Exploring UAVs for Participatory Mapping on Customary Lands to Understand Women's Land Rights in Northern Region of Ghana

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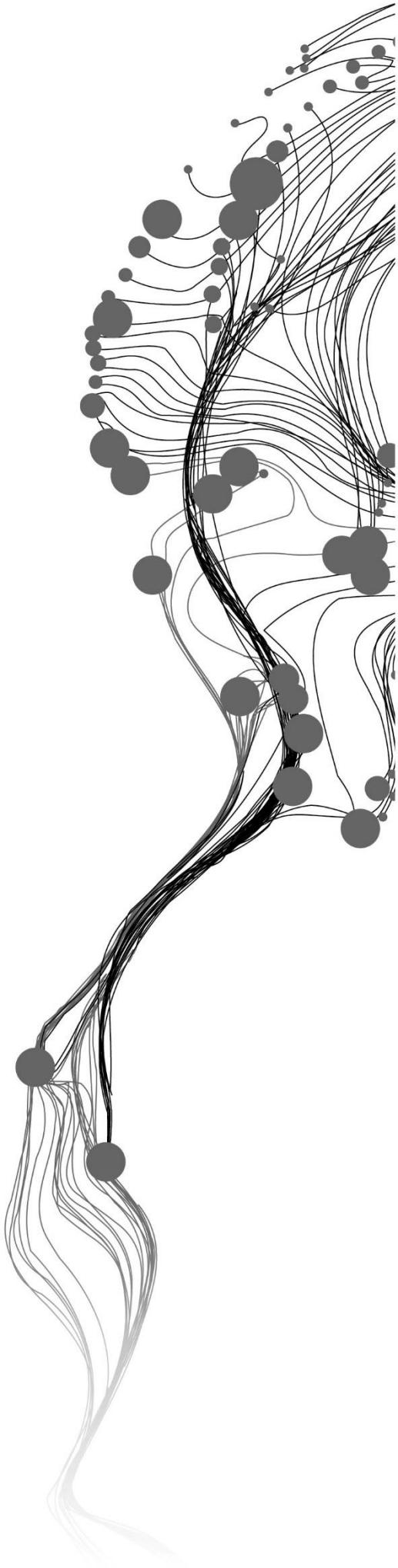

Exploring UAVs for Participatory Mapping on Customary Lands to Understand Women's Land Rights in Northern Region of Ghana

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Enschede, The Netherlands, June 2022

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Geo-information Management for Land Administration

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ABSTRACT

Unmanned aerial vehicles (UAVs) have proved promising for solving the global land problem of an estimated 70 percent undocumented land over the last decade. Its low cost, accuracy, flexibility, and timeliness offer intervention to map and document land rights to the advantage of the poor and marginalized, such as rural women. However, of all the success stories of UAVs, its potential to secure women's land rights has received little attention. Many rural women in sub-Sahara Africa exercise secondary land rights which are unrecognized under the formal land registration system. Though locally recognized in communities, these socially embedded land rights are often not documented and left unsecured. Meanwhile, interventions for strengthening women's land rights usually strategize through legal and gender perspectives but little through a technological lens.

Against this background, the study explored the potential of using UAV imagery for participatory mapping and proposed an approach that ensures the inclusion and recognition of women's land rights. Key informant interviews, household interviews, participatory mapping, literature review, and focus group discussion were the main data collection methods. The proposed approach was designed to be gender-based. A UAV orthorectified imagery was acquired as secondary data and printed on A0 matte paper size to experiment the designed approach within two rural communities in the urban peripheries of Tamale, Northern Ghana. After participatory mapping, the imagery was scanned, georeferenced, and the parcel boundaries were vectorized. The approach was evaluated using five fit-for-purpose land administration elements: participation, reliability, affordability, inclusiveness, and attainability. It was found that the proposed approach had great potential to support recognition of women's land rights as well as customary land administration in Ghana. Among both genders, participation was high, features were easily recognized and mapped, resulting in time efficiency during the mapping. The UAV imagery used for the mapping was compared with the reference layout scheme availed by the Land Use and Spatial Planning Authority (LUSPA) in Ghana for verification. The result revealed that the individual parcel boundaries did not conform to the shapes and sizes on the reference layout scheme, but the roads and lanes conformed. The UAV imagery reflected the existing ground situation, whiles the layout scheme failed, proving the up-to-datedness of the UAV imagery for customary land administration.

Beyond the proposed approach, information about the current women's land rights situation in the study areas was collected and analyzed. Among others, the main factors influencing women's land rights were identified as customary practices, literacy, patriarchy, peri-urbanism, and individualized land certification. It should be noted that the women's land rights problem is first of all linked to existing social and cultural relationships. Therefore, the approach should be considered an intervention, not a remedy for securing women's land rights.

Keywords: *Participatory Mapping, UAV imagery, Women's land rights, Customary land*

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LIST OF ABBREVIATIONS

CLS	Customary Land Secretariat
GCP	Ground Control Points
GSD	Ground Sampling Distance
GLSS	Ghana Living Standard Survey
GSS	Ghana Statistical Service
FAO	Food and Agriculture Organization of the United Nations
FFP-LA	Fit-for-Purpose Lands Administration
FIG	International Federation of Surveyors
IFAD	International Fund for Agricultural Development
GNSS	Global Navigation Satellite System
LC	Lands Commission
LUSPA	Land Use and Spatial Planning Authority
MLNR	Ministry of Lands and Natural Resources
OASL	Office of the Administrator of Stool Lands
OHCHR	Office of the United Nations High Commissioner for Human Rights
PPK	Post Processing Kinematic
QGIS	Quantum GIS
RTK	Real Time Kinematic
SG	Survey of Ghana
SMD	Survey and Mapping Division
UAV	Unmanned Aerial Vehicle
USD	US Dollars

1. INTRODUCTION

1.1. Background and Justification

Ensuring secured land access and control over land is key to rural livelihoods, regardless of gender. Women represent a significant proportion of the 2.5 billion people in the world who depend on customary or community-based land for their main source of livelihood, producing between 60 - 80 percent of food (Errico, 2021). Yet, globally, less than 20 percent of land owners are women (UN-Women, 2020). Increasingly, women's land rights have gained global attention, forming part of three Sustainable Development Goal indicators: ending poverty (SDG 1.4.2), achieving food security (SDG 2.3), and gender equality (SDG 5.A.2). Despite the high-level support, limitations with overreliance on western-style land administration approaches coupled with complex social embeddedness of women's land rights still leave women, particularly rural women in Sub-Sahara Africa, in the estimated global 70 percent undocumented land rights problem (Enemark et al., 2021a).

In Ghana, especially among the five Northern regions: Upper West, Upper East, North East, Savannah, and Northern, women enjoy weaker land rights with less tenure security on customary lands than men (Richardson & Gaafar, 2016). Meanwhile, the 34.8 percent of rural women in active agricultural workforce in Ghana largely depend on customary land (GLSS7, 2019). Gendered land access, unequal land ownership rights, shaped by cultural norms and exacerbated by high land registration costs, beset the women's land rights. It should be noted that customary lands constitute up to 80 percent of the total land in Ghana (Nara, 2021). The country is no exception to the estimated 90 percent of undocumented customary lands identified in sub-Sahara Africa (Enemark et al., 2021b).

Over the years, efforts made to strengthen women's land rights in Ghana, such as the Land Access and Tenure Security Project (LATSIP) (Richardson & Gaafar, 2016), have chalked little success in the context of delivering secured land rights for rural women. Studies such as the IIED (2021) have interrogated the approaches used in similar intervention initiatives: individual land titling, which focuses on the main land rights, excluding the secondary rights which women often exercise as an essential part of the social tenure system. Accordingly, a more robust approach based on innovative technological applications that recognizes the complex web of social and cultural relationships of women's land rights is required to strengthen the rights instead of treating them as mere land tenure.

Towards this end, Fit-for-Purpose land administration (FFP-LA) recommends using remotely sensed images to build cheap but efficient spatial framework and adopt participatory approaches to record all recognized land rights (Enemark et al., 2016). UN-HABITAT (2019) agree that community mapping or participatory mapping is an effective grassroots-led tool that increases women's awareness to claim, gain, and secure their land rights. Experiences from Rwanda (Sagashya & English, 2009), Indonesia (Aditya et al., 2020), and Ethiopia (Lemmen & Zevenbergen, 2010) have shown remarkable results. In Rwanda, Ali et al. (2014) noted that Systematic Land Registration which followed the FFP-LA recommendation, positively impacted legally married women's access to land and investment in soil conservation.

Amongst others, imageries from unmanned aerial vehicles (UAVs) have shown great potential for recording land rights using participatory mapping over the last decade (Aditya et al., 2020). Nurdin et al. (2019) used UAV imagery to map the boundaries of coastal villages in Indonesia using participatory mapping. Ramadhani (2016) also explored UAVs for cadastral boundary delineation and designed an

approach that utilizes participatory mapping. The proven benefits of UAV imagery for mapping land rights include low cost, time efficiency, accuracy, and flexibility (Bennett et al., 2020; Koeva et al., 2020). However, UAVs with participatory mapping on customary lands, particularly using approaches that aim at strengthening women's land rights, have rarely been tested in Ghana.
The study contributes to decision-making on alternative customary land administration approaches and strategies for strengthening women's land rights. It will also accelerate the usability of UAVs for land administration in Ghana.

1.2. Research Problem

Contemporary studies have surged in exploring UAV potentials in cadastral data acquisition toward securing land rights for all. Many studies have focused on adjudication (Yuangen, 2016), land tenure recordation (Koeva et al., 2020; Ramadhani et al., 2018), and cadastral surveying and mapping (Mantey & Tagoe, 2019; Stöcker et al., 2022) in both rural and urban areas. However, less attention has been given to UAVs potential for empowering and securing women's land rights in rural communities.

The conventional land registration and cadastral mapping techniques have been criticized for being anti-poor and failing to secure the land rights of the vulnerable, particularly women (Enemark et al., 2014; Zevenbergen et al., 2013, 2016). In Ghana, traditional field surveys are costly (Mantey & Tagoe, 2019) and unaffordable to many people (Asiama, 2019). In some instances, customary heads are compelled to give away large tracts of land in return for surveying services. Consequently, the land rights of most poor and marginalized groups, including women, are often left undocumented, leaving their lands liable to land grabs. Alhassan, Shaibu, and Kuwornu (2018) recounted that speculators take advantage of unsecured lands in some parts of Ghana, displace peasant farmers, deforest, undertake illegal mining activities, and commoditize the land. Rural women are often the most vulnerable to the effects of unsecured land rights due to their undocumented secondary land rights (Adoko & Akin, 2011; Motloung, 2016; UN-Habitat, 2007). The result of unsecured land rights contributes to food insecurity, increased poverty, and massive rural-urban migration causing an overspill in the cities. According to Land Portal (2016), this threatens the achievement of SDG goal 1, "end poverty in all its forms everywhere," and its 1.4.2 indicator in Ghana.

Towards addressing the land rights problem in many Low-and-Middle-Income Countries, aerial imageries have proven successful following the FFP-LA recommendations, including participatory mapping approaches (Enemark et al., 2016; Zevenbergen et al., 2016). Studies on UAV imagery for cadastral surveys in Ghana have shown promising results (Brookman-Amissah et al., 2021; Quaye-Ballard et al., 2020). However, participatory approaches were not employed, and the focus of the studies was not to secure land rights on customary lands. Thus, the potential of UAV imagery for securing women's land rights in Ghana remains unexplored.

1.3. Research Objectives and Questions

1.3.1. Overarching Objective:

The overarching objective of the study is:

"To explore UAV imagery's potential for participatory mapping and propose an approach that recognizes women's land rights in customary land administration of Northern Ghana."

1.3.2. Sub-Objectives and Questions

1 **To review the existing customary land administration practices and cadastral boundary acquisition techniques in Ghana**

1.1 What are the existing practices, legal frameworks, and cadastral boundary techniques for administering customary lands in Ghana?

1.2 What are the effects of the current practices on women's land rights?

2 **To design a participatory boundary mapping approach that recognizes women's land rights using UAV imagery**

2.1 Which regulations and restrictions guide the acquisition of UAV imageries in Ghana?

2.2 Which procedures should be included in the proposed approach?

2.3 How should the boundaries be verified?

3 **Evaluate the proposed approach**

3.1 What are the strengths and limitations of the proposed approach?

3.2 What is the proposed approach's ability to support customary land administration?

3.3 What is the contribution of the proposed approach toward the security of women's land rights?

3.4 What are the recommendations for future implementation?

1.4. Conceptual Framework

The conceptual framework of the study based on a synthesis of the key concepts is shown in Figure 1. Participatory mapping has proven effective in many studies as a useful mechanism for mapping land rights (Stöcker et al., 2022). Existing participatory mapping studies in Ghana which used satellite imagery revealed the approach is viable for administering customary lands (Arko-Adjei, 2011a; Asiama, 2019). However, the potential of UAV imagery for participatory mapping and administration of customary lands, particularly with a focus on women's land rights, is yet to be explored in Ghana.

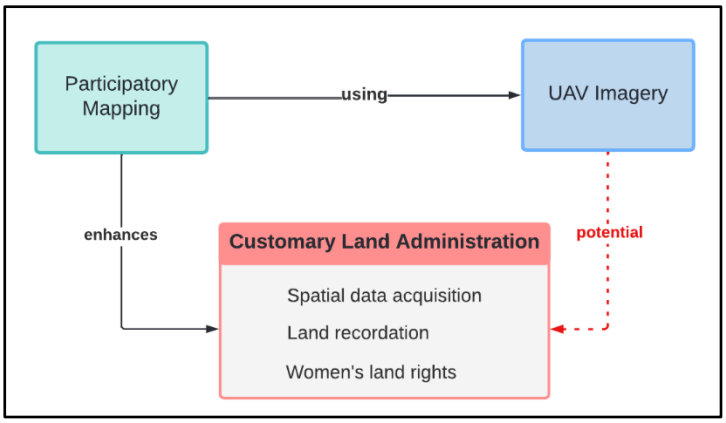


Figure 1: Conceptual Framework

1.5. Structure of Thesis

This thesis is arranged into six chapters as described below:

Chapter One: Background and Justification

This chapter introduces the study by providing the background and justification underlying the research. It also discusses the research problem, objectives, and research questions.

Chapter Two: Literature Review and Concepts
Chapter two reviews existing literature on the key concepts and theories on which the study is based. The concepts include participatory mapping, cadastral boundary, remote sensing for cadastral boundary mapping, Fit-for-purpose land administration, Women's land rights, and customary land administration.

Chapter Three: Study Area and Methodology
This chapter discusses the research design and methods used in answering the research questions. The chapter further provides background information about the study area. The research design is structured into pre-fieldwork, fieldwork, and post-fieldwork in alignment with the objectives.

Chapter Four: Results and Findings
The finding obtained from the data collection is presented in this chapter with brief interpretations of the results. The chapter presents the proposed participatory mapping approach using UAV imagery.

Chapter Five: Evaluation and Discussion
This chapter thoroughly discusses the link between existing literature and findings. An evaluation of the proposed approach using the FFP elements and SWOT analysis is also presented in this chapter.

Chapter Six: Conclusion and Recommendation
Linking the findings to the set objectives, the chapter concludes and makes recommendations for future studies.

An overview of the objectives, methods, and expected results are also explained in the form of the research matrix attached in appendix 1.

2. LITERATURE REVIEW

2.1. Introduction

Using UAV imagery for participatory mapping of customary land rights, particularly women's land rights, require a good understanding of the concepts, theories, and practices. In this regard, empirical studies in the form of literature provide a good insight into these concepts. This chapter reviews existing literature on the study's main concepts, with some focus on Ghana. Participatory mapping, cadastral boundary, customary land administration, women's land rights, remote sensing for cadastral boundary mapping, land recordation, and fit-for-purpose land administration are the main concepts discussed.

2.2. Participatory Mapping

Participatory mapping is a map-making-process that engages small groups (usually local communities) to express their spatial knowledge transparently and inclusively. The approach is widely adopted and used in many domains (Chambers, 2006). In the domain of land administration, the approach is used to facilitate local land administration (Asiama et al., 2017; Ramadhani et al., 2018) through identification (adjudication), delineating, and recording of communal or indigenous land rights (Di Gessa, 2008). The process involves delineating general or visible boundaries on printed high-resolution orthophotos (Lemmen et al., 2015). The experimental study of high-resolution imagery-based adjudication in Ethiopia adopted participatory mapping (Lemmen & Zevenbergen, 2010). The cadastral boundary data collection for Rwanda's Nationwide systematic land registration was also conducted using a participatory approach (Enemark et al., 2014; Sagashya & English, 2009). In the domain of spatial planning, Lemma, Sluizas, and Kuffer (2006) also used participatory mapping to monitor slum conditions in Ethiopia.

Participatory mapping is useful for promoting women's inclusion in land-related matters. According to (IFAD, 2010), women usually have distinct perspectives about a community's land and how they relate to it. As a checklist for good participatory mapping, it is recommended that women's involvement should be paramount to achieving holistic mapping results. Di Gessa (2008) describes participatory mapping as an effective empowerment tool for poor and vulnerable groups, including rural women, to secure their land rights and access to natural resources. Empirical studies indicate that participatory mapping enhances women's contribution to planning, natural resources management, and land-related decisions (McCall & Minang, 2005). It also encourages responsible land administration through the involvement of people (Enemark et al., 2014; Zevenbergen et al., 2016).

Participatory mapping emerged in the 1980s from participatory rural appraisal methodologies (IFAD, 2010) and has now gained prominence as a community-based mapping tool (Chambers, 2006). Similar terms used to refer to participatory mapping in other domains are participatory GIS, community mapping, indigenous mapping, bottom-up GIS, and public participation (Cochrane & Corbett, 2018). The terms have differences in their application, but fundamental to these is using the collective indigenous knowledge of a group to make maps (IFAD, 2009).

2.3. Cadastral Boundary

Literally, the spatial extent of a land parcel and its associated records, such as ownership, nature of rights, value, and developments, constitute its cadastral boundary. The International Federation of Surveyors

(FIG) defines a cadastre as a parcel-based and up-to-date land information system containing a record of interests in land (FIG, 1995, pg 1). It includes a geometric description of the parcels linked to records, such as the nature of interests, ownership, control, value, and improvements on the parcel (Ibid).

By origin, land is one continuum (Zevenbergen, 2002); therefore, a clear identification of a part (parcel) is critical for securing land rights and also necessary for land registration (Deininger, 2003). Parcel identification is tantamount to the boundary. Generally, a boundary is an imaginary line that marks the mutual extent and limits of two adjacent land parcels (Ortiz, 2017). Dale and McLaughlin (1988)explain that legally, a boundary is a "vertical surface that defines where one landowner's territory ends, and the next begins." Per the two definitions, a boundary can be considered as an 'imaginary vertical line' separating the spatial extent of two adjoining parcels. Zevenbergen (2002) argues that this vertical surface can be an endless space running from the center of the earth to infinity but where it meets with the earth's surface is what matters. The intersection with the earth's surface can be visualized using monuments.

