis crops/cultivation over the geographic area of interest. It was generated based on forest coverage, elevation above the sea level and the occurrence of large cities/settlements, and by removing areas deemed unsuitable for cannabis cultivation. A forest mask was produced from the Global Forest Change (GFC) project data to derive the percentage of canopy cover updated to the year 2014 by merging the two 30m spatial resolution GFC datasets (Tree Cover 2000 and Forest Cover Loss 2000–2014) over the AOI. Forest areas suitable for cannabis cultivation were considered as those pixels with raster values of tree cover between 20 per cent and 80 per cent. The values below 20 per cent were not considered as forests, and the pixels above 80 per cent were assumed to have too dense a canopy cover for cannabis cultivation.

An elevation mask was built with the Shutter Radar Topography Mission (SRTM) digital elevation model (DEM) to avoid surveying lowlands. All pixels higher than (or equal to) 12m above the sea level were assigned the value 1 and pixels below this altitude threshold, the value 0.

In order to create the final risk map, a 2x2km vector grid was built, then a layer of centroids was created over the grid to transfer raster information to the vector grid. The total risk at grid cell level was calculated according to the following equation:

$$\text{Total Risk} = F \times E \times C$$

Where

- $F$ is the risk factor related to forest proximity [floating range (0–1)]
- $E$ is the risk factor related to elevation [binary (0/1)]
- $C$ is the risk factor related to cities [binary (0/1)]

Mean values were calculated for forest and elevation masks at the grid cell level: the proportion of pixels with value 1 within the cell for elevation, and the proportion of ‘forest cover’ pixels in case of a forest mask. Risk related to forest ($F$) was thus calculated at grid cell level as the proportion of canopy cover; for example, a completely covered cell assumes a value = 1, while a half-covered cell, a value = 0.5. For all cells of the elevation mask where the coverage value calculated from the mask was below 0.5m, elevation (E) was considered to have a 0 value. Otherwise, the value 1 was assumed.

Large cities (> 4,800 ha) were taken into account while producing the risk map. Thus, all grid cells intersecting the “large cities” shapefile were assigned a C value of 0, while for the other cells the C factor was assumed to be 1. The final output was stratified into two classes, “high risk” and “low risk”, to represent the probability of risk, considering the land cover. A total risk of 0.5 was used as a threshold, and for survey purposes a risk > 0.5 was considered high. The resulting risk map is shown below.

The risk map was further refined by removing areas deemed unsuitable for cannabis cultivation, namely lowland areas often flooded according to annual precipitation and water discharge, and large cities. For the sampling frame, high and low risk were not considered but all risk was merged to one category. The final masked risk area is shown below.

Sampling approach, sample size and sample selection/allocation

Because of the large size of the study area (92,000 km²), a sampling approach was the most cost-effective method, given the required accuracy. An area frame sampling design is a widely used methodology in agricultural statistics and in other illicit crop monitoring surveys within the framework of the UNODC’s global Illicit Crop Monitoring Programme.

The sampling frame was defined within the final masked risk area. The frame was established as longi-
MAP. 9  Risk map

MAP. 10  Final masked risk area for sampling frame
tudinal flight lines to better accommodate the operational requirements of an aircraft and to maximize the survey share budgeted flight time by reducing the transfer time from one sample unit to the other. The risk defined in the risk map was multiplied by the length of each flight line of the potential sampling frame, and 20 per cent of areas with shortest segments were cut off before creating the final sampling frames (for each state). The cut-off was done for operational reasons, i.e., to maximize the area covered with longer flight lines, as the main aim of the survey was to geographically cover as much as possible for the first baseline study in the six states. Longer flight lines were considered as more efficient to cover a larger survey area with less flying time. For the same reason, high and low risk were not considered in the definition of the sampling frame. After cutting off the shortest segments, the final sampling frame was created for each state.

A systematic random sampling was applied to each state frame. The available flight hours were allocated equally between the states and defined the sampling interval. In total, 67 sampled flight lines were selected for the aerial mission. Eventually, however, sample flight lines were split to 152 shorter flight strips for operational reasons.

Data collection during aerial overflights

The acquisition of very high-resolution aerial imagery at the appropriate growth stage of the cannabis plants is key to the successful identification of cannabis fields on images. The overflight mission to collect the data was conducted at the end of the rainy season and immediately before the reported main annual harvesting time. The mission commenced on 20 September 2019 from Lagos airport and ended on 18 October 2019. Eventually, 55 flight hours were completed over 10 days of effective flight (adverse weather conditions did not allow for flying on a daily basis).

