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Land governance and lack of an appropriate cadastral management system

The case study of land rights regularization in informal settlement using geospatial data collected with uav in yaoundé, cameroon.

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ABSTRACT

The Unmanned Aerial vehicle (UAV), also known as drone, is a photogrammetric platform used as alternative solution to overcome the limits of traditional surveying methods. This study aims to analyze a small study area in Yaoundé, Cameroun using high resolution geospatial data of UAV and STDM for recording of land right in informal settlement. The study shows that, the high-resolution aerial images of UAV based on orthophotos can be used to solve problems related to land governance and the regularization of tenure rights through participatory boundary delineation and mapping approach. We noticed many problems related to the land ownership illustrated by contradictions between the municipal administration data and the results of our investigations. The CUY publishes that, out of 16.70% of the people with land certificates, 9% of the potential owners confirmed their rights, while the land map issued by the council is showing three. A well-established municipal housing estate would never have been transformed into an informal settlement with the existence of its own computerize land management system. The advantages of UAVs (large and rapid aerial georeferenced data collection in less time, with high accuracy at low cost) make it possible to develop such a system in order to secure the land rights of all, particularly for the poor living in informal settlements.

Keywords:

Cadastre, Illegal occupation, Informal settlement, Unmanned Aerial Vehicle, Tenure insecurity

1. Introduction

The accelerated urbanization in Yaoundé, like in most capital cities of developing countries, is attributed to an unprecedented population increase resulting from rural-urban migration. The unrestricted growth and expansion have resulted in the attendant expansion of development on the fringe of disaster-prone areas. It has been observed that the proliferation of indiscriminate informal settlements is attributed to the defects in the urban planning policies, such as improper housing policies, incompatible and inconsistent master and layout plans, lack of harmonized land tenure and administration. The fragile implementation and reinforcement of land development regulations and violation of urban planning rules and standards are an evidence that the authorities in charge lack adequate geospatial data and its processing power to handle the dynamics of the informal settlements. Most satellite informal settlements around major cities across the world especially in developing countries have since degenerated into slums/ ghettos with poor substandard living environment, acute shortage of drinking water, inadequate health care centres, noise and air pollution, indiscriminate waste dumpsites, blocked drainage channels, and impassable appalling road networks. These scenarios present wonderful challenges to urban planners and development and have hindered service delivery. It requires a set of criteria for public space such as streets, affordable housing and the integration of land uses (UN-Habitat, 2018), expected to meet the requirements of international standards on development. Up to date and accurate urban plans and other supporting technical documents provide the basis for any sustainable intervention and reforms of informal and vulnerable settlements to attain a formal status. This task requires a well-designed standard cadastral plan, land use plans and layout plan of the entire cities. Cameroon in general and the city of Yaoundé in particular are in the list of developing countries where less than 30% of the land is covered by a cadastral plan (Lemmen, Augustinus, Haile, and Van Oosterom, 2009). It then implies that about 70% of the landed properties in these countries are not included in a formal registration system (Lemmen & Augustinus, 2009; Augustinus, 2010; Lemmen, 2010; Zevenbergen et al., 2013) to better manage the occupation of land (UN-FIG, 1999).

In the past decades, well-known traditional surveying methods, and worldwide accepted, have played an important role in the field of mapping. However, these methods are of limited use in the case of inaccessible areas which present dangers for the safety of surveyors. UAVs are alternative tools that can overcome these limitations and rapidly produce a large volume of georeferenced geospatial data at a lower cost (Darwin, 2017; Mantey & Tagoe, 2019; Eisenbeiss, 2011; Everaerts, 2008 cited by Mantey & Tagoe , 2019) with accuracy which is practically impossible with the manual methods. The advantages of this technique show that it can be used by several actors in the fields such as: municipal services, agriculture, forestry, town planners as well as cadastral services for drawing up plans and land data management for tenure security (Darwin et al., 2013; Barnes, et al., 2014; Darwin, 2017). UAVs also represent an important tool necessary for improvement of urban planning, land administration and management; property demarcation, beside supporting land registration and recording of relationships between people and the land (Manyoky, et al., 2011; Barnes & Volkman, 2014; Mumbone, 2015; Darwin, 2017; Odwe, 2017; its4land,2017, Claudia, Bennet, Zevenbergen, 2017).The urban growth and insufficient housing supply to meet the ever-

increasing demand have led people to settling indiscriminately and sometimes in disaster prone areas that are unsuitable for human inhabitation.

2. Problem statement

The accelerated urbanization in Yaoundé, like in most capital cities of the developing countries, is attributed to the unprecedented population increase resulting from rural-urban migration. The urbanization rate of the city of Yaoundé is about 7.9 percent with an annual population growth rate of 5.7 percent (BUCREP, 2010). The unrestricted growth and expansion have resulted in the attendant expansion of development on the fringe of disaster-prone areas. It was observed that the proliferation of indiscriminate informal settlements is attributed to the defects in the urban planning fonts, such as improper housing policies, incompatible and inconsistent master and layout plans, lack of harmonized land tenure and administration. The fragile implementation and reinforcement of land development regulations, urban policy plans by the Municipal Authorities are an evidence that the authorities lack adequate geospatial data and their processing power to handle the informal occupation dynamics. The customary land law based on the inheritance rights is opposed to the inherited land legislation of the colonial administration, whose main principle is transcription and registration (Decree 26/07, 1932). This has resulted into various problems ranging from bureaucratic bottle necks land tenure security, costly and tedious procedures.