There are two main categories of boundaries: fixed and general boundaries, as shown in figure 2. Fixed boundaries are exact or accurately surveyed boundaries for which the line of division is mutually agreed between the adjoining landowners (Dale & McLaughlin, 1988). This agreed line becomes fixed in space (Tuladhar, 1996) and is also recorded as fixed in the register. On the other hand, the general boundary, also known as visible (Lemmen et al., 2015), is an approximate line between adjoining parcels that is deliberately left undetermined (Zevenbergen, 2002). The unspecified boundary line is usually marked on a map and placed out of focus (Ibid). It requires a good identification of monuments such as hedges, fenced walls, or ditches as a reference. The strength of general boundaries is that it does not demand strict adherence to survey standards. It is less costly than fixed boundary surveys, and it prevents arguments and the proverbial splitting of hairs (Dale & McLaughlin, 1988). According to Tuladhar (1996), a country's use of general boundaries depends on its land laws. In the case of Ghana, section 90 of Land Act 2020, Act 1036, recognizes the use of general boundaries, especially in the case of boundary dispute resolution. General boundaries are recommended for FFP-LA and Pro-poor land recordation instead of fixed boundaries. This study uses general boundaries because they are quicker, cheaper, and also allowed by the laws in Ghana (Zevenbergen, 2002).

(a) (b) (c)

Figure 2: Fixed boundary (a) and (b), General boundary (c). Source: Koeva et al. (2020)

2.4. Remote Sensing for Cadastral Boundary Mapping

Crommelinck (2019) describes cadastral boundary mapping as a process of delineating boundaries of land parcels to identify the precise spatial extent for recording ownerships. Cadastral surveying techniques for boundary mapping can be *direct* or *indirect*. Direct techniques involve measuring the exact boundary position in space, while indirect techniques employ remotely sensed data such as satellite or aerial imageries (Crommelinck et al., 2016). Enemark et al. (2014) argue that relying on the direct or ground-based cadastral surveying techniques, which often aim at high positional accuracy for boundary mapping, will require centuries to complete land registration coverage in many countries. The ground-based

techniques have been asserted as slow and labor-intensive (Enemark et al., 2016). With advances in remote sensing and photogrammetry, indirect cadastral boundary surveying techniques have emerged to accelerate spatial data collection for land registration (Bennett et al., 2020; Koeva et al., 2020).

Contemporary use of remotely sensed data for boundary mapping often applies different methods to provide cost-effective, fast, and accurate results to speed up cadastral data acquisition. The existing techniques include automatic (Crommelinck, 2019; Wassie, 2016), semi-automatic (Kohli et al., 2017), manual digitalization (Manyoky et al., 2012), and participatory approaches (Asiama et al., 2017; Nurdin et al., 2019). Participatory methods also apply manual digitalization after visually identifying the boundaries.

2.4.1. UAV Imagery for Cadastral Boundary Mapping

Integrated with on-board global navigation satellite system (GNSS), UAVs have increasingly gained prominence in acquiring precise and georeferenced high-resolution orthoimages for cadastral boundary mapping. Unmanned Aerial Vehicle (UAVs), also known as Drone or Remotely-Piloted Aerial System (RPAS), have their origin in military applications, but it is now applicable in a wide area of domains (Nex & Remondino, 2014). Among all the uses, UAV applications for acquiring aerial imagery and geospatial data have been described as the most valuable and lasting (Barthel, 2015).

It is important to note that most UAVs are usually equipped with single-frequency GNSS receivers, requiring ground control points (GCP) for accurate absolute positioning and georeferencing for cadastral purposes (Nex, 2020). Nowadays, an increasing number of modern UAVs are equipped with RTK-GNSS (real-time kinematic) for instantaneous corrections, as shown in figure 3 or PPK (post-processing kinematic) corrections (Nex, 2020). These dual-frequency receivers obtain centimeter-level accuracy, using few or no GCPs (Forlani et al., 2020; Stöcker et al., 2020). GCPs are ground points with coordinates known in the spatial reference system (Nex & Remondino, 2014). According to Stott et al. (2020), when using RTK-GNSS equipped UAVs, adding GCPs does not significantly improve the accuracy, as essential as accuracy is to surveying and mapping projects. However, Nex (2020) recommends using at least a few GCPs even where accurate RTK-UAVs are used to minimize possible systematic errors due to synchronization uncertainties between the camera trigger and satellite receivers (Gerke & Przybilla, 2016).

UAV imagery is highly flexible and efficient for participatory mapping, as shown in figure 4 (Stöcker et al., 2022). In the Democratic Republic of Congo, a pilot project entitled 'Drones for Land Clarification and the Empowerment of Women' under the Cities Alliance Innovation Programme was implemented (IRDAC, 2020). The project demonstrated that UAVs and participatory processes could help strengthen women's land rights through secured land tenure.

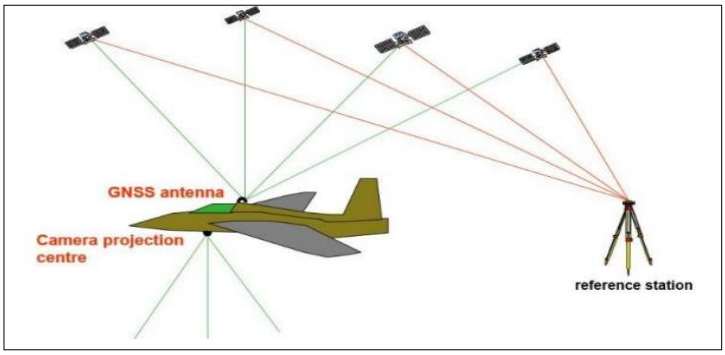


Figure 3: Absolute positioning in RTK-GNSS equipped UAVs. Source: Nex (2020)

Figure 4: UAV Imagery for cadastral mapping. Source: Koeva et al. (2021)

2.5. Customary land administration

Customary lands are collectively owned lands administered by rules, customs, norms, and traditions regarding their allocation, use, access, and transfer (USAID, 2013). The term 'Customary land' is generally used interchangeably with 'communal land,' 'community land,' 'traditional land,' 'tribal land,' and 'indigenous land' to connote local or rural land tenure systems (Arko-Adjei, 2011b; Chipofya et al., 2021; Wily, 2011b). However, Arko-Adjei (2011a) clarifies that customary land can exist in rural, urban, or peri-urban areas in Ghana, unlike other African countries such as Nigeria or Malawi.

Customary land practices are tied to existing local cultures; thus, the rules will rarely remain binding beyond a particular community (Wily, 2011a). The establishment of customary practices is linked to historical antecedents that had evolved since time immemorial, devolving from one generation to another (Akolgo-Azupogo et al., 2021). However, some customary norms are also made by present-day communities (Wily, 2011a). Socio-cultural practices and customary beliefs have it that land belongs to the dead, the living, and the unborn generation (Ollenu, 1962). Thus, the living are only custodians of the land. Under the customary way of administering land, the traditional leaders, as custodians, manage and control the lands in trusts for the subjects as a symbol of traditional authority (MLNR, 1999). Biitir & Nara (2016) describe these key social actors who regulate and enforce the rules governing customary lands as customary land institutions.

As put forward by learned Judges, there is no land in Ghana without an owner (Kludze, 1974). Thus, customary lands and their administration in Ghana rest with the leaders of Stools (Southern Ghana), Skins (Northern Ghana), Families, and Clans as the allodial landowners (Ubink & Amanor, 2008). Accordingly, Chiefdoms, Family heads ("Abusuapanyin"), and Tendanas (Earth Priest) are the customary land institutions that hold land on behalf of their subjects (Zaid, 2020). Among many traditional groups in Ghana, especially in the North, the leadership of customary groups is gendered in favour of men. Over the last decade, Customary Land Secretariats (CLS) in Ghana have been strengthened as a third land registration institution to record the allocation of lands made by customary heads (article 80 (1) Act 1036 of Land Act 2020). Thus, three systems of land registration are now recognized by law: deeds, title, and customary.

2.5.1. Rights and Interests in Customary land: Ghana in context

The rights exercised over customary lands are a complex bundle stemming from the different levels of authority, control, and access by individuals and groups, forming a continuum as shown in figure 5. As often referred to, these 'bundles of rights' are described as hierarchical, overlapping, or interlocking in character (Meek, 1968; Zaid, 2020). Registrable rights and interests in customary land can be categorized into four: allodial title, usufructuary interest, leasehold interest, and customary tenancies/ sharecropping

(Ghana Land Act, Act 1036, 2020). These rights and interests exist concurrently, making complex land rights in customary lands.

Allodial title: This is the highest proprietary interest or right known to exist in customary land tenure. It is not subject to any restrictions or obligations except those imposed by statute. The allodial title may be acquired through first settlement, conquest, gift, compulsory acquisition, and purchase. This interest rests in communities, represented by the stool, sub-stools, skin, clans, and families. According to Amanor and Ubink (2008), allodial interests are vested in a continual flow of people and remain in them for generations.

Usufructuary Interest: This is an inherent right or interest for members of a customary group such as stool, skin, or family, as a lifelong interest. It is a sub-interest acquired from the allodial title. Usufructuary rights include the right to use, occupy, develop, bequeath, and alienate. Ideally, all subjects of customary groups enjoy usufructuary right on customary land irrespective of gender. But the extent of access, use, and control is further affected by cultural norms such as inheritance, creating differences in access between genders. Alienation to a non-subject is made with the consent of the allodial owner. The word 'usufructuary' is derived from *usus*, the right to use or access land, and *fructus*, the right to make a profit or loss (Doss & Meinzen-Dick, 2020). Researchers (Amanor & Ubink, 2008; Zaid, 2020) have criticized the formal land registration system for failing to secure this perpetual right enjoyed by usufructs when registered under the system. Usufructs have their interests truncated when it is formalized (Abubakari et al., 2020).

Leasehold Interest: Leaseholds are terminable interest that expires after an agreed period. It is derived from a higher interest such as allodial or usufructuary interest. Other interests that can arise out of leaseholds include sub-leases, assignments, and licenses (Ghana Land Act, Act 1036, 2020). Leasehold interest does not extinguish the grantor's interest; instead, both interests run concurrently.

Customary Tenancies/ Share Cropping: This interest is an arrangement between allodial owners or usufructs and non-subjects of their lands. Under this agreement, the land is given to non-subjects to cultivate crops. After harvesting, the proceeds are shared according to the initial arrangements. The common tenancies are the *'Abunu'* (sharing into equal parts) and *'Abusa'* (sharing into three parts).

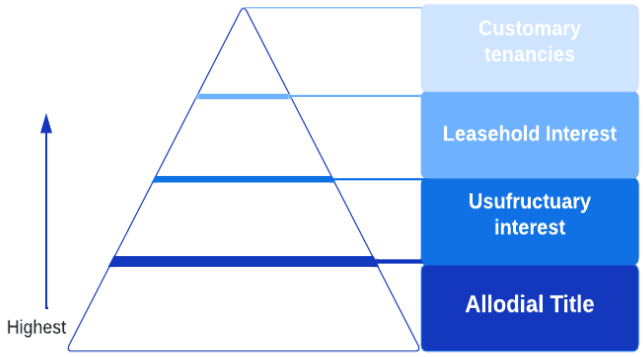


Figure 5: Ghana: Hierarchies of interests/Rights in land

2.6. Women's Right to Land

UN-Women (2020) defines women's land rights as "the ability of women to own, use, access, control, transfer, inherit, and otherwise make decisions about land and related resources" (UN-Women, 2020, pg

5). In many countries, women own less land, often smaller plots of lesser quality, and with less tenure security than men (OHCHR, 2017). Also, land decision-making often excludes women since they are not considered landowners (OHCHR, 2017). Estimates from countries such as Bangladesh, Ethiopia, Uganda, Niger, Tanzania, Malawi, and Viet Nam, indicate that agricultural lands owned solely by women are about 15 percent, compared to 62 percent owned by men and 24 percent in joint ownership (FAO, 2020). However, such findings must not be generalized across different geographical areas. As noted by Akter et al. (2017), empirical evidence from four Southeast Asia countries: Myanmar, Thailand, Indonesia, and Philippe, showed that women have equal access and greater control over land than men. But in general, the global community is addressing women's land rights to bridge the unequal gender gap in land rights and ensure equal access, ownership, and control over land.

According to the European Commission (2017), men and women in many sub-Saharan African countries, in one way or another, enjoy informal land rights, that is, rights not documented but managed through customary norms. But, the rights exercised by women are considered secondary due to cultural practices where women need to access land through their male counterparts (Duncan, 2010; Richardson & Gaafar, 2016; Spichiger, R. & Stacey, 2014). It implies that the security of women's land rights is inextricably linked to existing social and cultural practices (IIED, 2021). Secondary land rights refer to "land rights derived from another level of ownership" in the social tenure (Wily & Hammond, 2001, pg 4).

Traditionally, patriarchy and discriminatory social norms undermine the nature of land rights exercised by women (Errico, 2021; Kalabamu, 2006). Walby (1990) defines patriarchy as a "system of social structures and practices in which men dominate, oppress and exploit women." In terms of legal remedy, the European Commission (2017) reports that even when a country's land laws allow gender equality, other laws related to inheritance and marriage may contain certain provisions that will invariably inhibit equal land rights for both genders. A good example is Bangladesh, where the law guarantees non-discrimination and equal protection under Articles 27 and 26 of the 1972 Constitution. Hence, the existing patriarchal inheritance rules governed by the Shariah Law put women at a disadvantage (Chowdhury, 2019). To create awareness about women's land rights, researchers, including the UN-Women (2020), have advocated for legal literacy campaigns and programmes to be organized for women and community leaders.

2.7. Land Recordation

The land administration process comprises four main steps: adjudication, demarcation, surveying/mapping, and recording (Henssen, 2010). In many academic discourses, land recordation and land registration are often used interchangeably. The term land registration connotes a centralized repository of land records involving the public register, whiles land recordation is less centralized (Zevenbergen, 2002). This study chooses to use land recordation over land registration since it focuses on a local land recording.

In Ghana, customary land recordation is administered by the Customary Land Secretariats (CLSs). In some villages, Land Management Committee or Land Allocation Committees are set up under the aegis of the Chief or Traditional leaders to perform similar tasks (Arko-Adjei, 2011a). Land recordation captures information about the party (individual or group), type of interest, and the parcel or spatial extent (Nichols & McLaughlin, 1990). It is argued in some studies that land registration per se cannot guarantee tenure security, access to investment, or facilitate economic development (Raymond T Abdulai & Domeher, 2011; Raymond Talinbe Abdulai & Ochieng, 2017). However, this study holds a contrary position and thus equates land recordation to tenure security, as also described in Zevenbergen's (2002) 'black box.'

2.8. Fit-for-Purpose Land Administration (FFP-LA)

Driven by the urgent need for solutions to the global land tenure security divide, the International Federation of Surveyors (FIG) and the World Bank developed the concept of Fit-for-Purpose land administration (FFP-LA) (Enemark et al., 2014). The concept operates with principles and methods to ensure the delivery of secured land rights at scale (Enemark et al., 2021b). Fundamental to this concept are three characteristics: focus on purpose, flexibility, and incremental improvement. Flexibility is central, and the three components of the concept: spatial, legal, and institutional framework, revolve around it (Enemark et al., 2014). Flexibility also underlies the methods of spatial data collection in terms of accuracy demands, range of different land rights, and range in the recording of the land rights to provide secured land rights for all (Enemark et al., 2016). These are further accommodated in the 'continuum-of-continuums.'

Four principles guide the spatial framework to ensure land administration is built relatively quickly using affordable and scalable approaches. These include general/ visual/physical boundaries instead of fixed boundaries, aerial/satellite imagery instead of field surveys, accuracy relating to purpose rather than technical standards, and the possibility of upgrading the spatial framework over time (Enemark et al., 2016). However, the application of the principles is not rigid. Field surveys can be employed as complementary where the boundaries are not visible (Lemmen et al., 2015). Notable of the FFP-LA approach are the seven elements: flexible, inclusive, participatory, affordable, reliable, attainable, and upgradable, as explained below:

- **Flexible** in the spatial data collection methods to support different land uses and occupations.
- **Inclusive** in scope to incorporate every land tenure and all land parcels.
- **Participatory** in the process of capturing data and ensuring community engagement.
- **Affordable** for the government to carry out and for society to use it.
- **Reliable** with regards to the information that is authentic and up to date.
- **Attainable** in terms of creating a system within a short timeframe and with available resources.
- **Upgradable** in relation to constant upgrading and improvement over time to respond to social and legal needs and economic opportunities.

The study adopts five of these seven elements to evaluate the proposed approach against its potential to support recognition of women's land rights.

2.9. Summary of the Chapter

This chapter discusses existing literature on the key concepts in the study. From existing studies, cadastral boundaries can be fixed or general depending on whether direct or indirect techniques are used. UAV imagery as an indirect technique was found capable of providing fast, efficient, and flexible orthoimages for mapping land rights. Participatory mapping was found as an effective mechanism for community-level land administration and women's land rights empowerment. But gender disparity in access and control of land was identified as a global problem. The main hierarchies of land interests in Ghana include allodial, usufructuary, leasehold, and customary tenancies. And women's exercising of usufructuary land rights is weakened by existing cultural practices. In all, the fit-for-purpose land administration concept offers solutions through recommendations for developing simple approaches to map and record all socially recognized land rights.

3. RESEARCH METHODS AND STUDY AREA

3.1. Introduction

The previous chapter discussed the theories and concepts that underlie the study. This chapter proceeds with a description of the data collection methods used to meet the research objectives. It begins with the study area description and women's land rights situation in Ghana. The limitations encountered in the data collection are also highlighted.

3.2. Study Area Description

The availability of UAV imagery primarily influenced the study area selection. It was also motivated by the study areas used by previous participatory mapping studies on customary lands in Ghana: Arko-Adjei (2011a) and Asiama et al. (2017). The Northern Region is one of the 16 regions in Ghana. Prior to the 2018 referendum for new Regions in Ghana, the region included the present-day Savannah Region and North East Regions. The region consists of 11 districts, 4 municipalities, and a metropolis. Tamale, a cosmopolitan city, is the region's administrative capital and the third-largest city in Ghana (Fuseini et al., 2017). The Metropolis is among the fastest-growing cities in the country, with an annual growth rate of 3.3 percent (Gyasi et al., 2014). Islam is the most predominant religion, and the people are largely of the Dagomba ethnic group.