The operator prepared a flight plan according to the selected aerial sample. The 67 sample flight lines were further split into 152 shorter strips due to operational and flight practicalities, the need for optimal camera recordings, and the desire to reduce costs. The length of each strip to be flown was on average 40km (between 25km and 50km) and the distance between the strips within a state varied between 11km and 15km. The overflights were conducted with a light fixed wing aircraft (Diamond DA 42) mounted with a vertical camera (Phase One 150MP RGB). The camera was programmed to take images with 40 per cent overlap along the strip for a better georeferencing and orthorectification of the images. The flight height was kept between 2425ft and 4062ft (739m–1238m).
above the ground considering optimal camera performance, weather conditions (to fly below cloud ceiling), and terrain. The flight operation team included 8 members (2 from the UNODC, 4 staff of the air-operator company, NDLEA, and a military observer).

Of the 152 strips, 127 were operated as planned whereas 25 could not be flown, 6,004km and 1,011km respectively, due to the prevailing weather (clouds, rain and storms) and logistical challenges. During the campaign, the core air base was moved from Lagos airport to Benin City (Edo state), to make more efficient use of the flight hours in the east of the AOI. The weather conditions were improving during the survey period, allowing for flying almost on a daily basis.

A coverage of 4,500 km² of aerial images were captured during the overflights, equivalent to approximately 17,185 photos with visible light channels (Red-Green-Blue) and 2.6 terabytes of data. The spatial resolution of the collected ‘raw data’ is 6–10cm depending on the varying flight altitude during the overflights.

### TABLE 2

<table>
<thead>
<tr>
<th>State</th>
<th>No. of sampled flight lines</th>
<th>No. of flight strip</th>
<th>Flight strips flown successfully</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edo</td>
<td>16</td>
<td>41</td>
<td>25</td>
</tr>
<tr>
<td>Ekiti</td>
<td>6</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Ogun</td>
<td>11</td>
<td>20</td>
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<td>Ondo</td>
<td>13</td>
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<td>24</td>
</tr>
<tr>
<td>Osun</td>
<td>9</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Oyo</td>
<td>12</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>152</td>
<td>127</td>
</tr>
</tbody>
</table>

Data pre-processing for analysis and interpretation

The images (originally in Phase One’s proprietary, IIQ format) were captured at pre-defined locations in the air, so that the optimal image overlap is obtained for the process of aerial triangulation. The size of the image is determined by the sensor, 150 megapixels in this instance.

The original raw images were fitted onto each other (through aerial triangulation) and then “mosaicked” into a single TIFF image. This single mosaic of images was too large for a PC and standard GIS software. Therefore, the orthoimage mosaic was “tiled”, i.e. divided into equal sizes (500m X 500m) along a grid.

The orthophoto tile therefore has a different number of pixels than the raw image. The tile might be fully covered or only partially covered by the captured images depending on the tile location definition and the position where the photo is captured. There was significant overlap (approximately 50 per cent) between individual raw images, which means that every pixel in the orthophoto is not unique (i.e. the pixel in the orthophoto might be captured by multiple raw images). An orthorectification process was carried out to correct distortions caused by the camera sensor and terrain. Each image was processed by projecting its pixels onto the SRTM-1 Digital Elevation Model (DEM) and mosaicking by selecting only the pixels nearest to the nadir from
MAP. 12  Final status of the operated flight strips

![Map showing the final status of the operated flight strips in Nigeria.](map.png)

TABLE 3  Number, length, and success of the operated flight strips

<table>
<thead>
<tr>
<th>State</th>
<th>No. of planned flight strips</th>
<th>Total length (km)</th>
<th>No. of strips flown</th>
<th>Flown (km)</th>
<th>Coverage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edo</td>
<td>41</td>
<td>1,592</td>
<td>25</td>
<td>953</td>
<td>60</td>
</tr>
<tr>
<td>Ekiti</td>
<td>11</td>
<td>405</td>
<td>11</td>
<td>405</td>
<td>100</td>
</tr>
<tr>
<td>Ogun</td>
<td>20</td>
<td>797</td>
<td>17</td>
<td>647</td>
<td>86</td>
</tr>
<tr>
<td>Ondo</td>
<td>25</td>
<td>932</td>
<td>24</td>
<td>895</td>
<td>96</td>
</tr>
<tr>
<td>Osun</td>
<td>15</td>
<td>621</td>
<td>15</td>
<td>621</td>
<td>100</td>
</tr>
<tr>
<td>Oyo</td>
<td>40</td>
<td>1,655</td>
<td>35</td>
<td>1435</td>
<td>87</td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td>6,002</td>
<td>127</td>
<td>4,957</td>
<td>83</td>
</tr>
</tbody>
</table>
TABLE 4  Survey coverage, risk area, by state and total.