After the country's independence in 1960, the city of Yaoundé, the country's political capital, experienced a series of planning operations aimed at better organizing the urban space. Thus, a municipal housing estate intended to re-settle displaced populations during urban planning operations created in the Nkolndongo neighborhood. It was created on the basis of Decree No. 65/40 of 1 March 1965 declaring public utility works for the development of Messa, Mfandena, Nkolndongo and Essos neighborhoods. The Nkolndongo district is one of these "resettlement areas" which was to receive the inhabitants of the city who were forced to leave the places previously occupied because of the town planning work undertaken in the city. The specifications related to the obligations for the allocation of a plot of land signed by the mayor of the city of Yaoundé on April 21, 1967 specify the conditions for the allocation of the said plots. The allocation of plots which took place between 1972 and 1973 (Franqueville, 1984), was done by a commission made up of the mayor and two councilors. This commission concedes free of charge to each beneficiary by issuing him with a provisional allocation certificate. The development of the plot within a period not exceeding one year is intended for the construction of a home in final or semi-final materials; Mandatory closing of the plot with an hedge planted as soon as the provisional award certificate is awarded; Filing of a building permit application which sets the rules relating to The alignment of the facades, the dimensions of the buildings and the dividing lines between constructions. Provisional concessionaires are prohibited from selling or renting or erecting constructions before the final title is granted.

The final title is only issued after approval by the municipal commission of recognition of the development of the plot in strict compliance with the clauses of the specifications. Failure to comply with these clauses leads to the forfeiture of the concessionaire and the plot goes to the city council of Yaoundé (CUY). Cameroon as a whole does not have a cadastral plan, less than 6 percent of the land is registered there (AfDB/ADF /2009/342). Thus, in the absence of any land information

management system covering the entire city of Yaoundé, it is not easy to make a clear inventory of the land issues in this district right now. In the absence of a reliable directory at the urban planning department of the CUY, making it impossible to clearly identify which plot belongs to which owner exactly. The reconstitution of land data relating to the first concessionaires and buyers becomes difficult if not impossible.

3. **Location of the study area**

Yaoundé, the political Capital of Cameroon, is located between 3 ° 45 'N and 3 ° 59' N of the Equator, and 10 ° 94 ' E and 11 ° 58' E of the Prime Meridian. It is situated at approximately 200km from Atlantic coast in the middle of equatorial forest. The city is built on a hilly site hence the name of "The city of seven hills". This study is about Nkolndongo 8 covering an area of 0.102km^2, located within a flood plain in Yaoundé IV subdivision. This explains why our study area figure 1 below, is situated in a flood plain.

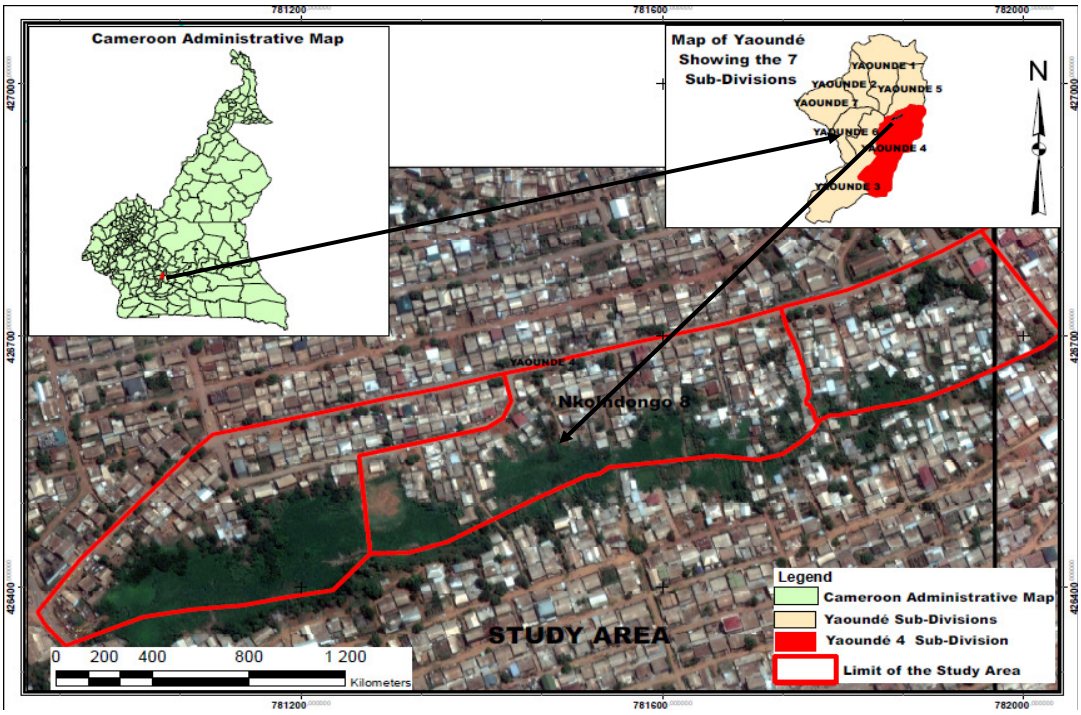

Figure 1a: Satellite Image of the Study area (Source: CUY)