The Northern region is a hub of agriculture and commercial activities, employing 74 percent of the active population (GLSS7, 2019). Agriculture is male-dominated per available estimates: 90.7 percent male and 9.3 percent female household heads in agriculture (Ibid). Agricultural activities include home gardens, crop farming, tree farming, and livestock rearing. The main crops cultivated are maize, rice, millet, groundnuts, and yam. Despite the high dependence on agriculture, the region experiences one rainfall season per year, causing the dry harmattan winds to be relatively intense between November to February and high sunshine between March and May (GSS, 2014). The region lies within the savanna woodland vegetation zone: vegetation that is largely grassland interspersed with short scattered trees (Ibid). Major trees present include Dawadawa, Neem, Acacia, Shea nut, and Baobab. The general topography is relatively flat but has an altitude of 132m above sea level (Gyasi et al., 2014).

Two communities, namely Ticheli and Woribogu-Kukuo, were used for the study. Ticheli is traditionally under the Nanton Paramountcy but administratively within the Tamale Metropolis. Its geographical location is on latitude 9.97000 North and longitude 1.710000 west. It is about 13 kilometers east of Tamale and off the Yendi to Tamale Road. The community is contiguous to Vittin, Wamale, Chanzheni, Zuo, Baglahi, and Pagazaa. Woribogu-Kukuo community, on the other hand, is under the Woribogu Paramountcy and within the Tolon District in terms of administration. The community is located on latitude 8.920000 North and longitude 1.720000 West. Woribogu-Kukuo lies along the Tamale to Tolon road, after the Kpalisogu community. The inhabitants of both Ticheli and Woribogu -Kukuo are mainly peasant farmers. Some women switch from farming to petty trading when farming activities are not favourable during the dry season. Figure 6 is the study area map showing the location of the communities within the Northern Region of Ghana.

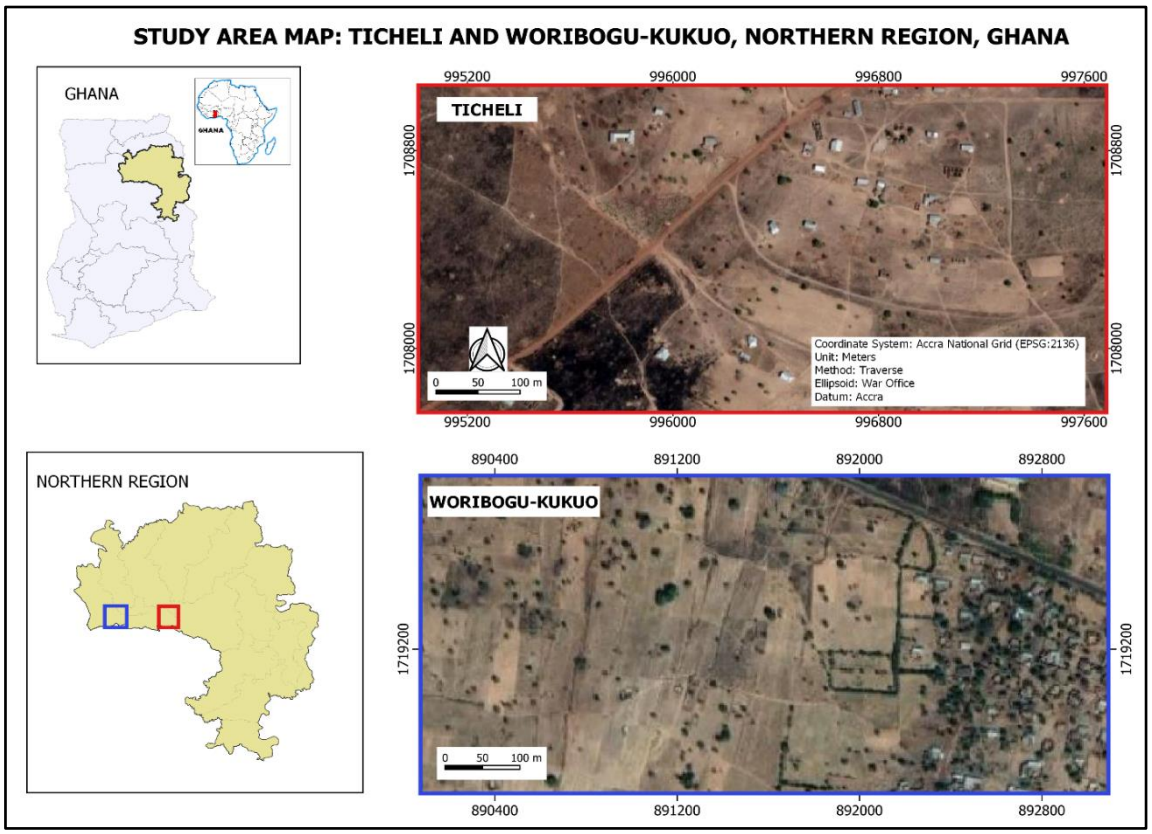


Figure 6: Study area map

3.3. Women's land rights and tenure security in Ghana

Unlike in other parts of the world, women's right to land in Ghana is considered better, though there are limitations (Apusigah, 2008; Wily & Hammond, 2001). Typically, women are not arbitrarily denied access to land (Rünger, 2006). Women in Ghana can access land through inheritance, marriage, contractual arrangement, gift, or purchase, although the cultural norms put women at a disadvantage amongst the different cultural groups (Duncan, 2010; Rünger, 2006).

Women in Northern Ghana enjoy limited land rights compared to those in the South (Kaunza-Nu-Dem et al., 2016). Richardson and Gaafar (2016) explain that before marriage, women in Northern Ghana access land through their fathers or brothers, then through their husbands when they are in a marriage. According to Apusigah (2008), women, especially wives, are considered temporary members of a family and therefore need to negotiate with men before accessing productive resources. The practice undermines women's land right to only a derived right or secondary right secured through marriage or membership in a lineage (Rünger, 2006). Widows risk eviction if they have no child with their deceased husband. Richardson and Gaafar (2016) describe women's land rights in Northern Ghana as insecure since their rights are indeterminate, uncertain, and usually not documented. The situation is exacerbated by the ethnic groups that practice the patrilineal inheritance system, where daughters are not allowed to inherit land from their fathers (Duncan & Brants, 2004).

In Southern Ghana, the women enjoy fewer restrictions in accessing land, as they can inherit or purchase land and document it in their names (Wily & Hammond, 2001). That notwithstanding, the women do not enjoy equal land rights as the men (Duncan, 2010). Higgins and Fenrich (2012) noted that women are

allocated marginal lands in smaller sizes. Also, similar to the practice in Northern Ghana, women in patrilineal lineages experience difficulties inheriting land (Spichiger & Stacey, 2014). However, daughters in the matrilineal system are permitted to inherit land from their mother's lineage and receive land as gift inter vivos from parents, grandparents, or spouses (Duncan, 2010).

Ghana is a signatory to major international human rights protection laws that frown on gender-based discrimination (Rünger, 2006). In response, legal provisions, including Articles 17 and 18 of the 1992 Constitution, the Intestate Succession Law 1985, and Customary Marriage and Divorce (Amendment) Law 1991, have been made to ensure equality and protection of rights for all. However, some researchers (Rünger, 2006; Spichiger & Stacey, 2014) have questioned the effectiveness of the legal provisions as the right of access to productive resources by many indigenous women remains inferior.

3.4. Research Approach

This study adopts a deductive approach to explore the use of UAV imagery for customary land administration, particularly to experiment a proposed approach that recognizes women's land rights. According to Crowe et al. (2011), using study areas in research enables an in-depth understanding of the study. First, the study develops the proposed participatory mapping approach in 8 steps using existing literature. After acquiring a UAV orthorectified image, the study adopts participatory mapping through a gender-based focus group discussion to experiment in the study area. The outcome was verified with higher accurate techniques and evaluated. These activities are summarized into pre-fieldwork, fieldwork, and post-fieldwork, as shown in figure 7. It is further explained in the subsequent sub-chapters.

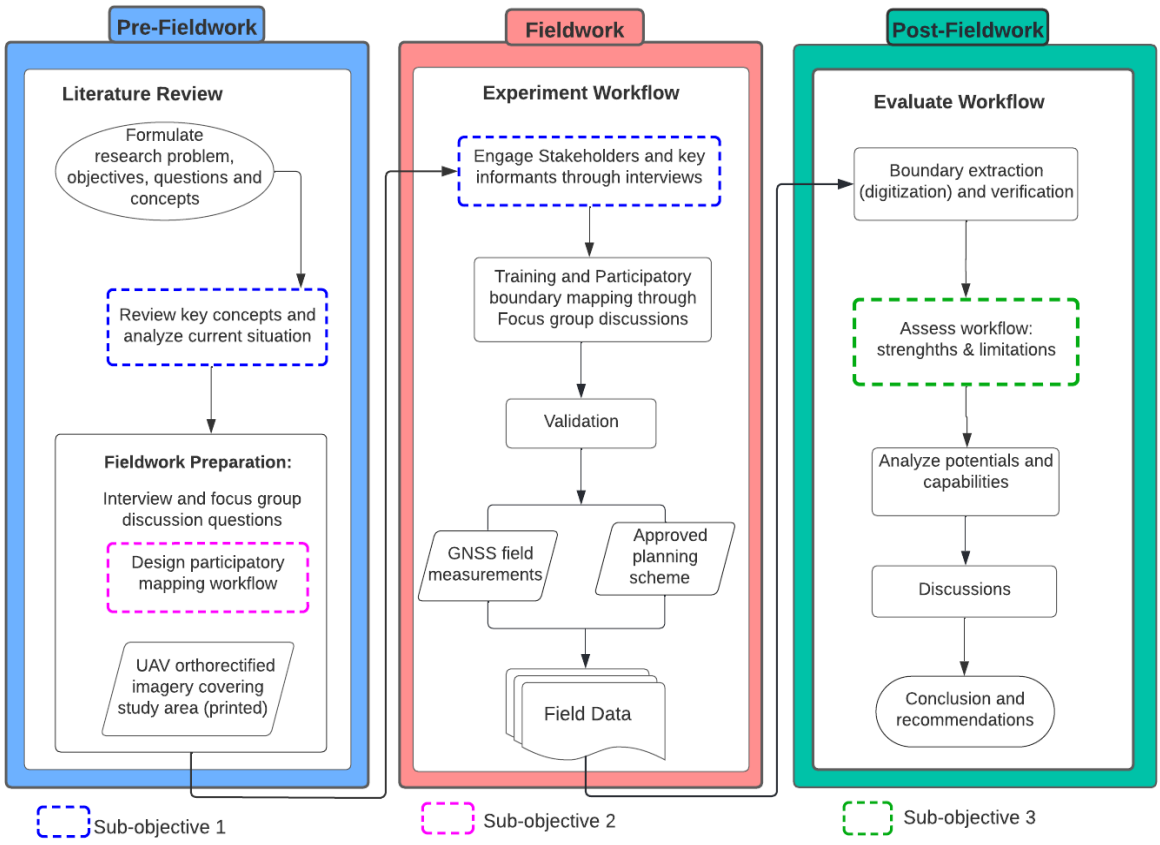


Figure 7: Methodology

3.5. Data Collection Methods

The study adopted a mixed-method research design for the data collection. Thus, both qualitative and quantitative data were collected from primary and secondary sources. The primary data sources included interviews, field observations, field measurements, and focus group discussions. The secondary data sources were UAV imagery and existing literature. Mertens (2013) argues that integrating quantitative and qualitative data enables comprehensive and rich data collection.

3.5.1. Pre-Field Work

Mainly, the pre-fieldwork activities comprised of literature review and fieldwork preparations. The research problem, questions, and objectives were formulated by reviewing the existing literature. Previous studies on the study's key concepts: UAVs, customary land administration, participatory mapping, women's land rights, and cadastral mapping were also reviewed. This study phase was meant to answer sub-objective 1 and its' two research questions. Sub-objective 1 aims to review existing customary land administration practices and cadastral boundary acquisition techniques in Ghana.

3.5.1.1. Designing the proposed approach

A proposed participatory mapping approach was designed as part of the fieldwork preparations. It involved eight major steps based on a synthesis of existing literature on participatory mapping. The proposed approach design was purposed to answer sub-objective 2 of the study: to design a participatory boundary mapping approach using UAV imagery for administering customary lands. Figure 8 is the illustration of the proposed approach.

Figure 8: The proposed approach design

The design of the proposed approach relied on a review of similar participatory mapping projects and research as secondary data sources. Although not all the studies used UAV imagery in the mapping or researched women's land rights, a generic understanding of the participatory mapping principles was the most important. The main documents reviewed for the proposed approach's design are listed in table 1.

Table 1: List of key literature used to design the proposed approach

Title of Document	Type	Summary/ Relevance
First experiences with high-resolution imagery-based adjudication approach in Ethiopia (Lemmen & Zevenbergen, 2010)	Published Book Chapter	This study experimented high-resolution satellite imagery for establishing parcel index maps in some villages in Ethiopia. A participatory mapping approach was used. The major processes involved were adopted in the proposed approach design.
Indigenous knowledge and local capacity for land administration (Arko-Adjei, 2011)	Ph.D. Thesis Chapter	This study explored the potential of participatory GIS to enhance local land administration in Ghana. High-resolution satellite imagery was used. Since this study focuses on customary lands and participatory mapping, procedures and methods were substantially considered and adopted.
The usage of unmanned aerial vehicle technology in participatory land-use planning and mapping (FAO, 2020)	Published Project report	This project by FAO was undertaken to explore UAVs for village-level mapping using participatory approaches. Though the intended purpose was land use mapping, the proposed approach's design took cognizance of the methods used since it also involves village mapping.
Participatory land administration in Indonesia: Quality and usability assessment (Aditya et al., 2020)	Published Article	This study conducted a quality and usability analysis of participatory land registration in Indonesia. The evaluation criteria used to assess the effectiveness of the spatial data collection inspired the activities to be included in each stage of the proposed approach.

3.5.2. FieldWork

The fieldwork phase involved primary data collection. This phase formed the crux of the data collection. The field data was required to complement and validate the data collected from existing literature. It was also conducted to answer the questions under sub-objectives 2 and 3.

3.5.2.1. Interviews

Two types of interviews were conducted: semi-structured interviews for key informants and structured interviews for the households. The key informants selected were the main representatives of the institutions mentioned in Table 2. In the case of the Survey and Mapping Division, the key informants selected were the head of Remote Sensing and Photogrammetry for Lands Commission Ghana, Accra, and the Northern Regional Director of Surveys in Tamale. Interview guides and questionnaires were prepared and uploaded into Kobo Collect software. The expert interviews enhanced information retrieval about cadastral boundary acquisition, land registration, and customary land administration in the study area to complement sub-objective 1. Research question 2.1, about the UAV regulations for cadastral surveying in Ghana, was also partly obtained from the key expert interview. Research questions relating to

customary land administration and women's land rights were answered through household interviews. An interpreter was engaged during household interviews since the researcher was unfamiliar with the local language in the study area. Figure 9 also shows some pictures taken during the interviews.

Table 2: Summary of Interviewees

Respondent	**Objective**	**Type of Interview**	**Men**	**Women**	**Total**
Survey and Mapping Division of Lands Commission	UAVs, Surveying, and mapping practices in Ghana	Semi-structured	2	-	2
Land Registration Division of Lands Commission	LC's part played in customary land administration	Semi-structured	1	-	1
Customary Land Secretariat (Ticheli & Woribogu-Kukuo)	Customary land administration structure and practices	Semi-structured	2	-	4
Ticheli Households	Customary land rights practices	Structured	20	20	40
Worigu – Kukuo households	Customary land rights practices	Structured	23	23	46

3.5.2.2. Sampling Technique for Household Interviews

Due to cost and time constraints, selecting a sampling technique and sample size are often considered crucial in research. But a study's usefulness and reliability depend on how the respondents were selected. This study adopted a combination of stratified sampling and random techniques to select the respondents for household interviews. The approach was intended to ensure that both genders were well represented in the data collected. Below is how the sample size was calculated based on the Alain Bouchard formula.

- ***Community name***: Ticheli

$$\text{Sample Size (n)} = \frac{(Z\alpha/2)2 \ * p(1-p) * N}{[E2 * N] + [\ (Z\alpha/2)^2 \ * p(1-p)]}$$

Where, N = Population Size (N = 60)
P = the estimated frequency for the sample size n; that is the proportion of success (50% in this study)
E = Tolerable Error (10% for this study)
Zα/2 = Value given for the confidence interval according to the precision desired (1.96 for this study)

$$\text{Sample size (n)} = \frac{(1.96)2 \ * 0.5 \ (1- \ 0.5) * 60}{[(0.1)^2 * 60] + [(1.96)^2 * 0.5(1-0.5)]}$$

$$\approx \mathbf{37}$$

Though the calculated sample size was 37 households, 40 households in the Ticheli community were reached. It was to ensure equal representation among both genders.

- ***Community name:*** Woribogu-Kukuo

$$\text{Sample Size (n)} = \frac{(Z\alpha/2)2 \ * p(1-p) * N}{[E2 * N] + [\ (Z\alpha/2)^2 \ * p(1-p)]}$$

Where, N = Population Size (N = 87)

P = the estimated frequency for the sample size n; that is proportion of success (50% in this study)
E = Tolerable Error (10% for this study)
Zα/2 = Value given for the confidence interval according to the precision desired (1.96 for this study)

$$\text{Sample size (n)} = \frac{(1.96)2 * 0.5\ (1- 0.5) * 87}{[(0.1)2 * 87] + [(1.96)^2 * 0.5(1-0.5)]}$$

$$\approx \mathbf{46}$$

A total of 46 households were reached in the Woribogu-Kukuo community, that is, 23 men and 23 women, for equal representation.

Figure 9: Interview Sessions

3.5.2.3. Focus Group Discussion

A focus group discussion was held in both communities. In the case of the Ticheli community, the group comprised the Village Chief and principal elders, who were all men. Steps were taken to avoid an all-male group in the case of the Woribogu-Kukuo community, and thus, separate group discussions were held for both genders. The essence was to make room for information retrieval from the feminine side. The segregation ensured the research maintained its gender-sensitive dimension. During the discussion in both communities, questions relating to customary land practices and the position of women's land rights pertaining to each community were thoroughly discussed. Specific close-ended questions in the household questionnaires were also rephrased with follow-up questions to tease out extensive explanations from the groups. The Ticheli group comprised 10 men, while the Woribogu-Kukuo group consisted of 5 and 9 men and women, including an interpreter in each instance. The key members of the community selected the participants for each group. Figure 10 shows some pictures taken during the focus group discussion.