<table>
<thead>
<tr>
<th>State</th>
<th>State area (km²)</th>
<th>Risk area (km²)</th>
<th>Sample coverage (km²) *</th>
<th>Processed sample coverage (km²) **</th>
<th>% of risk area represented by processed sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edo</td>
<td>19,589</td>
<td>17,075</td>
<td>895</td>
<td>681</td>
<td>4.0</td>
</tr>
<tr>
<td>Ekiti</td>
<td>5,237</td>
<td>5,069</td>
<td>395</td>
<td>269</td>
<td>5.3</td>
</tr>
<tr>
<td>Ogun</td>
<td>16,093</td>
<td>11,734</td>
<td>565</td>
<td>450</td>
<td>3.9</td>
</tr>
<tr>
<td>Ondo</td>
<td>14,527</td>
<td>11,060</td>
<td>796</td>
<td>579</td>
<td>5.2</td>
</tr>
<tr>
<td>Osun</td>
<td>9,190</td>
<td>8,561</td>
<td>548</td>
<td>422</td>
<td>4.9</td>
</tr>
<tr>
<td>Oyo</td>
<td>27,399</td>
<td>26,250</td>
<td>1,322</td>
<td>997</td>
<td>3.8</td>
</tr>
<tr>
<td>Total</td>
<td>92,035</td>
<td>79,749</td>
<td>4,521</td>
<td>3,399</td>
<td>4.2</td>
</tr>
</tbody>
</table>

* Area in raw images acquired with camera including areas of so-called background pixels that cannot be used for analysis and interpretation.
** Area in processed ortho images that can be used for the analysis and interpretation of cannabis fields.

individual images, thus ‘trimming’ the overlapping areas. Due to these various factors, the number of raw images and number of orthophoto mosaic tiles will be different. As a result, 30,044 image tiles of approximately 500m x 500m and of 0.10m spatial resolution were generated.

Enhanced Compression Wavelet (ECW) was chosen as the final format for the orthophotos because they have a near-lossless compression, they have a smaller file size (than GeoTIFF), and because they render more quickly and are thus easier to use in various GIS software. All orthophoto files were named with a unique numbering sequence, consisting of a flight strip and a consecutive number.

Footprints were generated in Shapefile format for each orthoimage to facilitate a better exploitation of imagery for analysis, interpretation and the calculation of final estimates. Footprints were created for the actual image area captured, excluding background pixels that do not represent real landscape features on the ground. Each footprint in the Shapefile was attached to the corresponding image file name and other relevant attributes such as the acreage.

Analysis and interpretation

The analysis was based on a visual interpretation technique which used all orthophotos as the principal dataset for analysis, supported by a few auxiliary datasets, e.g. the footprints, administrative boundaries, open source satellite imagery and the data eradicated from NDLEA. The work was conducted systematically, strip by strip, to analyse and interpret all images and digitize detected cannabis fields. A typical analysis and interpretation workflow included the following steps and considerations for analysis, not necessarily in the order given below:

- Familiarize oneself with typical agricultural practices and common crop types on the imagery within the AOI.
- Import a limited batch (~50-100) of ECW images to avoid GIS software and computer hardware performance issues.
- Review images with auxiliary datasets to enhance visual understanding of cannabis and other crops.
- Look for scale indicators, e.g. features of known size (palm trees, huts, etc.) as a reference, to enhance visual understanding of the scene.
- If clearly identifiable cannabis was found, scan
surroundings visually and look for similar patterns (colour, structure, arrangement of fields) and typical features identified in the vicinity of confirmed cannabis fields (e.g. rudimentary huts, shelters, drying facilities).

- Be aware that the inclination/angle from which the image was acquired from the plane significantly affects the appearance of cannabis on the image, e.g. whether a field is viewed vertically straight down from the nadir angle or from oblique angles.

- Place markers at suspicious fields in the first round of interpretation for further analysis and confirmation in the second round.

- Place markers on the images for observed features that help to facilitate a better understanding of a scene. Some are placed near the remaining cannabis plants within the category 2 or 3 fields (see the categories below). Some other ones are placed near other features that may be associated with cannabis cultivation such as rudimentary shelters, drying facilities for harvested cannabis and other typical features found near the cannabis fields.

- The ability to identify cannabis fields improves gradually over time, as the experience of the particular landscape and context increases.

- Start digitizing field boundaries in the second run, due to the experience gained in the first run. New fields are likely to be found in addition to those already marked in the first round.

- Assign appropriate class numbers to the identified fields that were confirmed as cannabis.

The main output derived from the analysis was a Shapefile containing all confirmed cannabis fields as polygon features, thus enabling the storage of accurate field boundaries and information pertaining to attributes, e.g. acreage for each interpreted field. All fields were classified into three categories as follows:

- Category 1: Fields with clearly visible standing cannabis plants
- Category 2: Fields harvested partially, directly adjacent to a Category 1 field (assumed former extend of the field)
- Category 3: Fields fully or mostly harvested, i.e. isolated fields with sparse sporadic cannabis visible within the suspected extent of a former field

Category 1 includes some 90 per cent of all confirmed fields that were detected on the imagery. The field boundaries of the two other categories are somehow speculative. However, these fields were also confirmed as current or former cannabis fields.