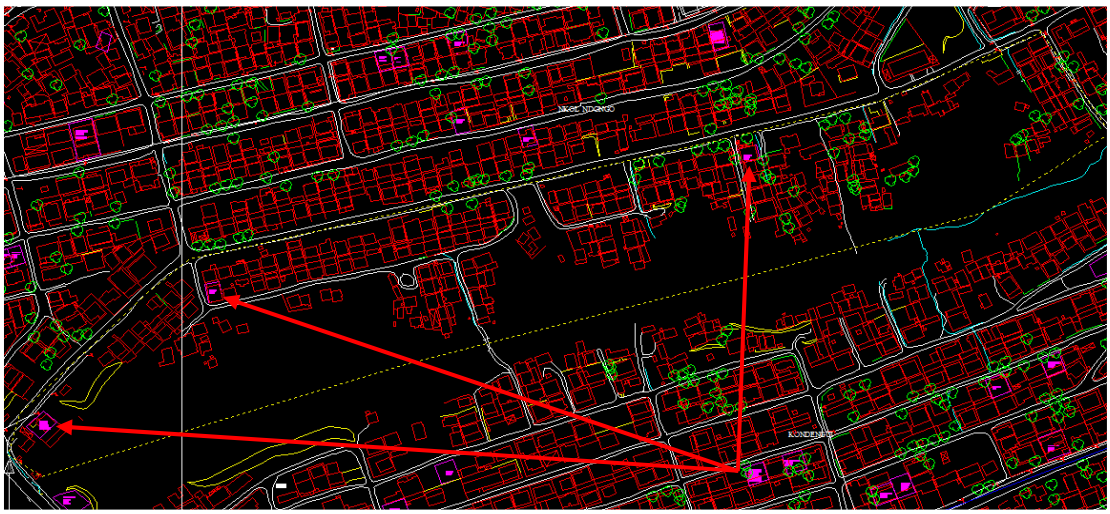

Figure 1b: A land map of the study area showing 3 land titles
(Source: CUY last updated on 07/07/2015)

4. Justification for the use of UAVs to regularize the area and development of cadastral plans

From the observations made in the previous studies, it is wise for cadastral and municipal services to use UAVs to overcome the problem of varied and incompatible reference systems (Mantey & Tagoe, 2019). UAV also called Drone or Unpiloted Vehicle Systemor represents an aircraft flying without human body on board (Saripalli et al., 2003; Valavanis, 2008; Anon.,2017 cited by Mantey & Tagoe, 2019). As suggested through effective and efficient land administration framework, geospatial data may be integrated to land sector as support in achieving sustainable development goals (UN-GGIM, 2019). Moreover, the use of geospatial information is an essential basis for an effective and efficient land information system to support the administration of land policy frameworks, customary rights, security of tenure, property rights, sustainable development and overall environmental, economic and social wellbeing. Access to geo-referenced images with high spatial resolution of UAVs allows the collection of more data at a lower cost and a relatively short time (Barnes et al., 2014; Norzailawati, 2018; Mantey & Tagoe, 2019). UAV Surveys with their very high-resolution imagery are an alternative tool to solve challenges associated with classical land surveying methods to create cadastral plans (Darwin et al., 2013, Puniach et al., 2018).

4.1 UAVs geospatial data as foundation of cadastral and urban planning plans

This imagery has greater value, and can be tied to the new Cameroonian geodetic control network, which is the spatial foundation to implementing cadastral plan (AfDB,2009). A study conducted by Zein (2016) demonstrates that very high-resolution aerial images are ideal for urban work and their use depends on the level of details desired. This technique has the advantage of allowing several users to access and this usage of information. These services are: Land administration, Cadastral, cartographic, municipality, urban planning etc. In 2017, Norzailawati & Nur had conducted a study on the evolution of UAVs application from the urban planning perspectives. With the rapidly evolving technology, UAVs provide potential uses in many aspects of urban life, including urban planning fields. The multiple use of UAVs images also helps with land valuation, the development of participatory mapping, and the subsequent registration of land rights of inhabitants (Norzailawati, 2018). This new spatial data acquisition technology is an alternative way to overcome the use of

traditional topography, photogrammetry or remote sensing methods used up to now for the development of cadastral maps. This can serve as a basis for the MINDCAF to set up an accurate cadastral system, based on high-resolution UAV geospatial data (figure 2a and 2b) below.

Figure 2a: UAVs single scene imagery

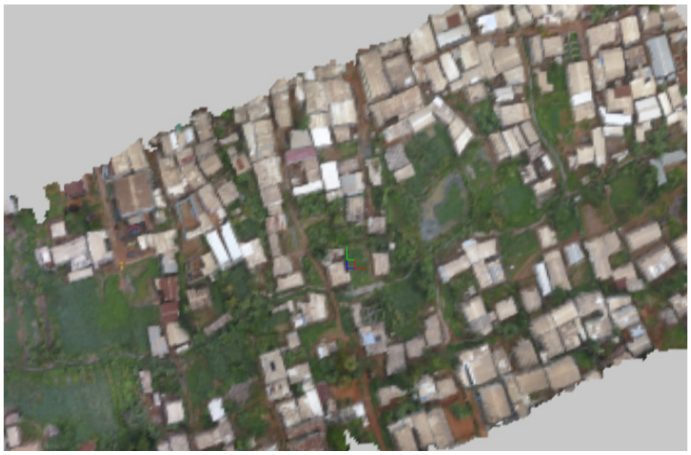

Figure 2b Orthophoto for map production

UAV technology can be applied to solve this problem as highlighted by the last few studies in highly automated mapping techniques and offers a new methodology for producing better and cheaper data (Kelm, 2014, Norzailawati, 2018; Mantey & Tagoe, 2019). This cheaper support can tie the production of planning documents not always available in municipalities. Easily accessible technology, municipal technical staff can acquire it to support local land management. The MINDCAF can also facilitate the integration of UAVs data collection in the development of cadastral plan, participatory mapping and governance network.

4.2 Benefits of the cadastre in the urban area

4.2.1 Benefits in the security of tenure:

As defined by Bruce & Mighot-Adholla (1994), tenure security is "the right, felt by the owner of a parcel of land, to manage and use his parcel, to dispose of his product, to engage in transactions, including temporary or permanent transfers, without interference from any natural or legal person".