Figure 10: Focus group discussions held separately for men and women

3.5.2.4. Participatory Boundary Mapping

Interactive and participatory boundary mapping sessions were held in both communities, where the people's spatial and indigenous knowledge came to play. Each participant who exercises rights on any parcel on the image took a turn in the delineation. The participants also collaborated using their common knowledge to delineate the parcels of their neighbours who were not present at the gathering. During the exercise, the gender-based focus of the study was maintained. The men and women undertook their boundary mapping on separate platforms and at different times. This approach enabled the women to participate and demonstrate their spatial knowledge without any influence from the men. Also, close observations were made during the participatory mapping session to find out how easily the participants could identify key features on the map. Some pictures taken during the participatory mapping are shown in figure 11.

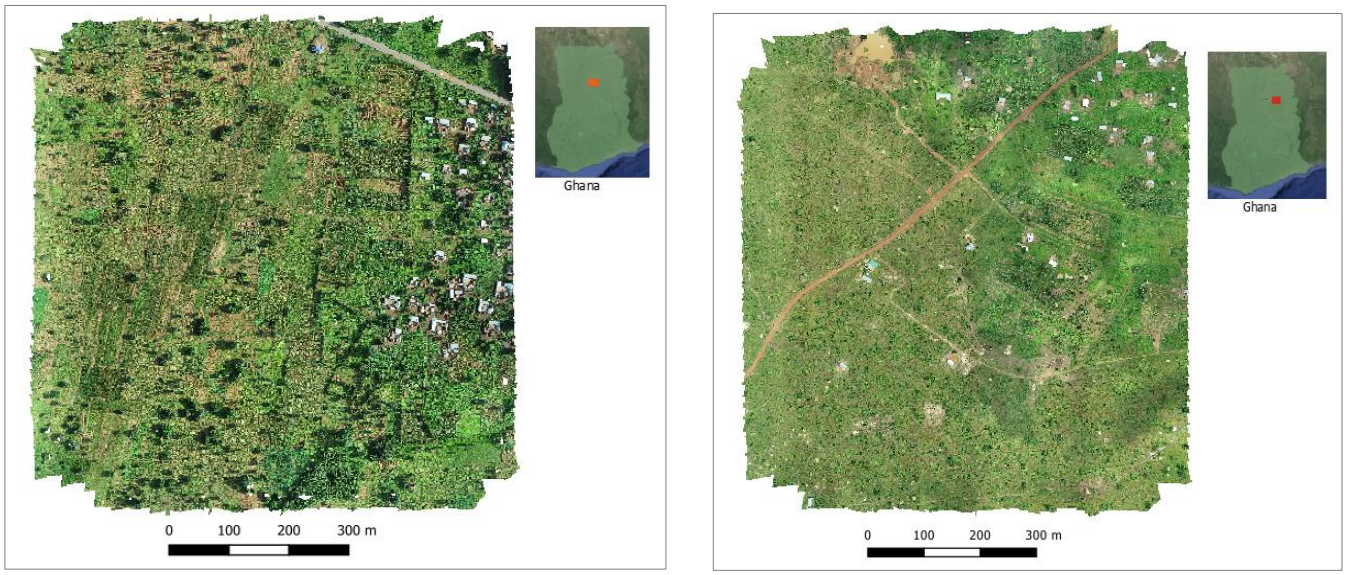
Figure 11: Participatory boundary mapping

3.5.2.5. UAV Imagery used for the Participatory boundary mapping

The study relied on UAV orthorectified imagery from PlaceFund Company, a geospatial firm based in the United States. The imagery was acquired as secondary data. It covers some portions of the two communities, mostly farmlands. The data was captured at an altitude of 100m with a DJIFC6310R camera having a focal length of 8.8 mm. The resulting orthoimage reached a spatial resolution (ground sampling distance) of 3cm. No ground control points (GCPs) were used, and the UAV was not RTK-equipped. The company, PlaceFund, indicated that high accuracy was not their primary focus because that project was for mapping farmlands where accuracy was not a priority. Table 3 summarizes the details, and Figure 12 is a pictorial view of the orthoimages.

Table 3: Details of UAV dataset Used

Description	**Details**
Data	UAV orthorectified image
Spatial resolution (GSD)	3cm
Type	RGB
Size	Aprox. 49 hectare
Date Acquired	September 2021
Source	PlaceFund Company
Number of GCPs used	None



(a) Woribogu-Kukuo (b) Ticheli

Figure 12: UAV orthoimages covering portions of the two communities studied: (a) and (b)

3.5.2.6. Field Measurements and Observations

Two buildings within the Woribogu-Kukuo community were measured with a static GNSS receiver. The measurement was conducted with the support of officials from the Survey and Mapping Division of the Lands Commission. The purpose was to verify the accuracy of the UAV image. In the case of the Ticheli community, an approved layout planning scheme covering the community was available. A soft copy of the scheme in Autocad format was made available from the Land Use and Spatial Planning Authority (LUSPA) in the Tamale metropolis.

3.6. Data Analysis Methods

The data collected from the field were processed and analyzed using a combination of descriptive, inferential, content, relational, and spatial analysis. The main activities included transcribing audio recordings from the interviews and focus group discussions, retrieving uploaded data from the Kobotoolbox software, and digitizing maps using QGIS software. The transcribed data in Ms Word format was subjected to content analysis using Atlas.ti 22 by coding the major themes such as customary land practices, cadastral mapping, UAVs, and Women's land rights. Descriptive analysis of the categorical data from household interviews employed the statistical package for social sciences (SPSS) software to process and display the charts and graphs. Results from the analysis were discussed in correspondence to the set objectives, based on which conclusions were drawn, and recommendations were made for future implementation. The proposed approach was evaluated with the fit-for-purpose elements to analyze its potential for customary land administration and contribution to the recognition of women's land rights.

3.7. Limitations of the Data Collection

The UAV imagery obtained for this explorative study largely covered farming areas and a few developing parts of the two communities. In the case of the Ticheli community, the area covered in the imagery was no longer used for farming but had been allocated as individual plots for building purposes. Therefore,

although the attendance was encouraging, it turned into an exhibition fair for many participants since they exercise no land rights over the areas covered in the imagery.
Also, due to time constraints, a separate validation session could not be held; therefore, the research collected feedback from the participants only during the participatory mapping sessions.

3.8. Ethical Considerations

The study adhered to the following ethical considerations: voluntary participation, informed consent, anonymity, and confidentiality to protect respondents from risks and harm. Prior to the data collection, official permission letters were sent to the targeted institutions where the key informants were selected, such as the Survey and Mapping Division of the Lands and Customary Land Secretariats. The permission letters shield respondents against any internal policy regarding releasing information to third parties. In addition, the respondents were asked to voluntarily affirm their consent during audio recording, picture taking, or even partaking in the data collection. Concerning anonymity, the respondents' identities were not disclosed in the study's write-up. Last, the raw data collected will be stored in ITC's data repository for security purposes.

3.9. Summary of the Chapter

This chapter highlights the methods used for data collection and analysis and describes the study area. It also briefly discusses women's land rights as it pertains to Ghana. The sequence of activities in the study summarized into pre-fieldwork, fieldwork, and post-fieldwork are extensively explained. Literature review was the main activity undertaken during the pre-fieldwork stage. The data collection methods used during fieldwork comprised of interviews, focus group discussions, and participatory mapping. The data collected were analyzed and processed during the post-fieldwork stage using descriptive, content, relational, inferential, and spatial analysis methods.

4. RESULTS AND FINDINGS

4.1. Introduction

This Chapter presents the findings from field data collection and aligns with the study's objectives. The first two sub-chapters outline the current cadastral mapping practices, customary land administration practices, women's land rights situation in the study area, and UAV operations in the context of Ghana based on literature and key informant interviews. The subsequent sub-chapters present results from the participatory mapping experiment and the developed approach for women's land rights recognition. Findings presented on customary land administration practices partly include outcomes from the household interviews.

4.2. Existing Cadastral Mapping and Customary Land Administration Practices

Cadastral mapping establishes the spatial dimension as an essential component of customary land administration. This section provides insights into the current practices of cadastral mapping and customary land administration in Ghana, with a specific focus on the study area. The effects of the current practices are used to discuss and evaluate the proposed approach for recognition of women's land rights per objective 1 of the study.

4.2.1. Legal Framework: Cadastral Surveying and Mapping Practices

Legally, cadastral surveying and mapping in Ghana is governed by the Survey Act, Act 127 of 1962, and the legislative instrument L.I. 1444 of 1989. The practice was first guided by the Gold Coast Survey Technical Instructions for the Cadastral Branch 1921 (Ofori-Boadu, 2006). With periodic revisions, it is now replaced with the Technical Guidelines for Surveying and mapping in Ghana 2020, though unpublished. These guidelines and technical instructions regulate the practices by setting common standards to ensure accuracy and consistency in the survey operations. The Survey and Mapping Division of the Lands Commission is the mandated body responsible for regulating, supervising, and controlling all land surveys and photogrammetric surveys to conform to the national spatial reference system of the country. Section 20 of the Lands Commission Act, 2008 (Act 767) and Sections 23 - 28 of the Land Act, 2020, Act 1036 provide the legal backing for the power to direct surveys in Ghana. The standard of surveying and mapping is uniformly applied to all the different landholding systems in the country, including customary lands.

4.2.2. Legal Framework: Customary Land Administration

Customary land management in Ghana evolved through cultural norms and traditions practiced since time immemorial. With state interventions, it is now fashioned into a formal administrative framework. The current customary land administration system operates under the Ministry of Lands and Natural Resources and collaborates with land agencies such as the Lands Commission and the Office of Administrator of Stool Lands (OASL). Enactments on customary land practices date back to colonial times when some ordinances were formulated to deal with specific land-related problems and serve as a guide (MLNR, 1999). Regulations concerning land dispositions and management of proceeds from customary lands are enshrined in article 267 of the 1992 Constitution to ensure decorum in the land system. Sections 13- 21 of the Land Act, 2020, Act 1036 underpins the formalization of customary land administration. It makes provisions to accentuate customary land management as the fiduciary duty of customary authorities and establish secretariats to ensure maximum accountability and fairness. The law

also defines the functions of customary land secretariats (CLS), which is mainly the recordation of land transactions, including oral grants. The CLS's are expected to submit recorded transactions to the Lands Commission and the OASL every six months to create checks and balances per Act 1036.

4.2.3. Technical Framework: Current Cadastral Surveying and Mapping Practices

In Ghana, cadastral boundary surveying and mapping adopt the fixed boundary system with strict adherence to exact measurements and high accuracy standards (Ofori-Boadu, 2006). The Survey Act, 1962, Act 127 defines a cadastral plan as a map or plan purporting to show boundaries of land with accuracy and giving exact measurements by which the boundaries may be demarcated or re-demarcated on the ground. The plan must be surveyed by an Official Surveyor or Licensed Surveyor and approved by the Director of Surveys or a representative. According to the respondent from the Remote Sensing and Photogrammetry Section of the Lands Commission, GNSS, Total Station, and Theodolite are the main techniques used for the field surveys. Also, measurements from remote sensing and photogrammetric products are acceptable for land registration as long as the basic standards such as digitizing accuracy and orientation accuracy are met. The required level for digitizing and orientation accuracies are 1m and 1.5m, respectively, in planimetry (SG, 2020). The accuracy standard for cadastral measurements is the average measure (mean, median) of relative positional accuracies for a station mark's coordinates in relation to the adjacent station at a 95 percent confidence level (Ibid).

4.2.4. Current Cadastral Surveying and Mapping Process for Customary lands

The process of cadastral boundary mapping forms an integral part of customary land administration and intertwines with the work of other land agencies. Respondents from the customary land secretariats disclosed that customary land institutions often initiate the process by requesting a basemap preparation from the Survey and Mapping Division (SMD) of the Lands Commission. Basemaps have been described as maps representing the topography, physical terrain features, and significant structures on land, based on which subsequent mapping can be done (Gomis & Turon, 2018). The Land Use and Spatial Planning Authority (LUSPA) prepares a draft layout with the prepared basemap. This draft scheme is further tested on the ground by the SMD. Where no technical defects are found, it receives approval from the Regional Spatial Planning Committee and is adopted as a workable layout scheme. The SMD proceed further to conduct demarcation and pillaring of all the plots in the layout on the ground. These processes are summarized in figure 14. For deed registration, landowners would need to engage the services of certified or licensed Surveyors to prepare cadastral plans. It was noted that none of the landowners interviewed during the data collection had taken steps to engage a surveyor for cadastral plan preparation. Upon questioning, high survey cost was mentioned as the major deterrent.

Cadastral surveys and land registration follow a sporadic process in Ghana. According to the respondent from the Tamale Survey and mapping Division, the following generic procedures are typically followed for the preparation of cadastral plans for deeds registration:

1. The client sends an official request to the SMD. The request could be a written letter attached to the allocation note from the Chief and an extract of the approved layout plan.

2. Upon receipt of the request, the SMD conducts a reconnaissance survey on the land to identify existing ground control points closer to the site or some noticeable ground features as reference points. This activity is done with the assistance of the client.

3. Back in the office, the request is given a job number (or cadastral number) for the work to commence. Further checks are carried out to find if there are any existing maps/plans covering the subject area.

4. A date is scheduled with the client for the actual fieldwork. On the field, the surveyor establishes the cadastral project controls before undertaking the cadastral measurements. The surveyors fix the boundary pillars and inscribe the job number on them where there are no boundary pillars. The cadastral measurement entails running a GPS traverse for the pillars using Static positioning, Fast-static positioning, Post-processing Kinematic, or Real-Time Kinematic methods depending on the availability of COR (continuously operating reference) station.

5. Further processing in the office includes downloading the data, computation, plotting, examination, checking, quality control, and final approval. The entire process is summarized in figure 13.

4.2.4.1. Cost of Cadastral Surveying and Mapping

The SMD respondent at Tamale disclosed that official fees charged for survey and mapping services are categorized into different service delivery activities. Land size is often a major determinant. But in sum, basemap preparation costs GHC 5400 (USD 700) for a hectare of land. Cadastral plan preparation for deed registration also costs GHC 1200 (USD 155) for a plot size of 0.22 acres. The survey cost is usually unaffordable to many landowners and customary institutions; thus, some resort to alternative funding methods such as gifting plots. During the interview with the customary land secretariats, it was revealed that the professionals who prepared the layout scheme at Ticheli community were given some plots of land as professional fees for the services rendered, see Appendix 2.

4.2.4.2. Turnaround time for Cadastral Surveying and Mapping

According to the respondents from SMD, the time utilized for cadastral surveying and mapping may vary depending on the location, land size, the client's readiness, availability of instruments, and staff in the office. All other things being equal, basemap preparation takes about 3 days, and cadastral plan preparation takes barely 2 weeks using the existing methods. Table 4 provides a summary.

Table 4: Time and Cost of Cadastral mapping Services using existing methods

	Basemap (per hectare)	**Cadastral Plan (per 0.22 acre)**
Cost	USD 700	USD 155
Time	3 days	2 Weeks

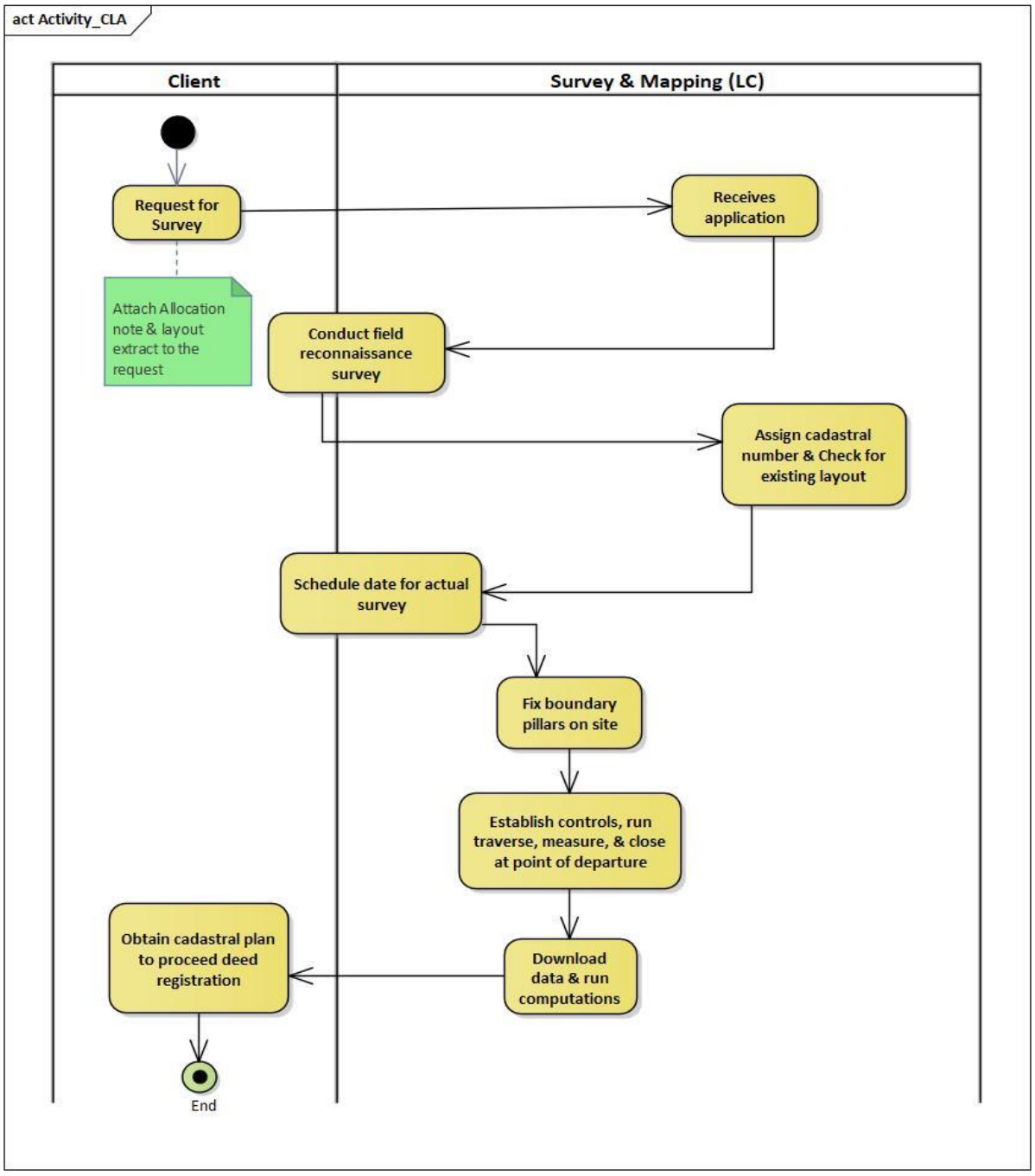


Figure 13: Cadastral plan preparation process

4.2.5. Structure: Customary Land Administration in the Study Area

As revealed by the respondents from the CLSs, customary land administration in the Northern Region is structured in a hierarchical order in accordance with the Dagbon customary law. At the top of the hierarchy is the overlord King, Yaa-Naa, who holds the absolute allodial ownership of all lands within the Dagbon traditional kingdom. From the Gbewaa Palace in Yendi, the Yaa-Naa manages the land through the Paramount /Divisional Chiefs to the sub-Chiefs. Sub-Chiefs are also called Caretaker Chiefs or Village

Chiefs. The Paramount chiefs are in charge of overseeing specific areas. Within the territory of each Paramount Chief, direct management and control of lands are administered locally at the community level under the supervision of the sub-Chiefs. The administration of customary lands, therefore, takes a bottom-up approach. Usufructs or indigenes access land through their family heads and the Village Chief.