In addition to the confirmed cannabis fields, around 80 suspected fields were identified on the aerial imagery, all of them in Ondo and Edo states, and digitized as Shapefile points for possible later analysis. These fields, however, could not be confirmed as cannabis fields and were not considered in the area estimate. Their boundaries could not be clearly interpreted for various reasons, such as the fact that cannabis may have been cultivated together with other crops (intercropping) or that cannabis may have been harvested before the image acquisition.

Quality control

An independent quality control mechanism was applied to the image interpretation process, with each analyst’s work being checked by other experts. Corrections to field delineations and classifications where made, when needed.

Due to security and logistic issues, it was not possible to conduct a ground truthing mission in a timely manner. (The aerial survey was carried out just before the harvesting time.) However, because of the extremely high spatial resolution and the very good overall quality of the imagery used as a primary data source, the identification of cannabis fields has a high degree of precision.

Area estimation

The area estimation of the extent of cannabis cultivation at the national level was a ratio estimate using the observed area as an auxiliary variable. The estimation was done separately for each state and the total was a sum of these separate estimates. To that end, a simple ratio estimate was calculated, which was then extrapolated to the risk area for each state.

The sample mean was calculated as the sum of all cannabis detected in the strips over the total area observed in the state (combined ratio estimate). The area estimate was then the product of the sample mean and the risk area identified in each state. The estimate for the entire AOI was obtained by adding up the state estimates.

Bootstrapping\(^{33}\) was performed to estimate the confidence intervals of the area estimates. This was necessary as the heavily skewed distribution of cannabis cultivation in the samples led to unrealistic confidence intervals when applying the standard methods.

\(^{33}\) http://cran.r-project.org/web/packages/boot/index.html
Cannabis cultivation density map

Cannabis density was calculated based on detected fields during the aerial survey and a map was generated to depict densities in the surveyed states. The map is based on the fields found in the observed area; the presence of cannabis fields outside of this area cannot be ruled out. Densities were calculated as the relative number of fields found located within a radius of 40 kilometres around a location. “High density” represents areas with the highest observed concentration of cannabis fields per unit area, “low density”, with at least a single field within the radius.

The output values are points per area (i.e., square kilometer). The magnitude of the value corresponds to the relative frequency of points that can be found considering the identified 711 fields. In this case 0.16 is the highest value that is expected for a cell and this value depends on the cell size and the total number of points in the population (711). The total volume of the density surface is equal to the entire population, i.e., the sum of all the cells is nearly 711.

Structured key informant interviews

Questionnaire design

The questionnaire was designed to collect information on common agricultural practices of cannabis cultivation, the organization of cannabis trafficking in the region and Nigeria, common cannabis products trafficked, and information on prices in the region. All questions were designed in an open-ended format, that allowed for the filling-in of any information that is deemed relevant. The questionnaire was divided into six modules, aiming at gaining an understanding of the following topics:

Module 1: Introduction
Module 2: Agricultural practices of cannabis cultivation
Module 3: Information on cannabis farmers and cannabis supply chains
Module 4: Cannabis products and the early stages of trafficking
Module 5: Markets and prices
Module 6: Additional information

Conducting the survey

The key informant survey focused on the six states (Edo, Ekiti, Ogun, Ondo, Osun, and Oyo) that were surveyed with aerial overflights. Additionally, informants from 17 other states were interviewed with the same questionnaire to support the analysis of the six states.

Data analysis

All informants of the six core states in the major cannabis-producing part of Nigeria (Edo, Ekiti, Ogun, Ondo, Osun, Oyo) completed and returned the cannabis survey questionnaire. Interviews were coded and analysed using thematic analysis. This involved the reading and re-reading of interview reports submitted by informants after which an initial idea was formed, often related to suggested leads in the questioning. After collating, reading and carefully going through the data, codes were generated systematically. At this stage, data relevant to each code was collated. Codes were then grouped into potential themes and all data relevant to each theme was gathered.

In the case of this study, the already-existing modules were used as the themes, and the four themes used are as follows:

Module 2: Agricultural practices of cannabis cultivation,
Module 3: Information on cannabis farmers and cannabis supply chains,
Module 4: Cannabis products and the early stages of trafficking, and
Module 5: Markets and prices.

These themes were defined, and names adopted after ensuring that the sub-themes and the coded extracts were related. A thematic map was then created. To enhance the reliability and validity of the findings, some experts in qualitative research independently read sample transcripts and assessed the coding scheme (Syed and Nelson 2015). Discrepancies and confusion highlighted by the assessors were discussed and unreliable codes were dropped or merged, and definitions of the codes were clarified. The narrative report highlights key findings for each sub-theme and in most cases lists the responses from each of the project states.