This definition, which is considered to be fairly complete, assumes that land tenure security gives the holder of the parcel all the prerogatives of the right of ownership. In this case the owner is the absolute master of his plot. But he can be deprived of his rights in case of declaration of public utility for the construction of an infrastructure for community benefit. However, according to the city council authorities, 83.30% current occupants in our study area do not have any temporary allocation certificate issued by the local authority allowing them to benefit from land security on their plot. This situation could have led the municipal authorities to evacuate them. The lack of a cadastral system with a unique identification number (Silva & Stukjaer, 2002; Enemark, 2010; Williamson, Enemark, Wallace and Rajabifad, 2010), associated with a directory making it possible to easily find and locate the beneficiaries of the plots during resettlement operations doubled to a large number of illegal occupiers that led the municipal authorities to initiate a land regularization operation in this area. The identification number and the directory would have made it easier to find the illegal occupants. According to Dale & McLaughlin (1999) cited by Francis & Alain (2008), the cadastre is

defined as a public register of land ownership, which assigns value and which illustrates the fragmentation of a territory with each of these parcels registered separately and which identifies the owner. Land administration in Cameroon does not allow an inventory of land properties. It is difficult, if not impossible, to say exactly who owns a particular piece of land, at a particular location with such geometric features. Access to land, individual and secured land tenure rights are widely recognized as a vital component for fighting against poverty, housing and sustainable agriculture, management of natural resources and environmental protection (Agenda 21,1992).

Around the 1970s, when resettling the populations evacuated during town centre development operations, Cameroon did not have the IT tools for developing subdivision plans. The plans drawn up by hand (Figure 3) and poorly preserved do not currently make it possible to retrieve useful information or to facilitate their updating. These benefits also secure the security of land rights which must be enjoyed by populations such as those settled in this study area. The benefits of a cadastral system set up will help the cadastral administration to overcome the shortcomings identified in the diagnostic study cited above.

4.2.2 Benefit at the technical level:

The Cadastral system, mostly when computerized, has several benefits at technical and economic levels. It can easily be combined with GIS and facilitate the updating, display, removal, backup and dissemination of geospatial information. It is a technical instrument of land information management system and its use enables decisions making with spatial reference (Enemark, 2004, Bennett et al., 2008; Williamson, 2008; Dale & Mc Laughlin, 1999, cited by Francis & Alain, 2008). The cadastre can allow the local administration to control its territory in order to ensure environmental friendly development. A well-drawn up cadastral at this period would have been based on the previous layout plan. Even when the layout plan in Figure 3 has numbers, these ultimately do not refer to any information on the official holder of the said plot. These information on the owners of the parcels would have been a possible solution to limit illegal and uncontrolled occupations. It can be used as a control tool for the municipal technical services. They will serve as a benchmark for the municipality to reconstitute the register of beneficiaries having benefited from the plots of land in the study area. This will prevent illegal occupations in the future and limit the creation of informal settlements.

5. Cameroonian land administration system and its weaknesses

The present status of land administration in Cameroon does not allow an inventory of land properties. Today, less than 6% of land is titled in Cameroon (AfDB, 2009), which does not allow a real assessment of the land occupied and belonging to well-defined people. Cameroon is amongst the list of some developing countries where less than 30% of the land is covered by a cadastral plan (Lemmen, Augustinus, Haile, and Van Oosterom, 2009). It then implies that about 70% of the landed properties in these countries are not included in a formal registration system (Lemmen & Augustinus, 2009; Augustinus, 2010; Lemmen, 2010; Zevenbergen et al., 2013) to better manage the occupation of land (UN-FIG, 1999). With the current state of inconsistence in land administration and cadastre information management system in the country, it is difficult, if not impossible, to say exactly who owns a particular piece of land at a particular location. According to Dale & McLaughlin (1999) cited by Francis & Alain (2008), the cadastre is defined as a public register of land ownership,

which assigns value and which illustrates the fragmentation of a territory with each of these parcels registered separately and which identifies the owner. Atilola (2011) opined that every Government must develop and provide appropriate institutional framework that would ensure transparency and accountability and public confidence in all land administration and reform programme.

Diagnostic studies to improve the management of cadastral system and state property in Cameroon (AfDB, 2009) have identified five shortcomings, including: 1) Difficult access to land ownership; 2) insufficient supply of public land; 3) Poor management of state assets; 4) No reliable cadastre; 5) Insufficient human and material resources. Finding solutions to these shortcomings is a prerequisite for the implementation of a multipurpose and reliable cadastre for the whole Cameroon. In addition, the country has a basic cartography developed at a scale of 1: 200,000, which does not allow the implementation of cadastral plans (AfDB, 2009).

This inadequacy of the cadastral system seems to be a common problem in urban areas and sees the emergence of informal settlements where the occupants are without basic urban infrastructures, neither sanitation system, nor access to drinking water, electricity and living with stress of potential eviction. To find support for these weaknesses, all the administrations in charge of land matters (municipalities and Mindcaf services) must favour the computerization of their services in order to facilitate the processing, management and backup of files relating to the protection of land rights, mostly for the poor living in informal settlements.

Internationally, the Global Land TOOL Network (GLTN) supported by UN-Habitat has developed a pro-poor land management tool to reduce the gaps related to untitled land, assist in the rehabilitation of informal settlements and manage land in rural as well as in urban areas (Agustinus, 2010). This system of management and land administration for poor people in urban and rural areas can be linked to the cadastral system to allow registration and securing the land rights of all (Augustinus, Lemmen & Van Oosterom, 2006). Thus, Cameroon, which is in the midst of land reform, has set up since 2009 (ADF/BD/IF/2009/342) a feasibility study and on the 5th January 2011, the reinforcement of a project supporting the modernization of the cadastre and the business climate (PAMOCCA). As a pilot project, PAMOCCA's objectives were to provide support to the government to strengthen land governance and land management through the modernization of the cadastre in four cities before being implemented throughout the country. PAMOCCA also aimed at participating in the revision of the regulatory and institutional framework related to land. The feasibility studies for this project identified deficiencies and made the recommendations provided in Table 1 below;

Table 1: **Insufficiency and recommendations for the establishment of PAMOCCA**.

Identified Insuficiencies	Recommandations
Difficulties of access to land ownership, Insufficient supply of state land; Poor management of state assets, Absence of a reliable cadastre system and Insufficient human and material resources	Revision of the institutional and regulatory framework Modernization of the logistical management of the cadastre and the domains, endowing the services in equipment performing and securing the archives; and Staff capacity building through appropriate initial and continuing training.