In the case of Ticheli, it was informed that the community elders, which include heads of the different families in the community, make allocations with the approval of the Village Chief. However, Woribogu-Kukuo had lost its Village Chief at the time of data collection; therefore, the Paramount Chief at Woribogu collaborates with the community elders to administer the community's land. These elders also constitute the Land management committee in the community. During the interviews with the customary land secretariats in both communities, it was informed that no woman formed part of the land committee or among any decision-making group on land, although there existed women groups led by the *Magazias*.

4.2.6. Customary Land Recordation

In both communities, the CLS reps disclosed that only land allocations meant for building purposes are recorded. Accordingly, lands allocated solely for farming purposes are not recorded unless the allottee is a profit-making entity. An explanation given for this practice was that farmlands are susceptible to land-use changes, which can also be taken over or re-entered by the Chief at anytime, though with the current land user's prior consent. In addition, farmlands are collectively used by all members of a land-owning group, while land for building purposes has individual or joint ownerships. Impliedly, only ownership rights are recorded. Since many women in both communities exercised only use rights on farms accessed through their male counters, it was found that most women had their land rights unrecorded.

Observations made at the customary land secretariats also revealed the recording of land transactions in both communities followed a manual process. It is first entered into books, after which an allocation paper is prepared with stamps from the local palace. A copy is attached in appendix 3. With the allocation note, the grantee proceeds to confirm the transaction from the Paramount Chief, based on which a formal lease agreement can be established between the grantee and the Yaa-Naa. Basic information entered during the recording process includes the grantee's name, date of transaction, plot number, and phone number. Both communities had no established offices, but the Secretaries were operating from their residence. The customary land administration processes are summarized in figure 14.

4.2.6.1. Cost of Customary land recordation

The CLS rep at Ticheli community disclosed that indigenes pay no fees for community-level land recordation while non-indigenes pay GHC100 (USD 13). However, the confirmation fee paid at the Paramountcy level was GHC 200 (USD 26) for a regular plot size of 0.22 acre for both indigenes and non-indigenes. The fee is adjusted upwards for plots bigger than a standard plot size. At Woribogu-Kukuo, the recordation fee for a regular plot size was GHC 200 (USD 26), both at the community and Paramountcy levels. It was observed from the household interviews that the recordation fees were unaffordable for many land owners in both communities. Regarding the cost of land recordation, it was observed that the women were not much concerned since many of them owned no building lands.

4.2.6.2. Timeframe for Customary land recordation

The CLS reps in both communities revealed that community-level land recordation typically takes a day while confirmation at Paramountcy takes a week. The difference is associated with the Paramount Chief's

availability, limited personnel, and workload at the Paramountcy. Timeframe for land recordation appeared very satisfactory to the people during the interview as they faced no frustration in the process.

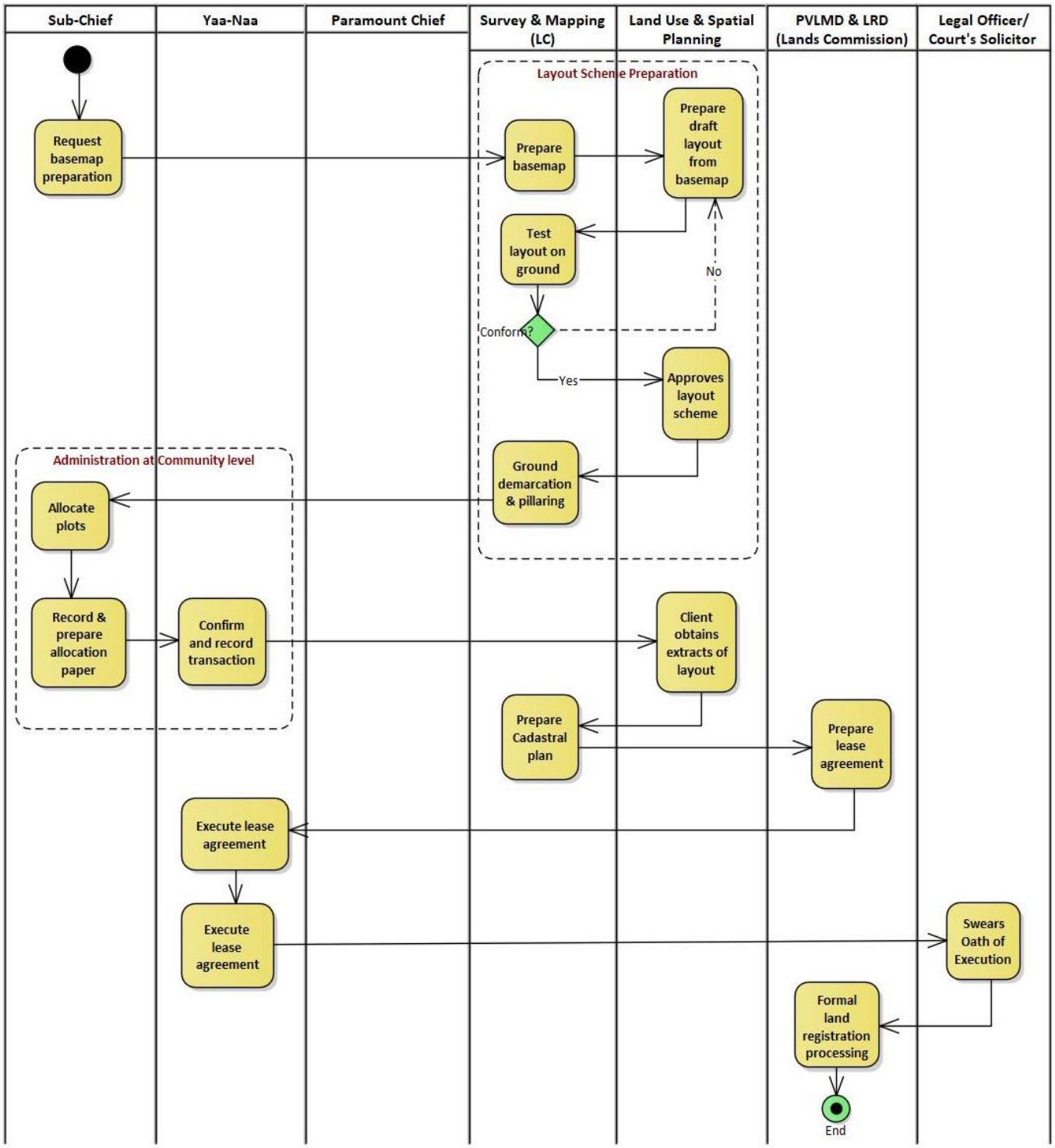


Figure 14: Customary Land Administration Processes

4.2.7. Rights Exercised on Land

By prima facie, all the indigenes have use rights on land, mainly for farming purposes, as inferred from the focus group discussion. The field data collected revealed that 67% of the households interviewed in Ticheli were engaged in crop farming and 72 % in the case of Woribogu-Kukuo, as displayed in figure 15. The proportion of men and women involved in farming in both communities is about the same.

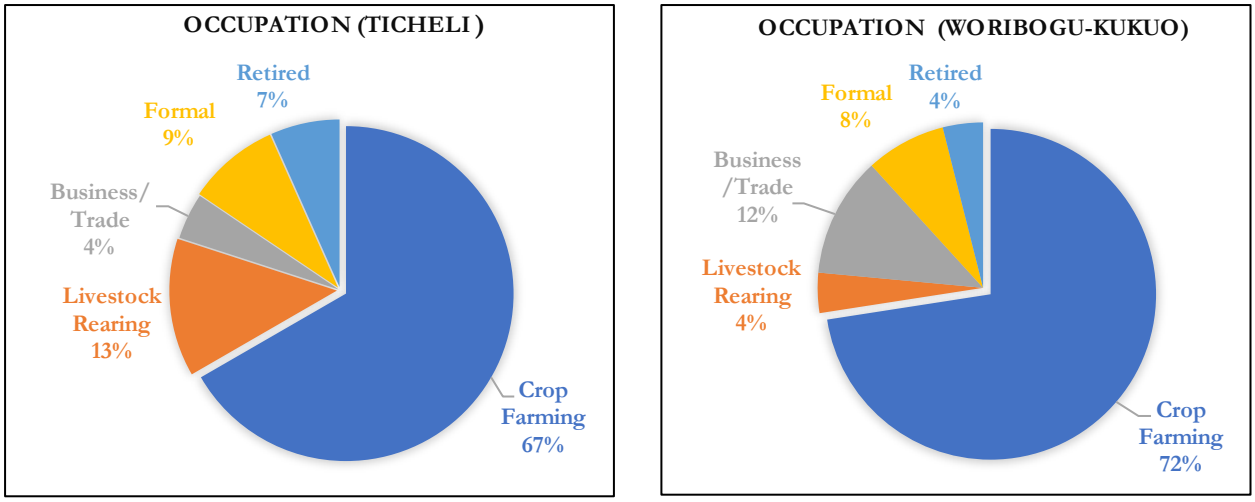


Figure 15: Occupation of Respondents

It was inferred from the focus group discussion that by tradition, ownership right in land is tied to lineage and inheritance. The patrilineal inheritance system is prevalent among the people in the Northern Region of Ghana, where land ownership is passed on to male members in a kinship group through successive generations. Therefore, the right to own land through inheritance is exercised by only the men, making it easy for them to access land. However, the CLS representatives explained that the norm turns in favour of women when there is no male heir. But in all, men enjoy more land rights with better security than women, as depicted in figure 16 and also identified in the study of Richardson and Gaafar (2016).

Also, during the focus group discussions, it was revealed that farmlands are inherited whiles building plots are purchased. That is to say, indigenes exercise their usufructuary rights on farmlands without restrictions, but a token must be paid if the use is for building purposes. However, since women do not inherit land by custom, obtaining exclusive access to land for farming was a challenge. Some men disclosed during the discussions that they often release small portions of their inherited lands to their wives for farming purposes. Others indicated that they jointly work on the farms with their wives or sometimes receive assistance from other women during the planting and harvesting seasons.

4.2.8. Women's Rights Exercised on land

Generally, the women enjoy use rights on farmlands and rights of occupancy in their father's or husband's house, depending on the marital status as inferred from the household interviews. From figure 16, less than 5 women interviewed in both communities had ownership rights over the land they occupied, either by purchase or leeway through the customs. The focus group discussions revealed that women who marry from families with no lands or limited lands are compelled to approach other families or nearby communities for farmlands on short-term agreement. At Worigu-Kukuo, it was told some women farm on the edges of their husband's land due to limited land available in the community.

Though women are not denied access, land ownership through inheritance excludes women as told in the focus group discussion. The main means through which women can own land is by purchase; even that, a male must always lead the woman to acquire the land from the Chief. However, exceptional cases were identified: a widower at Ticheli who owned a house explained she acquired the land as a gift from her deceased husband, a past Village Chief in the community. Also, at Woribogu-Kukuo, some widows and divorcees had been granted land from their father's kinship group to build and settle after their broken relationships.

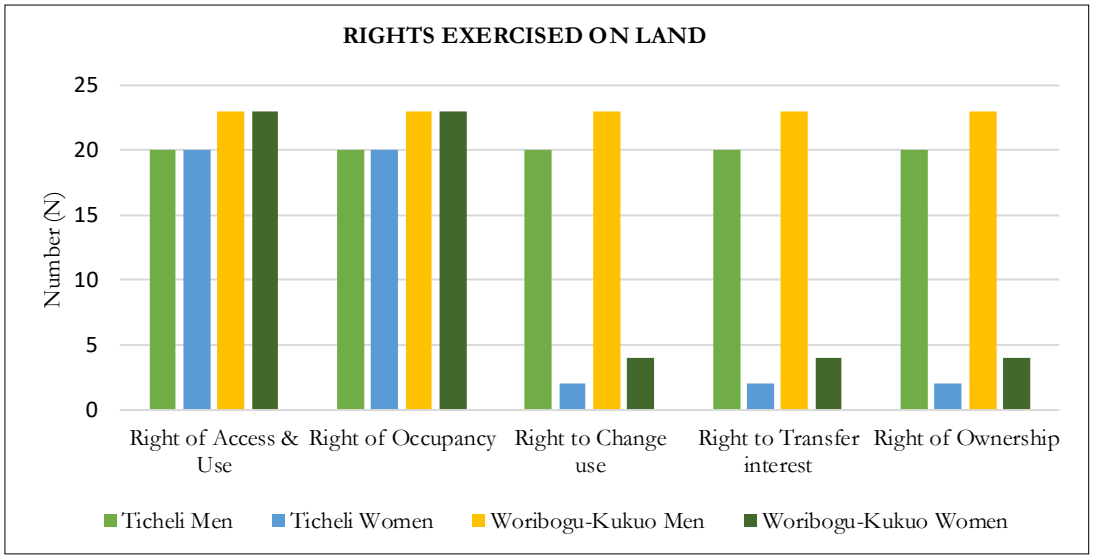


Figure 16: Rights exercised on land at Ticheli and Woribogu-Kukuo Community

No joint land ownership was recorded between couples in both communities studied. However, the data obtained on registered deeds at Tamale Lands Commission proved contrary, as shown in Table 6. The data revealed there had been 96 registered deeds in favour of couples out of a total of 3,835 deeds registered between 2016 and February 2022. This was attributed to cultural dynamics emanating from literacy among many educated couples in Tamale City. Most educated spouses prefer to register their jointly acquired properties in both names, knowing that each person has an equal share in the property per Article 22(3) of the 1992 constitution.

Table 5 also showed there had been 2,803 registered deeds in favour of men as against 466 in favour of women representing 73.1% and 12.1% of the total registered deeds, respectively. This observation is also attributed to literacy, as noted by (Ankrah et al., 2020), that highly educated women are more independent and prefer to have their individual property rights. Therefore, the data obtained from the Metropolis creates a divergence from the data in the communities.

Table 5: Registered Deeds at Lands Commission, Northern Region – Ghana from 2016 to Feb 2022

Application	**Male**	**Female**	**Couple**	**Company**	**Multiple**	*Total*
Application for Deed of Registration	2,803	466	96	428	43	*3,835*
Application for Discharge	37	4	0	24	23	*88*
Application to Mortgage	45	11	8	51	66	*181*
Total	*2,885*	*481*	*104*	*503*	*132*	*4,104*

4.2.9. Women's Opinion on existing land rights practices

When the women were asked about their individual opinions concerning the current land practices and the resulting effects on their economic life, diverse answers were received, as shown in table 6. At Ticheli, 45 percent of the women indicated that the practice does not have any adverse effects on them and that, with the availability of purchasing power, they can always acquire land. At Woribogu-Kukuo, 22 percent were of the opinion that although women have less access to farmlands, it emanates from the insufficient lands available in the community. And as long as the men, as household heads, play their part in taking care of the homes, they agree to cede ownerships to the men. These responses beef up Kaunza-Nu-Dem et al. (2016) findings where women who expressed satisfaction with the gendered land access in Northern Ghana indicated they are not good land managers and might mismanage land if ownership is entrusted to them.

Meanwhile, 43% and 30% in both communities believed that productivity could have increased if women had the opportunity to own land exclusively. Some women added that due to the cultural norms regarding land ownership against women, they are not motivated to combine resources with their husbands to develop. Traditionally, women who opt to remarry after widowhood or divorce lose access to all properties or lands acquired in the broken relationship, as Doss and Meinzen-Dick (2020) also noted. Thus, during the focus group discussions, some women shared substantive views about the gendered norms on land access and some steps they have taken. A woman remarked:

"Under the Islamic religion, husbands are required to completely take care of all the economic needs of their wives(s). To avoid economic hardships in the event of widowhood, divorce, or desertion, some of us have acquired land and properties in the name of our brothers, oblivious to our husbands. "

However, despite the diverse responses it was observed from the focus group discussions that most of the women desired exclusive ownership and control over farmlands instead of merely helping the men on farms, similar to Kaunza-Nu-Dem et al.'s (2016) findings.

Table 6: Impression of women about the existing customary land practices

As a woman, what effect do the limitations on land rights have on your economic life or empowerment for development?

	Ticheli Community		Woribogu-Kukuo Community	
Responses	*Number*	*%*	*Number*	*%*
No effect; I am comfortable with the norms	9	45.0	5	22.0
Low Productivity	6	30.0	10	43.0
Demotivated to develop	4	20.0	5	22.0
Unemployment	1	5.0	3	13.0
Total	*20*	*100*	*23*	*100*

4.2.10. Literacy level

The literacy level of the respondents was also collected to analyze the relationship between literacy and customary land practices in the study area. Data collected on literacy revealed that 72.5 % and 70 % of the respondents from Ticheli and Woribogu-Kukuo have no formal education and cannot read or write. That is, 29 out of 40 respondents and 32 out of 46 respondents from Ticheli and Woribogu-Kukuo, respectively, as presented in figure 17. The differences between the men and women regarding their literacy levels were relatively insignificant. The data was aimed to examine whether literacy contributes to the existing land practices or influences the responses received. This is further discussed in Chapter 5 of the study.

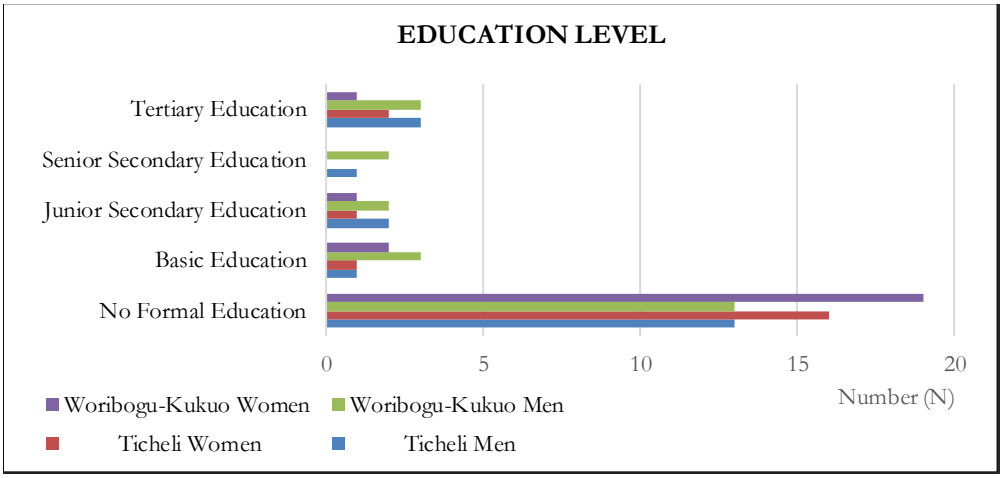


Figure 17: Literacy level of respondents

4.3. UAVs in Ghana

Existing Policies and Regulations

UAVs operation in Ghana does not have explicit legal backing in the existing laws. Currently, it is being regulated by the technical directives for Remotely Piloted Aircraft Systems (RPAS) 2018 Part 28, which was developed by the Ghana Civil Aviation Authority (GCAA). The directives underpin its acceptance into Ghana's airspace system, and thus its compliance is subject to the other existing flight directives provided by GCAA. The existing regulations cover areas of aviation such as certification, equipment, operation, and restrictions. Under Part 28.1 (8) of the directives, UAV pilots should be registered with the GCAA and be issued with an RPAS operating certificate (ROC), especially for commercial uses. Such flight permits must be renewed every year. UAVs must also be registered and insured before being used, per Part 28.6(2).

Restrictions

The directives outline certain restrictions to protect and minimize potential hazards to persons and property. Thus, UAV operators are restricted from flying within certain specified areas and aerodomes without prior authorization, such as within 10 kilometers radius from an Airport and around crowded areas. Also, vertical flights above 400 feet cannot be undertaken without necessary authorization from the GCAA. Prior authorization is also required for certain activities, including night flights, manufacturing, importing, and exporting of UAV equipment.

UAVs for Cadastral Surveys

Over the last decade, the use of UAVs in Ghana has accelerated in aerial photography and videos, real estate photography, automated package delivery, and electronic monitoring for commercial, recreational, and private purposes. However, UAVs for remote sensing and photogrammetry are still at a rudimentary stage. An interview conducted with the Head of Remote Sensing and Photogrammetry department of the Lands Commission (LC) indicated that the LC used UAVs for a lease regularization project at Batsona – Accra, a highly urbanized neighbourhood in the national capital. At a flying height of 80 meters, the institution extracted over 500 parcels using visual boundaries such as fence walls to guide the on-screen digitizing. The institution acknowledged the technique was very effective in terms of time, cost, and efficiency compared to GNSS.

Though there are generic regulations on remote sensing and photogrammetry in the drafted technical guidelines for surveying and mapping in Ghana, specific directives on UAVs are not yet included. It was disclosed during the interview that apart from cadastral surveys, UAVs are currently being used for mining and hydrographic surveys. Therefore, steps are being taken to liaise with GCAA and engineers to develop comprehensive UAV technical regulations for the application in the different surveys.

4.4. Results of the Proposed Participatory Mapping Design

In Chapter 3, a proposed participatory mapping approach to support the recognition of women's land rights was designed in eight steps, as shown in figure 4. The major activities in the design included (1) approach community, (2) stakeholder engagement, (3) training, (4) participatory mapping through focus group discussion, (5) onscreen digitizing, (6) display for verification, (7) verifying with existing local plans and GNSS, and (8) finalize map. The experimentation procedure are discussed as follows:

4.4.1. Planning and Preparation

Approach Community

First, steps were taken to establish a community protocol. Permission letters were sent to the Paramount Chief and Sub Chiefs in the communities ahead of the data collection. During this activity, the orthorectified UAV imagery was acquired from Placefund Company and printed on A0 (approx. 841 mm X 1189 mm) matte paper sheet at a scale of 1: 800, less than the FFP recommended scale of 1:2,000 to 10,000 for rural and remote areas (Enemark et al., 2016). This scale, however, enhanced visibility and participation.

Stakeholder Engagement

Having received the approval, a date was fixed to engage the key stakeholders. The purpose was to brief the stakeholders about the aim of the research and its intended relevance to customary land administration and women's land rights. A date for the participatory mapping exercise was also scheduled during the stakeholder engagement. In each of the communities studied, the key stakeholders willingly consented and promised their support.

Training

Before each participatory mapping exercise, the researcher explained what was required from the participants and clarified all questions.

4.4.2. Boundary data collection

Participatory mapping through focus group discussion

As the main focus of the proposed approach, the participatory mapping exercise was gender-based. In each community, the men conduct their mapping independent of the women. Participants took turns mapping out the parcel boundaries where they exercise some land rights. The parcel boundaries were mapped directly on the printed UAV images without using transparent sheets for better visibility and ease of georeferencing. Also, permanent markers with a 4mm tip were used for the boundary delineation to ensure clarity in the mapping. Figure 18 shows how some participants (left: woman, right: man) mapped their boundaries using indigenous knowledge of their traditional homes. The outcome of the participatory mapping is presented in figures 19 and 20. It was observed that the printed imagery generates discussion among group members soon after it is displayed before them. Their discussions were mainly about the features they identified on the image.

The mapping was highly participatory, transparent, and fun-filled. As noted by Jing (2011), boundaries are easy to interpret on high-resolution images, making it efficient to conduct mapping in one workshop. The women mapped their husband's farms as well as the farms they had exclusively cultivated. Through collaboration and common knowledge of the community, participants in each group at Woribogu-Kukuo identified all the parcel boundaries on the image using tree species, crop types, rooftops, house shapes, lanes, and roads. The parcels were indexed using the crop types. Plots owned by neighbors who were not present were also identified and mapped. Participants in each group had less difficulty identifying features which enhanced time efficiency to an average of 45 minutes by each group.

Figure 18: Mapping boundaries based on indigenous knowledge of boundaries

Figure 19: Participatory mapping results by men (left) and women (right) at Ticheli Community

Figure 20: Participatory mapping results by men (left) and women (right) at Woribogu-Kukuo Community

4.4.3. Data Processing

Scanning, georeferencing, and vectorization

After participatory mapping, the images were scanned into digital formats and georeferenced. The parcel boundaries were vectorized with QGIS software using on-screen digitizing techniques. Vectorization converts delineated boundaries on the image into vector data, which can be stored in a geo-database. This activity was planned to form part of the fieldwork, but due to the non-availability of a large format scanner in the study area and time constraints, it was undertaken as a post-fieldwork activity.

Figures 21 and 22 show the vectorized parcel boundaries on the imageries. It can be observed that the proposed approach enables the different locally recognized land rights: main and secondary land rights, to be mapped and displayed concurrently. The vectorization on both images: figures 21 and 22, affirms that the women's land rights are derived from or depend on that of the men, based on the overlay of the parcels in different colors. Thus, the proposed approach also makes the women's secondary land rights noticeable and recognized as recommended by the continuum of land rights approaches (Barry & Augustinus, 2016). The continuum approach offers an alternative to the primary focus on individual land titling to ensure tenure security for all.

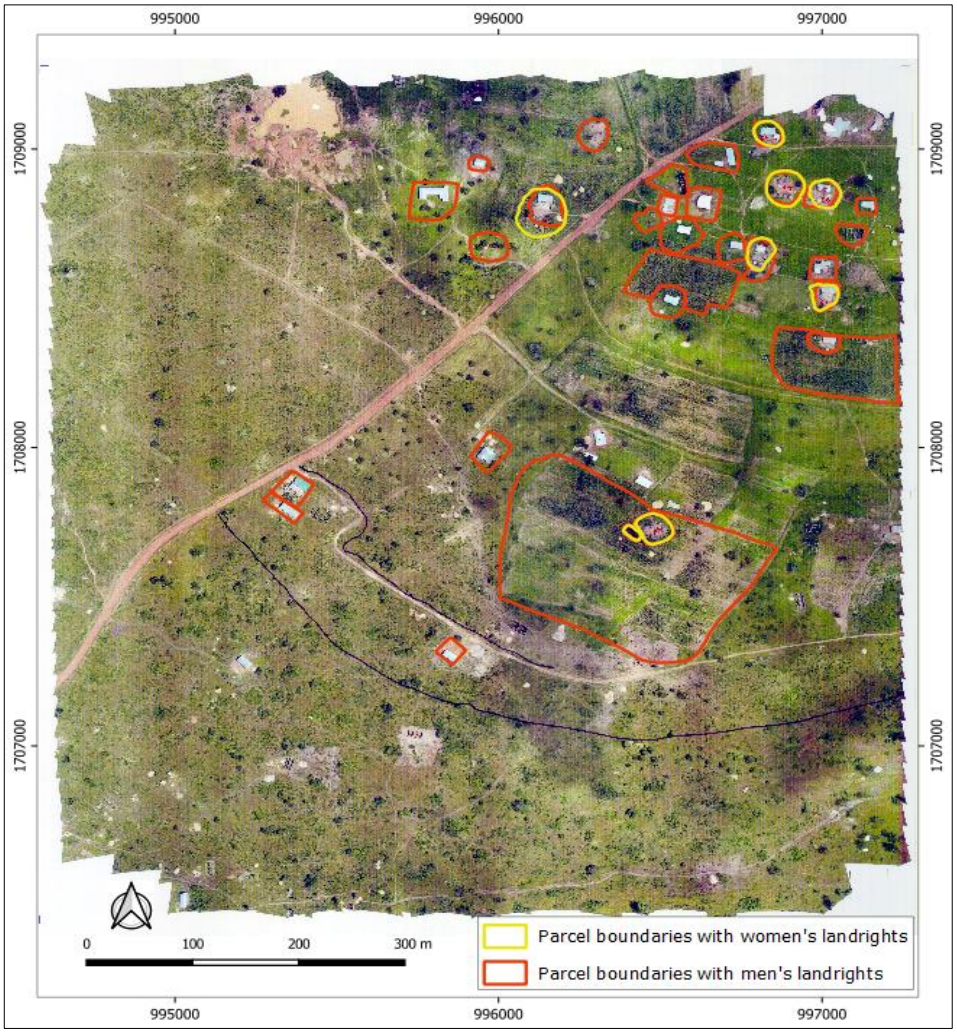


Figure 21: Parcel boundaries from the participatory mapping of land rights at Ticheli community

Parcels mapped at Ticheli:

At Ticheli, most of the participants, both men and women had no land rights over the area covered in the image. The subject area had been allocated to individuals as building plots. To the dismay of the researcher, most of the land owners whose lands were represented on the image lived outside the community. Reaching the absentee landowners to participate in the mapping was a challenge, resulting in a maximum of only 31 parcels out of 307 parcels being mapped.

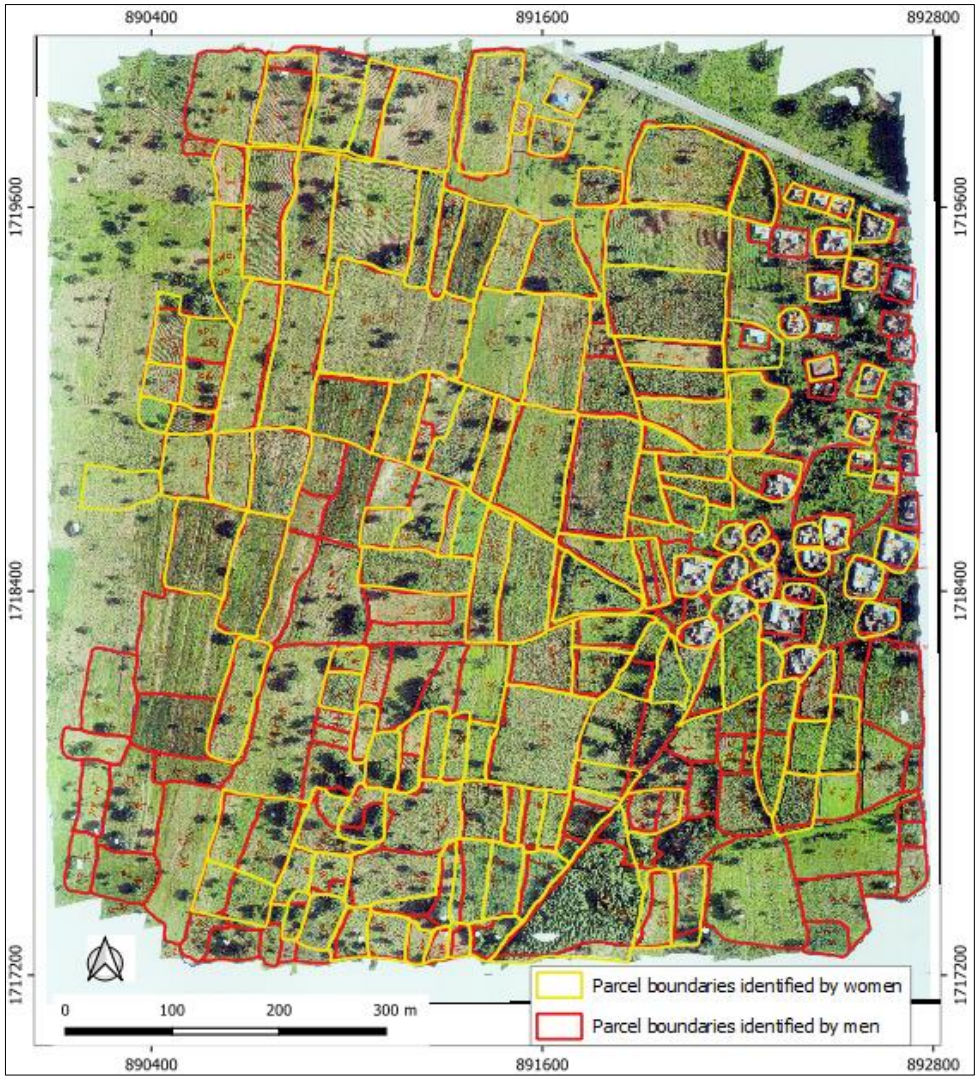


Figure 22: Woribogu-Kukuo: Parcels boundary delineated by men and women

Parcels mapped at Woribogu-Kukuo:

Good participation was observed among both genders during the mapping at Woribogu-Kukuo community. Overall, the total parcel boundaries mapped by women were 148, indicating the parcels on which they exercise a certain extent of land rights, mostly use rights for farming purposes or collecting forestry products such as firewood and shea butter. The men also mapped 209 parcel boundaries.

When the groups: men and women were asked to map the farms which they exclusively cultivated, the results in figure 23 were obtained. The result indicates that farms cultivated solely by women are fewer (92% less) than that in which men are involved. It also shows that there were only 13 plots on which women exercised exclusive use rights for farming during that planting season. During the focus group discussion, it was informed that many women help the men on farms and get paid with farm produce due to limited farmlands.

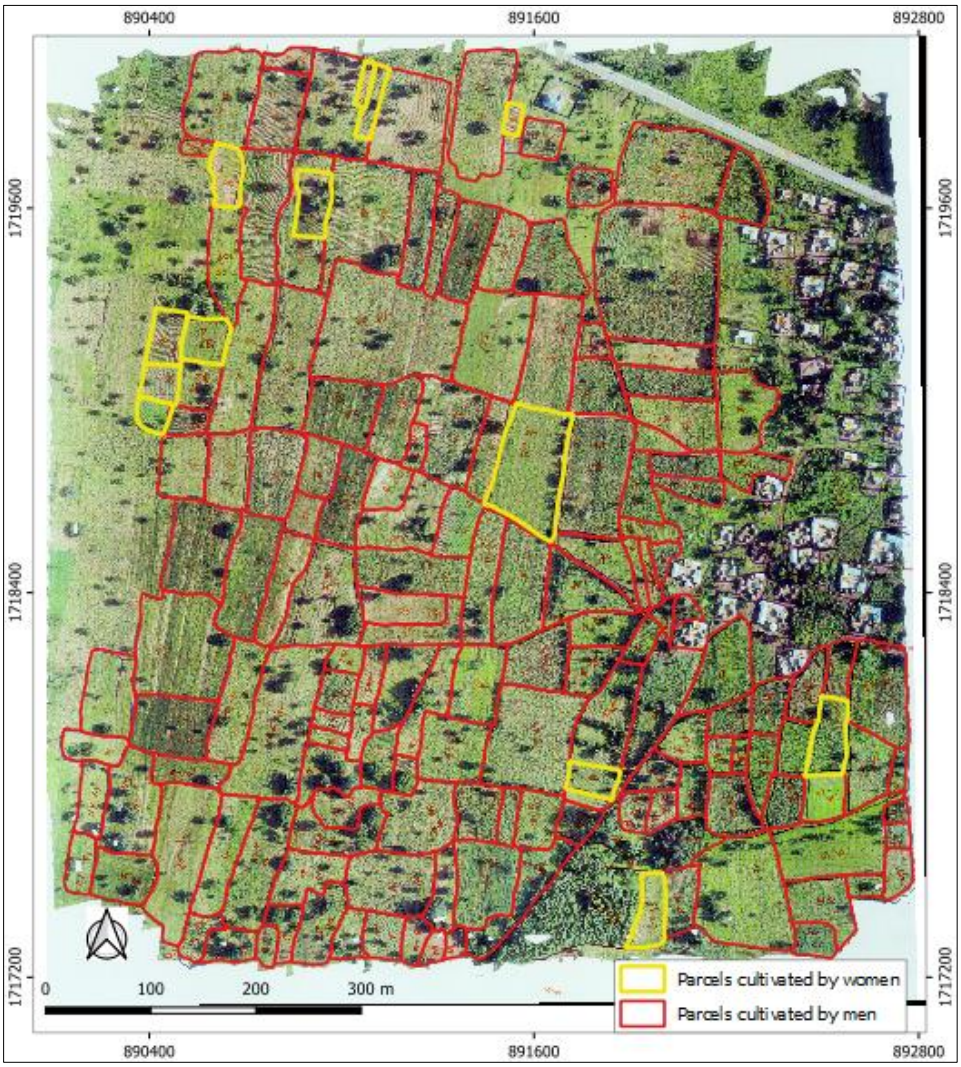


Figure 23: Woribogu-Kukuo: Farmlands cultivated by men and women

4.4.4. Verification

Display for verification

This step was not carried out due to time constraints. Ideally, the digitized map should be printed and displayed before the stakeholders for verification before adopting for use.

Verify with existing Layout Scheme and GNSS Measurements

The study relied on GNSS measurements and the existing layout planning scheme to evaluate the spatial accuracy of the UAV image and the parcel diagrams produced.

Layout Planning Scheme/ Reference Boundaries:

The approved layout planning scheme or the reference boundaries covering Ticheli was obtained from the Land Use and Spatial Planning Authority (LUSPA) in dwf file format. It was further converted to dxf format using ODA File Converter and visualized in QGIS. The layout scheme was superimposed on the UAV imagery to evaluate its conformity. As presented in figure 24, the results revealed that the shapes and sizes of the individual property boundaries on the UAV imagery were not in conformity with the existing layout scheme. However, the roads and lanes conformed. Thus, while the UAV imagery showed the existing ground situation, the layout scheme lacked up-to-datedness.