Source AfDB, 2009

6. Institutional frameworks

6.1 From municipal housing estate to informal settlement

Normally, the study area should not be a poorly structured neighborhood. During the resettlement operations that took place between 1972 and 1973, a relaxation in the monitoring of the installations of the populations in this part of the resettlement area located in a flood prone area was observed. Some of the beneficiaries having received the plots and having no financial resources allowing them to build within the deadlines imposed by the municipal authority, turned away and sold their plot in defiance of the conditions of allocation (Franqueville, 1984). During this period, certain customary owners also mingled by selling certain unoccupied plots.

Likewise, some recipients in bad faith also sold free plots close to theirs. Thus, step by step and over the years, the previously planned and organized area has turned into an informal neighbourhood.
It is in an attempt to make up for it that the CUY, following deliberation N ° 11/2003 / CU / YDE of July 23, 2003, signed by the government delegate to the urban community of Yaoundé, authorized the municipal authority to open negotiations with occupiers without rights or title in the resettlement areas of the CUY.

The weakness of the municipal technical services to reproduce the exact situation of 1972-73 is part of the weaknesses of the whole system of land and cadastral management throughout the country.

Yaoundé city Council is not covered by a cadastral plan, where it is available; the plan is drawn on an inconsistent and incompatible reference system other than UTM / WGS 84. This made the Minister of Domains, Cadastre and land affairs at the cabinet meeting of July 2019 to say that: "Cameroon is committed to modernize the land registry for the mastery and valuation of land capital. This modernization includes the densification of the points of the geodetic network, the physical and digital security of the cadastral documents (Emmanuel, 2019). Nkolndongo and its neighbourhood fall in areas of the city without a cadastral plan. The first attempt to produce a standard layout plan for Nkolndongo situated in Yaoundé IV subdivision, includes 99 parcels out of 863 of 350m^2 average surface area, resulted in a layout drawn at the scale of 1/2000 (figure 3) showing the previous layout plan to be implemented, started between 1972- 1973 (Franqueville, 1984). However, the layout plan is defective in design specifications not meeting the international standards. The inherent inconsistencies in the defective plan (Hand drawing copy), make it difficult to update or retrieve parcel information (see figure 3 below).

The present physical development does not reflect or conform to designed pattern of buildings in the layout plan shown in figure 3 below. Physically, it is difficult to notice distinction between plots; facilities of passage ways have become trails and are mostly encroached by dwellings. The spaces reserved for the construction of public interest conveniences (green spaces, playgrounds, etc.) are all occupied. More seriously, the occupants do not have any final title to the occupied parcel. However, the application of geospatial technology in cadastral management offering many advantages such as, storing, up-to-date, land use planning, land rights registration, cadastral plan etc, may reduce these illegal occupations.

Figure 3: Layout Plan of the study area (Source: CUY)
Figure 3: Hand drawing layout plan of the study area

6.2 Procedures of regularization of land ownership in the study area

The Councilors of Yaoundé City Council also known as Communauté Urbaine de Yaoundé (CUY) developed procedures for land ownership regularization in March 2003 Act.n° 11/2003/CU/YDE of 23 July, 2003 giving general rules to the Government Delegate to proceed with land regularization of occupants without rights or deeds in resettled areas including Nkolndongo 8. Thus, the occupants are expected to comply with these directives by meeting up with the requirements of land document regularization as defined in the following table 2.

Table 2: Procedures for Land Ownership Regularization of Occupations in the Nkolndongo Re-settlement Area.

Table 2: Steps for regularized land rights in the study area

S/N	Stages involved in Land Ownership Regularization Process at the CUY
1	Application for the building permit by enclosing the provisional allocation order of the parcel
2	Statement of enhancement
3	Request for Final Batch Award Order
4	Registration of the batch to the relevant tax departments
5	Application for fragmentation of Land Title 3292 of the Yaoundé City Council.
6	Establishment of the land title by the land curator of the Divisional Delegation of cadastre and land affairs of Mfoundi.
7	Application for a building permit in regularization

Source: Yaoundé city council archives

The occupants, who have exploited a parcel illegally acquired from a legal tenderer or a native, were asked to buy the plot for an amount corresponding to the payment of the sum of 8,37 US dollars or (5000 francs CFA) per m^2 and 836.71 US dollars or (500,000 CFA francs) for lack of building permit. This is done before starting the procedure described in Table 1 above. For occupants in flood-prone areas and under electricity lines, it is obvious that they will face eviction sooner or later. The CUY in 2003 gave the instruction to proceed with land ownership regularization in order to overcome some

of the shortcomings observed in the chain of registration and safeguarding land rights of informal settlement inhabitants.

7. Application of models in the regularization of land ownership

7.1 Fit-for-purpose land administration (FFPLA)

The FFPLA approach is not entirely new, but the novelty in this model is the ability to develop a sustainable land administration system fit for poor people living in informal settlements. The FFPLA (Zein, 2016) is particularly suitable for most developing countries, Cameroon inclusive of problems associated with multitude of tenure systems and tenure insecurity. The FFPLA approach has already been successfully applied in other countries such as: Ethiopia, Ghana, Indonesia, Namibia, Rwanda (Enemark, Keitth, Lemmen, McLaren, 2014). It offers land administration professionals and governments the opportunity to make significant improvements in land, including land tenure and cadastral systems (Enemark, Keitth, Lemmen, McLaren, 2014 and Zein, 2016). The four main factors of LA which include land tenure, value, use and development will also be acquired for poor populations living in informal areas. The ongoing land reform in the country should be able to take into account main features of this approach. This adoption and implementation of FFPLA will fit the needs of all the users, particularly low-income citizens. Land information in this case helps to insure land management and governance. This land information management system is a support of tenure security for a large number of citizen, particularly in our informal settlement born because of local authorities mismanagement.