Typically, the traditional homes of the communities are in round shapes, irregularly arranged, and mostly indefinite boundaries; that was how some participants mapped their boundaries. Meanwhile, the layout scheme or reference boundaries prepared by the Spatial planners have regular shapes. This finding indicates a dichotomy between the rural conception of land management and the formal systems (Kingwill, 2013). Figure 25 shows a sample of a typical local settlement captured on the UAV image (a) and the Ticheli layout scheme prepared by the Spatial Planners (b).

Figure 24: Results of Participatory mapping and layout site plan

(a) (b)

Figure 25: Indefinite parcel boundaries (a) in communities against definite boundaries on layout (b)

GNSS Measurements:

A Static GNSS survey method was employed to measure the corners of two buildings at Woribogu-Kukuo community for verification. The measurements were mainly taken with the assistance of some key staff of the Survey and Mapping Division- LC in Tamale, Northern Ghana. The coordinates of the points were plotted and compared to the corresponding points on the UAV image to calculate the root mean square error (RMSE). Static GNSS positioning has been argued to have the highest accuracy, even more than kinematic systems (Lauer, 2018). The results revealed a systematic error shift, as shown in figures 26 (a) and 27. The same points were also measured on Google satellite imagery for further comparison, as demonstrated in Figure 25(b). According to Goudarzi and Landry's (2017) study, Google Satellite Imagery has positional accuracy between 0.1 meters and 2.7 meters and, therefore, is suitable for comparison in this case. The results from the three measurements also showed discrepancies.

(a) (b)

Figure 26: Measurements on UAV image (a) and Google Satellite Image (b)

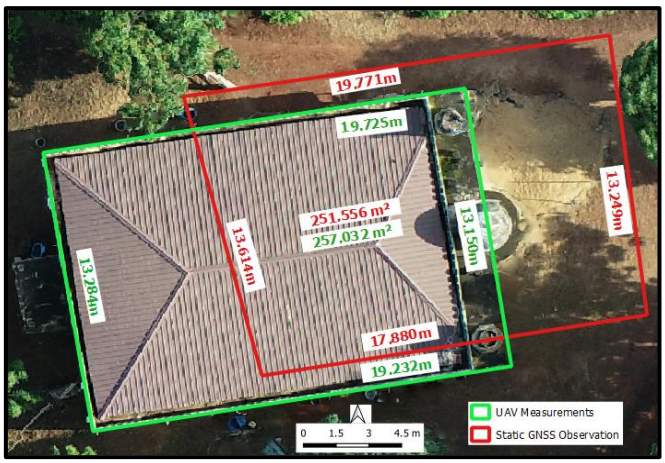


Figure 27: GNSS and UAV image measurements (Mosque)

Table 7 present the variance in the coordinates and the RMSE calculations. The systematic error shift resulted in an 18.5ft (5.6 m) error in X and a 13.4ft (4.1 m) error in Y. Also, as shown in table 8, the differences in distance measurements were generally within centimeters.

Table 7: GNSS and UAV Point Measurements

	GNSS Measurements		UAV Measurements		Residuals	
ID	**Easting X (ft)**	**Northing Y (ft)**	**Easting X (ft)**	**Northing Y (ft)**	**Easting Δ**	**Northing Δ**
	Building 1					
1	891770.027	1719978.217	891755.43	1719961.29	-14.597	-16.927
2	891725.547	1719888.101	891711.39	1719871.46	-14.157	-16.641
3	891620.927	1719930.187	891607.69	1719913.81	-13.237	-16.377
4	891666.848	1720021.692	891653.21	1720003.46	-13.638	-18.232
	Building 2					
A1	892506.234	1719083.092	892485.84	1719075.53	-20.394	-7.562
A2	892448.391	1719073.755	892423.25	1719065.46	-25.141	-8.295
A3	892436.61	1719116.688	892415.94	1719107.68	-20.67	-9.008
A4	892500.612	1719126.113	892478.5	1719117.62	-22.112	-8.493
				RMSE (ft)	18.50297554	13.43188438
				RMSE (m)	5.6	4.1

Table 8: GNSS and UAV Distance Measurements

	GNSS Measurements		UAV Measurements		Residuals	
ID	**Length (m)**	**Width (m)**	**Length (m)**	**Width (m)**	**Length Δ (m)**	**Width Δ (m)**
	Building 1					
1	34.145	31.246	33.935	30.905	-0.2	-0.34
2	34.426	30.698	34.328	30.606	-0.1	-0.09
	Building 2					
1	19.771	13.249	19.725	13.15	-0.05	-0.10
2	17.880	13.614	19.232	13.284	1.4	-0.33

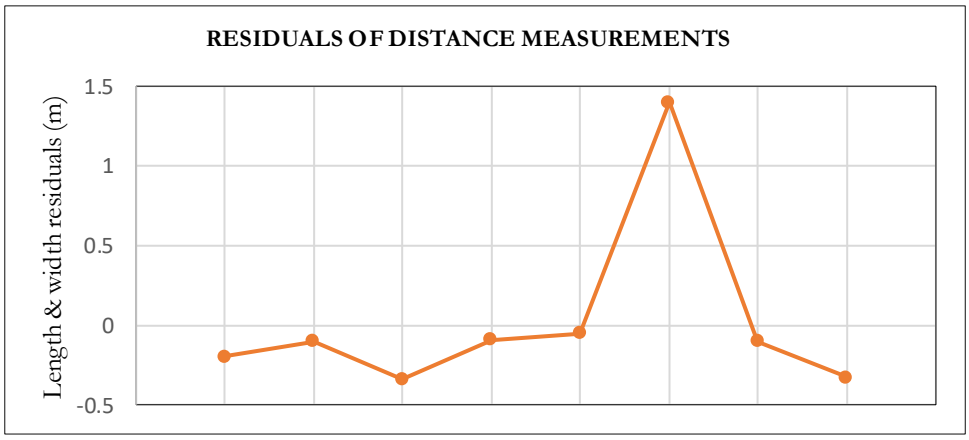


Figure 28: Residuals in distance measurements

Plausible reasons accounting for the error observed in figure 26 and 27:

First, the UAV imagery obtained from PlaceFund Company were used as supplied to extract coordinates of some points of interest for verification. The supplying company revealed that the image acquisition project targeted farmlands; therefore, high accuracy was not a priority, and no GCPs were used.

Traditionally GCPs are part of aerial mapping for geo-referencing and absolute positioning (Nex & Remondino, 2014). Using a few GCPs is recommended even where RTK-GNSS-equipped UAVs are used (Gerke & Przybilla, 2016; Nex, 2020). Therefore, the image acquisition without GCPs significantly contributed to the RMSE result of 5.6m in X and 4.1m in Y directions.

Second, there were possible misalignments between the positions measured on the ground and those measured on the imagery. Particularly for Building 2, the GNSS measurements were not taken at concrete or exact corner points of the building, as shown in figure 30. This is because the said building was not fenced or marked with monuments. Therefore, though the measurements attempted to align with the building corners, some shifts might still exist between points taken on the ground and those measured on the imagery.

Last, possibilities of multipath might have contributed to the error observed due to the existing trees and walls close to the measured points. As shown in Table 8 and in figure 28, the residuals recorded in the distances measured on the UAV imagery and the GNSS observations are all within centimeters except for one outlier.

It was observed that points measured without possible multipath achieved between 30cm and 2cm residuals in the distance measurements, as shown in the first four points in figure 28. This measurement is demonstrated in figure 29. However, points that were probably exposed to multipath due to trees or walls close to the measured points achieved between 5cm and 1.4m difference in the distance measurements. Figure 30 shows the possible multipath source.

Figure 29: Measurements on Building 1

Figure 30: Measurements on Building 2

With a ground sampling distance (GSD) of 3cm and up to 5.6m positional accuracy, the image was still found suitable for the participatory mapping study. This is particularly for mapping and recording land rights on farmlands, where less emphasis is placed on high positional accuracy. Indeed, as presented in the fit-for-purpose principles, accuracy relates to the purpose, and it can be improved incrementally over time Enemark et al. (2016).

4.4.5. Final Process

Lastly, the recorded data could be stored and managed in an open-source database such as the STDM software. STDM is pro-poor focused, affordable, and flexible for use. Other activities included in the final process are designing and issuing an improved customary allocation note or certificate and organizing a feedback forum. Again, this activity could not be carried out during the fieldwork since digitization was completed as a post-fieldwork activity.

4.5. Developed Participatory Approach for recognizing Women's land rights

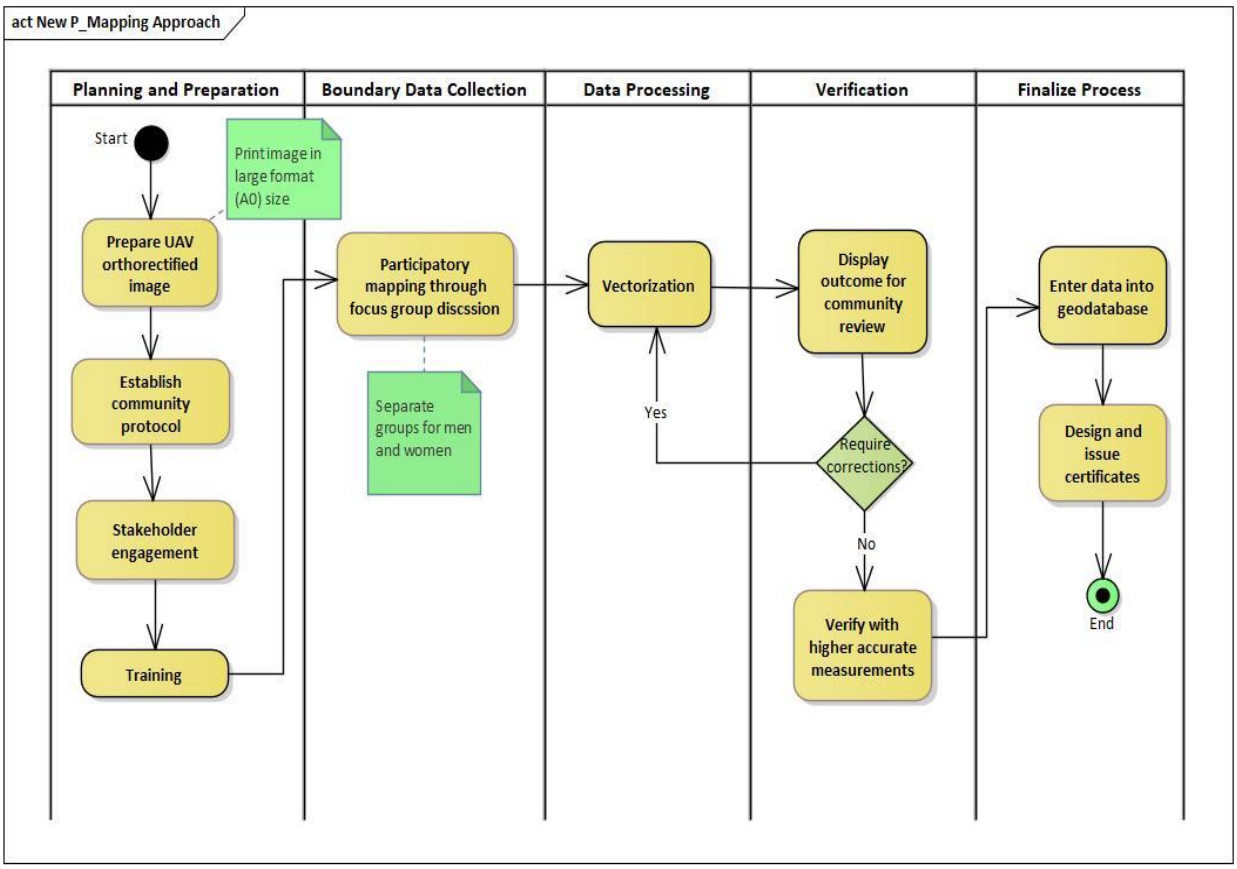


Figure 31: Developed participatory mapping approach to support recognition of Women's land rights

After experimenting the generic approach designed in figure 8, the study develops a proposed participatory mapping approach for customary land administration to support recognition of women's land rights using UAV imagery, as presented in figure 31. The proposed approach creates access for women to participate and map out their secondary land rights for recordation, which said land rights are typically not recognized in the formal land system (UN-HABITAT, 2012). The activities consist of a

synthesis of similar processes obtained from existing literature, such as Lemmen & Zevenbergen (2010) and Aditya et al. (2020).

4.6. Summary of the Chapter

This chapter presents the findings from customary land administration, women's land rights, UAVs in Ghana, and the experimentation of the proposed participatory mapping approach. The key findings are summarized in table 9 below:

Table 9: Summary of key findings

Sub-Heading	Summary
Cadastral Mapping & UAVs	- Field surveying techniques are mainly used - The process is long-winding, and costly - UAVs for surveying are still at a rudimentary stage in Ghana
Customary land administration	- Administered by laws and customary practices. - Liaises with Surveyors and land professionals for management - Records only main land rights
Women land rights	- Limited and unsecured land rights - Mostly exercise secondary land rights which are not recorded - Mixed responses on women's impression about the land practices, but many desire exclusive land ownerships
Proposed Participatory Mapping Approach	- Approach enables secondary land rights exercised by women to be mapped and recognized

5. EVALUATION AND DISCUSSION

5.1. Introduction

In this chapter, the findings vis-à-vis the existing literature are discussed in the context of the objectives. The chapter begins by evaluating the proposed approach with some selected fit-for-purpose land administration elements. It is followed by discussions on some key factors affecting women's land rights in the study area.

5.2. Evaluation of Proposed Approach

This section evaluates the proposed approach and its capability to support customary land administration and recognition of women's land rights in the light of the fit-for-purpose elements. It gives cognizance to sub-objective 3 of the study. The evaluation selects five out of the seven FFP elements, as highlighted in figure 32. The other two FFP elements which were excluded: flexible and upgradeable, are equally essential for evaluating the proposed approach. However, to effectively answer sub-objective questions 3.1, 3.2, and 3.3, the five selected elements were considered more appropriate.

Figure 32: Selected elements for evaluating the proposed approach

Brief interpretations of the selected elements and what they stand for in this evaluation are provided in table 10.

Table 10: Criteria for Assessment of Approach

Criteria	Description	Relevance
Affordability	Unit cost of land right recordation under the proposed approach compared to the existing approach	The ability of women and the poor in society to afford and record their land rights
Inclusive	Measure of coverage of all parcels on the image	Ability to identify all boundaries to record the land rights
Reliability	Up-to-datedness of the Imagery used	Potential to support customary land administration
Participatory	Interactive, transparency, and involvement of the stakeholders	Potential to make customary land administration responsible
Attainability	Time efficiency of the approach	Efficiency to enhance customary land administration.

5.2.1. Participatory

The entire processes in the proposed approach were interactive, engaging, transparent, and participatory. As attached in appendix 6, the responses received in the validation showed that 90 percent of participants strongly agreed, and 10 percent agreed that the proposed approach was highly participatory. In each community, the mapping sessions were averagely attended by 40 participants. All the stakeholders had the opportunity to contribute and participate at one stage or another.

An observation was that the approach's participatory nature could be instrumental in avoiding potential land disputes, especially using UAV imagery for the mapping. As common among all the groups, participants usually discuss to reach a consensus on boundaries before delineating. Participatory mapping, or PGIS in itself, has been identified (Mandara, 2007) as a useful mechanism for conflict resolution, but as Kyem (2021) remarked, PGIS alone cannot entirely resolve land conflicts owing to the maps involved. Kyem (2021) explained that the jointly produced PGIS maps could be obscuring, and the 'brightly coloured' maps could influence the disputing parties' judgments. However, per observations, using UAV images for participatory mapping avoids ambiguity, making the proposed approach an effective mechanism for preventing or resolving disputes in land administration.

For the women, the proposed approach was identified as a medium of empowerment to strengthen and recognize their land rights. Unlike the existing system, the rural women whose land rights are considered superficial felt motivated to participate in land-related matters in the community through the approach. As discussed in the literature review, (Di Gessa, 2008) indicated that participatory mapping creates empowerment for securing land access in communities. In this study, it was observed that the segregation of men from women during mapping and focus group discussions built the women's confidence to make substantial submissions more than during the household interviews.

5.2.2. Inclusive

Generally, the number of land parcels mapped depended on the availability of the landowners during the mapping. For instance, the area covered on the Ticheli image is predominantly a developing area where many landowners of the undeveloped parcels reside outside the community. As a result, those absentee landowners whose lands were covered on the image did not partake in the participatory mapping. The absence of those landowners and their indeterminate building parcel boundaries resulted in only 31 parcels out of 307 parcels being mapped on the Ticheli image. Appendix 4 shows a portion of such areas with indeterminate boundaries or non-monumented parcels. In the case of Stöcker et al. (2022), street publications and mobilization were organized each morning towards the participatory mapping exercise, resulting in 202 parcels being mapped in total. Thus, if the absentee landowners were reached, or their boundary monuments were in existence, more boundaries would have been mapped on that image.

In the case of Woribogu-Kukuo, as high as 209 parcel boundaries were mapped, including farmlands and building parcels. This was due to the availability and participation of the land owners who also resided in the community. Women also had the opportunity to delineate the farms they exclusively cultivated and those for their husbands. It indicates that the approach has the potential to include all parcels and all locally recognized land rights, unlike the formal system.

5.2.3. Reliability

Appraisal for up-to-datedness was obtained from the key informants' interviews and mapping responses. During the interview with the Survey and Mapping representative, the UAV imagery and the layout

scheme (or reference boundary) were explored. Superimposing the layout planning scheme (reference boundaries) on the UAV imagery revealed variations between the building parcels and the reference layout scheme. The imagery presented the up-to-date ground information. It became obvious from the discussions about the need to update the existing layout scheme to conform to the ground situation. As proven in the studies of Koeva et al. (2018) and Koeva et al. (2020), UAVs have a great potential to create up-to-date cadastral data for spatial planning and land administration.
The customary land secretariats also remarked the imagery presents up-to-date ground information, which becomes usable for their local land recordation.

5.2.4. Affordability

To evaluate affordability, cost of UAV image acquisitions was collated from literature, online webpage, and private surveying firms in Ghana. This cost data collection became necessary because the imagery used for the study was acquired at no cost.