7.2 Social tenure domain model (STDM)

The conventional land registration systems of land administration have not been able to accommodate the wide number of land tenure existing in many developing countries such as Cameroon. In order to take into account everyone's land rights in land administration, a flexible system was needed for registering the various types of land tenure in informal settlements (Augustinus, Lemmen, Haile, Van Oosterom, 2006). In developing world, important areas of land remain untitled with less than 30% of cadastral coverage, less than 6% in Cameroon (AfDB,2009). The city of Yaoundé where this study is conducted is partially covered by a cadastral plan. The STDM which is an approach capable of integrating all forms of tenure into land administration (Augustinus, Lemmen, Van Oosterom, 2010) should be adopted and applied in order to evaluate the land rights of the poor in this informal neighbourhood. The concept of STDM is based on the capacity to represent relationship between "people and the land". This relationship does not depend on the degree of legality, on the formality of the land rights held by these people, neither does it depend on the degree of technical precision of the documents representing the plot. It is an effective tool for registering the land of populations using modern information and communication technologies available in recent times. STDM is designed to describe the human-land tenure relationship and to provide a platform for the interactions between different land registration systems (Van Oosterom & Lemmen, 2006). On the one hand, the STDM system can generate documents specifying the nature of the rights available to the land owners on their plot. On the other hand, for the purpose of land administration, these documents can be used as legal titles to recognize land rights for residents of the study area. The figure 4 below shows the STDM model built in the study area.

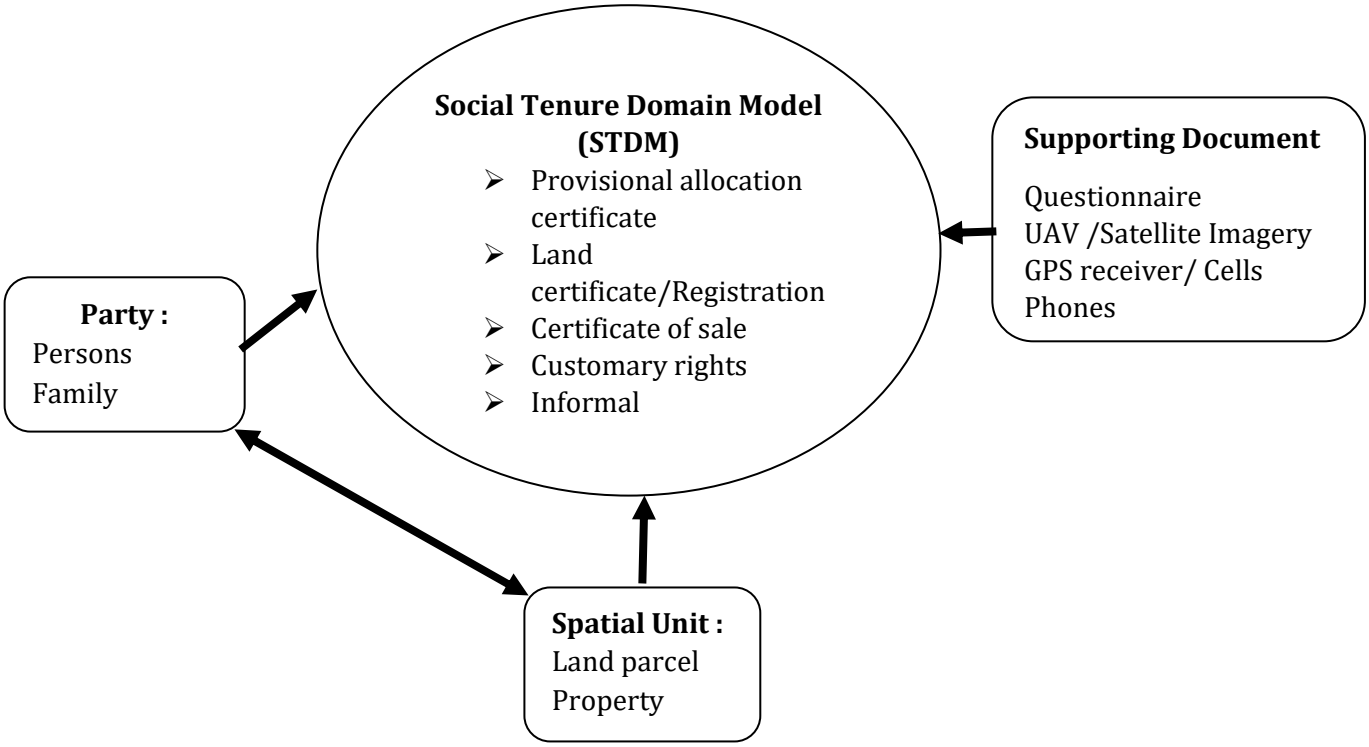

Figure 4: STDM Model in Nkolndongo 8

It can be integrated with free open source QGIS application software that will set up a graphical representation of processed plots as well as documents from the "person-to-land" relation. The integration of this model and tools will improve efficiency when adopted for securing the land rights. During the envisaged land reform, Cameroon can benefit from the advantages of this tool to register and secure the land rights of its property owners.

8. Material and methods

The study adopts the method of a combination field observation and social survey methods. The instruments used for the field observation and social survey are data capturing as well as using UAVs, digital data extraction from satellite images, and interview. Both primary and secondary data acquisition sources were employed to acquire the spatial and non-spatial data used in this study.

8.1 Data and sources.

The primary data used include:

(1) Ortho-rectified images obtained from the UAV DJI Mavic Pro;

(2) Satellite imagery obtained from the archives of the Yaoundé (Cameroon) City Council.

The secondary data used include:

(1) Land map of the study area (Source: Yaoundé (Cameroon) City Council)

(2) Layout plan of the study area obtained from Yaoundé (Cameroon) City Council.

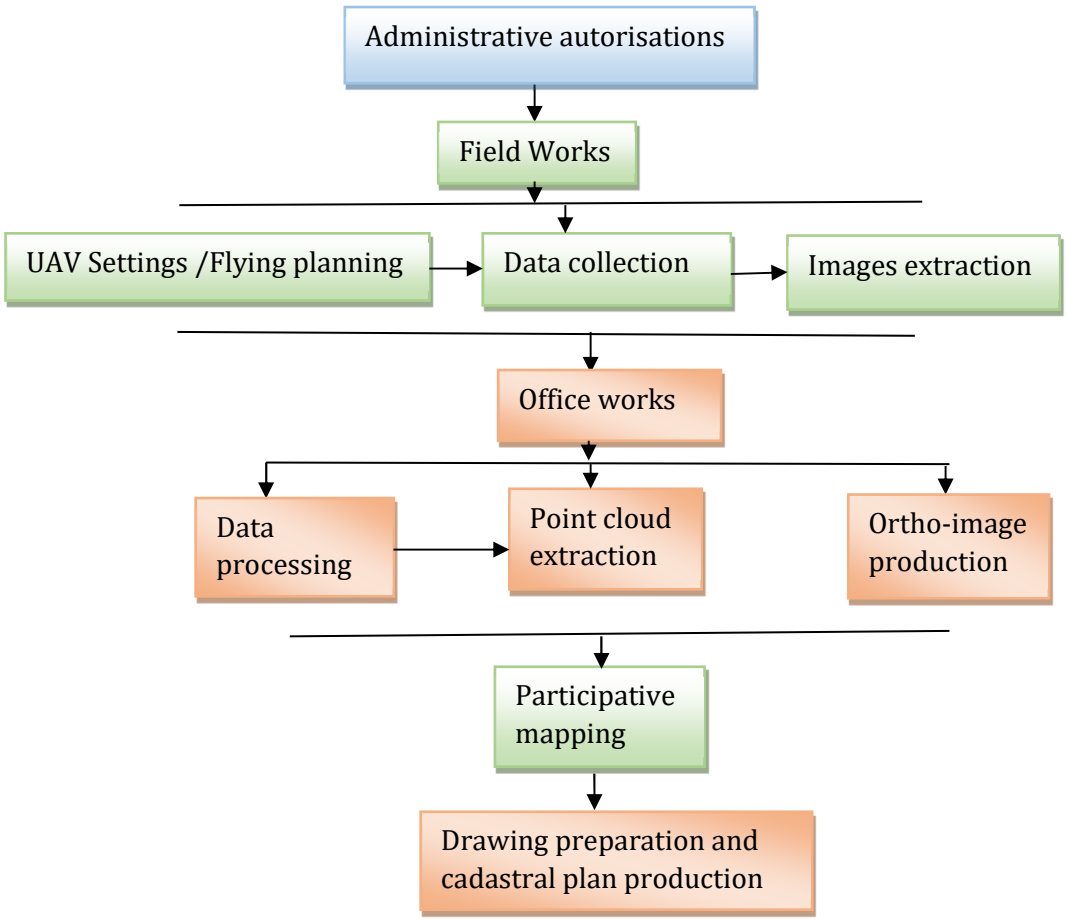

Figure 5: UAV Workflow for cadastral plan production

8.2 Data Acquisition

Having obtained an administrative flight authorization over the study area issued by the Ministry of Defense, the UAV-DJI Mavic pro was flown at an altitude of 50 metres above the ground, over the study area after setting and initializing the image capturing mode. A high-resolution UAV image of the study area was captured with ground sampling distance (GSD) at 0.22 cm/pixel.

8.3 Data Processing

The processing of this data was achieved using software such as Microsoft Word, Excel, ArcGIS 10.3.1, 3D Survey, Pix4Dmapper and QGIS desktop version 2.18.4 for STDM.

The data of the study area captured by the UAV-DJI Mavic pro was processed in 3D Survey, version 2.7 application software and helped to produce the plan of the actual situation as shown below in figure 6.

The first data collection campaign with the UAV took place in October 2018, but did not completely satisfy the researcher.

Figure 6: Actual situation on the field

Table 3 below is presenting the censor's specifications to help understand the results produced.

Table 3: Specifications of DJI Mavic pro UAV

Camera model	Resolution	Focal length	Sensor size	Pixel size
DJI FC220 Mavic pro	4000 × 3000	35mm	6.2 × 4.6 mm	1.542µm
Flying Time	28mn			
Flying altitude	50.00m	Georeferencing:		Yes
Ground sampling distance	0.0164m	**Pixel resolution:**		0.017m

8.4 Data integration and extraction

Very high-resolution UAV images, therefore, allow the collection of a large volume of geospatial data which would be difficult to obtain from conventional methods. The high-resolution and georeferenced images obtained and extracted from the UAV allow an ortho-mosaic (Figure 2b) to be extracted, from which the map is produced and registration of rights recorded during the participatory mapping. To those who agreed to receive us, locate with Green dot (figure 7) below, two questions were asked:

Figure 7: Localizing inhabitant who agreed to be interviewed

1) Can you recognize your house in this image? some answered yes, but seeing their hesitation, the young student topographers who assisted me could guide them and finally, they found themselves with joy.

2) Can you give us the area of your plot and delimit it on this photo? once again, with great reluctance, they tried without success. As with the first question, they were assisted by my team members. This is how we could register their rights without recording their names or any information likely to find

them. The condition of houses that are too tight is a major obstacle to the precise delimitation of properties that merge with the boundaries of the plots. Only dwellings can be defined from the roof. (Figure 8 below). In this figure, the green lines represent the property boundaries that overlap with the dwellings in red lines. This situation does not allow the inhabitants to build fences for fear of generating disputes between them. The work took place in a climate of mistrust, because we were taken as investigators of the CUY prior to a project of eviction. They were more or less reassured when we presented the research authorizations signed by the supervisors and the administrative authorities.

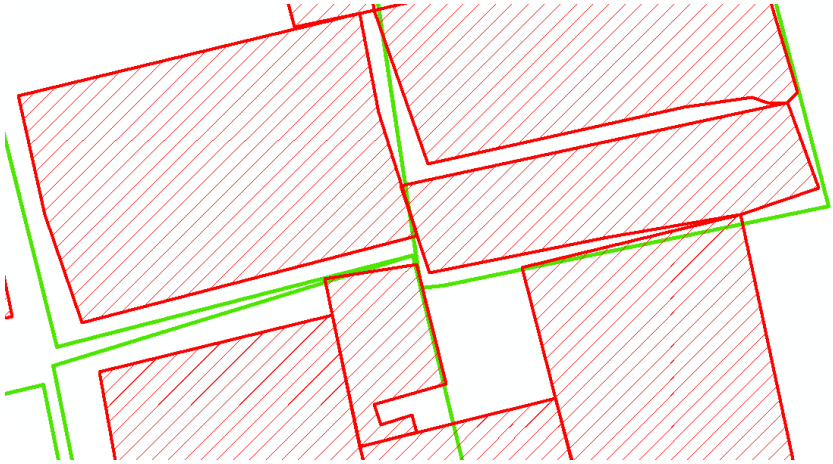

Figure 8: Parcel plan obtained from the Ortho-image

The processed and extracted data were exported to ArcGIS and QGIS for mapping procedures.

9. Results and discussion on findings

9.1 Results

The results of this study are hereby presented as shown below in forms of charts.

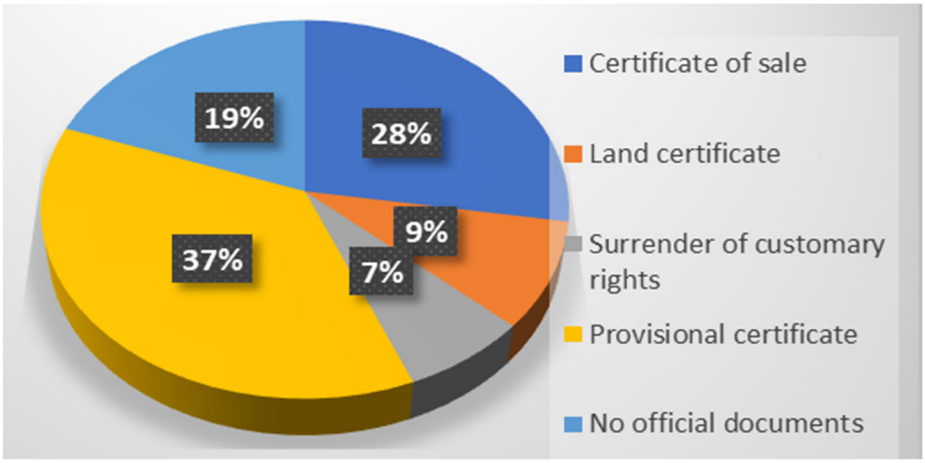

Figure 9: Pie chart indicating various categories of land title types

9.2 Discussion on findings

The results from the analysis of processed data as indicated on figure 9 show that, out of the 98 respondents involved in this study, only 36 occupants representing 37% of total respondents have a provisional allocation certificate issued by the Municipal Authority. That certificate which will enable them go through the process of obtaining the definitive land title that guarantees their security of tenure. 27 occupants representing 27% have a certificate of sale, 9 occupants representing 9% have land certificate, 7 occupants representing 7% have customary right and 19% respondents representing 19% have no official land documents. In general, the pattern of the physical developments in the study area revealed gross violation of building standards and specifications. Consequently, the results obtained during our investigations presented above, an inconsistency (19%) with the data of the CUY (83.30%) of owners without rights. In addition, the land map (Figure 1b), which was last updated on July 15, 2015, shows the existence of three land titles while on the study area, 9 people claim to have it. Also, it is Gauss Krugër coordinates system that is different from the UTM / WGS 84 system of satellite images or orthophotos obtained from UAV images. The same land map provided by the cadastral services executed in UTM coordinates shows a single land title in this study area. These inconsistencies/contradictions are justified by the absence of a reliable land information system for the conservation and up to date records since the re-settlement of populations more than 45 years ago. Furthermore, the layout plan in Figure 3, executed with arbitrary coordinates and poorly preserved does not allow to locate with accuracy, the current position of which plot had been allocated to which person. Similarly, there is no platform for coordinating and updating land documents between municipal services and cadastral conservation.

10. Conclusion

The study intends to safeguard land rights of inhabitants through regularization of an informal neighborhood in Yaoundé, Cameroon. Regularization of land rights is generally supported through a governmental project, that is useful. The study applies the Social Tenure Domain Model (STDM) with related software and the mapping of neighborhood by means of Unmanned Aerial Vehicles (UAVs) as two alternative means of regularization/upgrading land rights. The study presents initial steps of the regularization process in terms of archival studies, preparation/presentation of land map and outcome of interviews with current occupants on their mode of acquisition and land title.

Previous land reform projects in Cameroon have always produced unsatisfactory results. However, the problems relating to the management and securing of land rights in Cameroon are a major concern for the poor and vulnerable populations living in informal settlements. Can tools such as LADM coupled with geospatial data from UAVs used successfully in other countries give satisfactory results in the Cameroonian context? This approach would also be a solution to the inconsistencies noted in this study between the Cadastral services and municipal administration.

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13. Additional reading

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14. Key terms and definitions

Illegal occupation: Occupation of a parcel of land without title, without rights on land belonging to another or on a zone prohibited to construction.

Informal settlement: Neighborhood where people live in conditions unfit for human life, without basic infrastructure and sanitation

Unmanned Aerial Vehicle: A flying aircraft with no one on board to collect georeferenced spatial information of very high spatial resolution.

Tenure Insecurity: Absence of the right to land ownership that exposes the person concerned to any form of eviction and at any time.