According to Stöcker et al. (2022), high-resolution UAV image acquisition cost ranges between USD 500-1000 per km^2 (i.e., every 100 hectares) depending on the location, the UAV equipment model used, and the mapping scale. Other useful online information also revealed a cost range between USD 800-1100 per km^2 (Singh, 2022). However, inquiries made from private Surveying firms in Ghana revealed a cost range between GHC 50-100 per acre, that is, between USD 2000-3000 per km^2. A copy is attached in appendix 5. The exorbitant fee charged by private survey firms in Ghana may be related to the unregulated system of UAV surveys in the country, making the few companies take advantage to exploit.
After considering all factors including location, the study adopted USD 800 per km^2 to assess the cost.
In Table 4, the current cost of basemap and cadastral plan preparation in Ghana using ground surveying and mapping techniques was presented. The cost assessment in this section equates basemap preparation to imagery acquisition and cadastral plan preparation to individual local land certificates, including the parcel diagrams. The equated activities serve similar purposes.

Table 11: Cost assessment of the existing and proposed approach

No.	Description	Proposed Approach (USD)	Existing Approach (USD)
1.	Image acquisition (per Hectare)	8	-
2.	Printing, Scanning, & Stationery	10	-
3.	Verification/ground truthing	100	-
	Total estimated cost (per Hectare)	118	700
	Unit cost (per parcel)	**10.50 ≈ 11.00**	**155**

Table 11 shows that the proposed approach is cheap and affordable for the women and the rural poor to document their land rights. Interestingly, the cost estimates provided by the private companies in Ghana suggested a per hectare cost of USD 25 and a unit cost of USD 12 when USD 2500 per km^2 is adopted, which is still cheaper than the existing approach. With a unit cost of USD 11, the women will also be able to document their locally recognized land rights per the proposed approach, adding value to their economic life.

5.2.5. Attainability

In effect, the maximum time spent by each group on the mapping was an hour. Accordingly, participants gave 100 percent positive feedback on the time efficiency of the approach, see Appendix 7.

A summary of the length of time used for the processes in the proposed approach is presented in Table 12. Since the UAV imagery acquisition process did not form part of the study, the duration assessment relied on empirical studies such as Ali (2017), Koeva et al. (2017), Koeva et al. (2020), and Ramadhani et al. (2018). Like the cost assessment, basemap preparation is equated to imagery acquisition, and cadastral plan preparation is equated to individual local land certificates. All things being equal, it was found that the proposed approach was time-effective as a maximum of 3 days was sufficient to complete UAV image acquisition, mapping, and certification for an approximate 50-hectare area in a rural community.

Table 12: Duration assessment of Proposed and Existing approach

No.	Description	Proposed Approach	Existing Approach
1.	Image acquisition & processing	1 day	3 days (Basemap)
2.	Participatory Mapping	1 day	
3.	Processing & Finalization	1 day	
	Total time required	**3 days**	2 weeks (Cadastral Plan)

5.2.6. Evaluation Summary

A summary of the evaluation is presented in table 13 below:

Table 13: Evaluation Summary

Evaluation Criteria	Yes	No	Remarks
Participatory	✓		Involves all stakeholders
Inclusive	✓		Includes all parcels and locally recognized land rights
Reliability	✓		Up to date; image provides current ground information
Affordability	✓		Cheap; Approx. USD 11per parcel
Attainability	✓		Timely; 3 days maximum

5.2.7. SWOT Analysis of the Proposed Approach

To beef up the answer to research question 3.1, a SWOT analysis of the proposed approach is presented in table 14. SWOT represents – the strengths, weaknesses, opportunities, and threats of the proposed approach.

Table 14: SWOT Analysis of the proposed approach.

Strengths	**Weakness**
s1. Affordable for all rural landright holders s2. Women can map and document their land rights s3. Prevents or minimizes land disputes s4. Time-efficient s5. Less technical knowledge required s6. Ability to include all land rights s7. Large area coverage in one image	w1. Requires high participation of all landowners w2. Requires large format printing and scanning w3. Difficulty for mapping areas with indeterminate parcel boundaries
Opportunities	**Threats**
o1. Efficient for layout scheme updating o2. Capability to secure land rights for all o3. Catalyst for women's economic empowerment o4. Enhance responsible land administration o5. Strengthen women's land rights o6. Enhances ground rent and property rate assessments /collection	t1. No regulations for UAV surveys in Ghana t2. Limited UAV survey firms in Ghana t2. Exorbitant charges for imagery acquisition by local private firms

5.2.8. The Proposed Approach and Security of Women's land right

In response to research question 3.3, the contribution of the proposed approach to women's land rights in the context of tenure security is discussed in this section. Researchers are yet to reach a consensus on the definition of land tenure security. But among the various discourses, what fits most in this discussion is the degree of certainty that a person's land rights will be recognized by others and be protected when those rights are challenged (FAO, 2002).

By relating the FAO definition to the observations made in both communities studied, the women's land rights can be described as insecure. Inferences from the focus group discussion revealed that most women lose their rights to land upon widowhood, divorce, or even upon scarcity of land in the community due to land use dynamics. The existing practice also falls short of the women's land rights definition: "the ability of women to own, use, access, control, transfer, inherit, and otherwise make decisions about land and related resources" (UN-Women, 2020, pg 6). Remarking on interventions for women's land tenure security, Giovarelli and Richardson (2016) suggested the need to document and register the women's land rights, particularly with their involvement.

The proposed approach, UAVs for women's land rights, is gender-focused. It offers women the opportunity to let their land rights be recognized by being offered the opportunity to map their land rights independent of the men. The approach also enables women's involvement in land-related matters and document their secondary land rights at an affordable cost. Despite these benefits, it is important to note that the approach in itself may not mitigate all the impeding factors, especially the customary norms to guarantee women's land rights. That is to say technology is not the sole solution to the land rights problem in Ghana. The approach can be considered an intervention or pathway to safeguard women's land rights and empower them to develop.

Prospects

As discussed in the literature review, securing women's land rights is a great incentive to increase productivity, economic growth, and empowerment. Typically, the rural women depend on farming and forest products such as gathering firewood and shea butter nuts for their source of livelihood. During the household interview, 43 percent and 30 percent of women in Woribogu-Kukuo and Ticheli indicated low agricultural productivity as the critical impact on their economic lives following their limited land access. Indeed economic literature admits that land tenure security has a positive relationship with productivity on land (Huong, 2014). Documenting to secure land rights incentivizes women to invest in farming activities, such as purchasing products that boast the soil quality to maximize productivity. With customary land recordation having legal backing, it is perceived that a local land certificate (allocation note), particularly showing the parcel diagram and its geo-location, will suffice to secure short-term funding. The study is limited with empirical data on this assertion. However, in Ghana, there are pro-poor agricultural support programmes such as Affordable Agricultural Financing for Resilient Rural Development project (AAFORD) by IFAD and Rural Enterprises programmes which provide financial assistance to rural farmers.

5.3. Customary Land Practices and Effects on Women's Land Rights

The findings in Chapter 4 revealed insights into the existing land administration practices and their effects on women's land rights. A discussion of these highlighted findings vis-à-vis the existing literature is presented in this section. It brings attention to which factors need to be addressed regarding strengthening women's land rights in the study area.

5.3.1. Patriarchy and legal stance on women's land rights

In the literature review, patriarchy and discriminatory social norms were pointed out as some factors that undercut women's land rights. Patriarchy is considered an unequal power structure in society that places men as superiors over women (Walby, 1990). Like many academic discourses on women's right to land in Sub-Sahara Africa, the study found that women in the study areas are excluded from land-related issues by custom. Management and decision-making involving land in the communities were male-dominated. It was observed that, generally, the women's opinions were subjugated to the men, and their suggestions on land issues were considered trivial, as Yngstrom (2002) also indicated. A notable effect of this gendered norm was low self-esteem, mainly observed among the less educated. These patriarchal practices are reinforced, if not originated by the existing Muslim family laws, which puts the women in a subordinate position in the family and makes it normative. People in Northern Ghana are predominantly Muslims.

Meanwhile, the law guarantees men and women equal access to land and property per article 18 of Ghana's 1992 constitution. But practically, patrilineality restrains women's land ownership in their father's lineage unless there is no male heir. The study finds the existing laws weakened by the customs and not being effectively implemented to protect women's rights. As Rünger (2006) argued, the co-existence of the law with other social-cultural regulatory systems results in complexities in implementation, putting vulnerable people such as women at a disadvantage. The finding put Northern Ghana at par with countries such as Bangladesh, where although the constitution guarantees equal property rights, the women are deprived of equal inheritance rights owing to the Muslim Shariah law. However, patriarchal practices should not be generalized among all Muslim communities since countries such as Egypt, Tunisia, and Senegal enjoy equal property rights despite the Shariah law, as Chowdhury (2019) noticed.

5.3.2. Women's land rights, customary practices, and literacy

By profiling the participants in the household interviews, it was discovered that about 70 percent of the respondents had received no formal education. This result inspired further analysis into the potential intersection between literacy and unequal gender access to land in the communities.

Beyond the ability to read and write, literacy relates to how people understand, interpret, and interact with the surrounding world (UNESCO, 2021). Notably, illiteracy is not ignorance, but it supposes the two correlate positively in the study area. Indeed, laws and policies may exist to ensure equal land ownership and control, but its effectiveness significantly depends on the beneficiary's awareness of their rights, the capacity to defend them, and to receive societal acceptance. These three become achievable with better literacy. Of course, SIDA (2011) considers literacy as one of the entry points for increasing women's access to land. Doss and Meinzen-Dick (2020) also acknowledged there is a direct relationship between land tenure security and legal literacy. As typical among vulnerable and marginalized groups in most rural Africa (UN-HABITAT, 2008), the study observed that the women were clueless about their legal land rights in their marital homes and lacked the capacity to rise and defend it.
For instance, article 22(a) of the Constitution provides equal access to jointly acquired properties by couples during marriage. Even in the event of land registration in favour of only one spouse, the law presumes the registered land, if it was acquired during marriage, is co-owned by both spouses unless a contrary intention is expressly stated (section 97(5) of Ghana Lands Act, Act 1036). Despite these cogent legal protection aimed to safeguard women's land rights, the rural women consider themselves mere occupants in their marital homes. The existing customary norms somehow have disempowered the women to refute the status quo and rise to defend their legal entitlements.

Inferences from the focus group discussion revealed that, parallel to some existing studies, the society, through cultural dynamics, is gradually accepting women's inheritance rights to land, albeit in rare cases. In this instance of social acceptance, literacy is not at play, but it indicates with further enlightenment, gender inequality to land can gradually be eroded in Northern Ghana as it exists in SouthEast Asia (Akter et al., 2017). Table 5 indicates that some women in the Tamale Metropolis now boldly register their land rights in their names without fear from their male counterparts or facing social stigma. This finding suggests a gradual cultural dynamics in the urban areas through literacy, parallel to Higgins & Fenrich (2012) and Kaunza-Nu-Dem et al. (2016) findings in Ghana. The two studies revealed rural women preferred to register their land rights in the name of male relatives because traditional norms disapprove of women's land ownership in their own capacity. Thus, the study finds an intersection between literacy and gendered land rights in the study area.

5.3.3. Peri-Urbanism effects on women's land rights

Peri-urbanism relates to dynamic changes in land-use and livelihoods on the peripheries of an urban area, causing growth and expansion in the urban perimeter (Simon, 2021). The two communities studied: Ticheli and Woribogu-Kukuo, are rural settlements lying within the urban peripheries of Tamale, the Northern Regional capital in Ghana. As a result, developments were gradually taking over the available farmlands in the communities, per the observations made.
Woribogu-Kukuo had limited farmlands, whiles a greater part of Ticheli's lands had become infertile due to continuous farming. During the focus group discussions, the participants disclosed that many farmers in the community migrate to other rural hinterlands to find available lands to farm. Due to the limited farmlands, women at Woribogu-Kukuo were least considered for exclusive rights to farm on individual plots. They are either given small sizes of farming plots or allowed to plant leafy vegetables around the peripheries of their husband's land. Meanwhile, the participants stated that women in other communities

with available farmlands enjoy exclusive access to individual plots for farming. It suggests land commoditization amidst the transformation effects of peri-urbanism erodes even the superficial land rights women enjoy. Apusigah (2008) argues that peri-urbanism impact on women's land rights in Northern Ghana is one of the main forces that compels many to migrate to the cities searching for non-existing jobs.

5.3.4. Effects of recording Individualized land certification on Women's land rights

Secondary land rights holders are often excluded from the formal land registration system (UN-HABITAT, 2012). Such derivative rights, usually enjoyed by rural women, are obtained by virtue of social relationships and membership in households (Rünger, 2006). By its nature, the duration of secondary land rights lies in maintaining a good social relationship with the person on which such right depends.

The global land community advocates for documentation of every existing social land tenure in the 'continuum of land rights' to protect the interest of the vulnerable (Barry & Augustinus, 2016). However, it was observed in both communities studied that, apart from land allocations made for building purposes or acquired by purchase, all other interests/rights are not recorded by the Customary Land Secretariats. The duration granted for such acquisitions is 99 years; therefore, exclusive ownership is conferred. The local recordation followed the same manner as the formal land system to record only main land rights, creating individualized land ownerships and certifications to the disadvantage of secondary right holders. For undeveloped plots, especially farmlands, it was informed that ownership rights rest in the allodial owners by tradition; therefore, mere use rights are considered secondary and not recorded. The practice is unhelpful and makes the women's land rights more insecure because women usually exercise secondary rights on farmlands.

Legally, the law permits the recordation of all locally recognized land rights, even including oral grants (section 37(3) of the Ghana Lands Act, Act 1036). The Act requires the Customary Land Secretariats to record the following interests and rights in land: usufructuary interest, sale, gift, shared tenancies, assignment, mortgage, sowing tenure, and any related customary rights (item 3 of the first schedule in Act 1036). With the legal and institutional framework in place, the hope to strengthen women's land rights is by improving the spatial framework, as per the FFP-LA recommended frameworks (Enemark et al., 2014).

Figure 33 provides a summary of the factors affecting women's land rights in the study area.

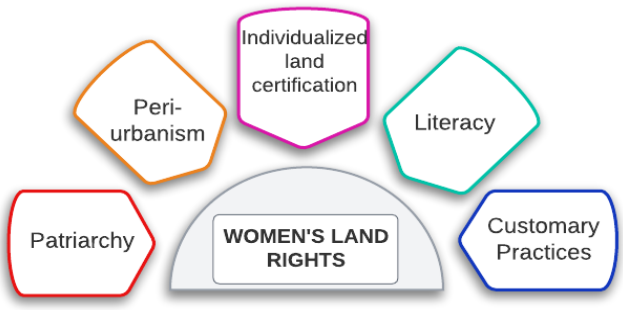


Figure 33: Key factors affecting women's land rights in the study area

5.4. Summary of the Chapter

The proposed approach was evaluated using five out of the seven FFP-LA elements. A SWOT analysis was also presented to assess the strengths and limitations of the proposed approach. The proposed approach was further discussed in the light of land tenure security.

Consequently, five factors affecting women's land rights in the study area were thoroughly discussed. The effects on the rural women are that the customary norms have disempowered women to defend their entitled rights and change the status quo. Secondly, the women lack awareness and capacity to defend their legal land rights due to low literacy. Patriarchy and poor implementation of the law have subsumed the women's land rights resulting in low self-confidence to develop or invest. Peri-urbanism effects are eroding the women's land rights, and lastly, recordation of individual land ownerships excludes secondary land rights, making the women's land rights insecure. A flexible spatial framework is required to improve customary land administration and protect women's land rights.

6. CONCLUSIONS AND RECOMMENDATION

The study mainly sought to explore the potential of using UAV imagery for participatory mapping and propose an approach that recognizes women's land rights customary land administration of Northern Ghana. Having presented the findings and discussed the results in relation to literature, this section summarizes and concludes on each sub-objective of the study. Recommendations for future implementation and research are also presented.

6.1. Conclusions

6.1.1. Sub-Objective 1: To review the existing customary land administration practices and cadastral boundary acquisition techniques in Ghana

Research question 1.1*: What are the existing practices, legal frameworks, and cadastral boundary techniques for administering customary lands in Ghana?*
The findings on existing cadastral mapping and customary land administrative practices were obtained from literature and key informants' interviews. Field surveying techniques such as GNSS and Total Station were identified as the predominant techniques used in Ghana. The cadastral boundary acquisition processes interconnect with the administrative work of customary land secretariats, where the latter first initiate the process through the Land Use and Spatial Planning Authority. The processes involved in cadastral boundary mapping were identified as long-winding, costly, and unaffordable to women and the poor in general. Also, customary land secretariats record only main land rights, particularly on lands for building purposes, leaving the women's secondary land rights unrecorded and unrecognized.

Research question 1.2: *What are the effects of the current practices on women's land rights?*
Effects of customary land practices on women's land rights were analyzed from household interviews, focus group discussion, and participatory mapping and juxtaposed with findings in the literature. Though not arbitrarily denied access, it was found that the women have little access to land and are excluded from participating in land-related matters. The study found that the main factors influencing women's land rights are peri-urbanism, patriarchy, literacy, customary norms, and individual land certification due to the existing land recordation practices that inadvertently erode women's land rights. Some effects were low self-esteem, lack of self-confidence to develop or invest, and low productivity from farming activities.

6.1.2. Sub-Objective 2: To design a participatory boundary mapping approach using UAV imagery for administering customary lands

Research question 2.1: *Which regulations and restrictions guide the acquisition of UAV imagery in Ghana?*
Information obtained from the key informant's interview indicated that UAVs for surveying purposes are at a rudimentary stage in Ghana, though UAVs are well utilized in other domains such as videos and photography. Currently, UAV operations are guided by generic regulations from the Ghana Civil Aviation Authority. Comprehensive technical guidelines and regulations for UAV surveys are underway to incorporate other domains where UAVs are also applied, such as in mining, hydrographic, and engineering surveys.

Research question 2.2: *Which procedures should be included in the framework of the proposed approach*?
The proposed approach, consisting of 8 steps, was designed using existing literature on similar mapping studies. It is presented in figure 8. During the mapping, all the participants had less difficulty identifying

their boundaries, and professionals admitted that the imagery is suitable for upgrading the existing layout scheme, thus, making UAV imagery suitable for customary land administration.

Research question 2.3: *How should the boundaries be verified?*
Verification of the parcel diagrams and UAV imagery relied on Static GNSS surveys and layout planning scheme (reference boundaries). After superimposing, the reference layout scheme on the UAV imagery, it revealed that the individual parcel boundaries did not conform to the shapes and sizes on the reference layout scheme, but the roads and lanes conformed. Therefore, whiles the UAV imagery reflected the existing ground situation, the layout scheme failed, proving the up-to-datedness of the UAV imagery for customary land administration.
With the GNSS measurements, lack of GCPs and possible misalignments between the points measured on the ground and those taken on the imagery resulted in absolute positional accuracy of up to 5.6m.

6.1.3. Sub-Objective 3: To evaluate the proposed approach

Research question 3.1: *What are the strengths and limitations of the proposed approach?*
The proposed approach was evaluated with five FFP elements, after which a SWOT analysis was also presented. The approach was generally found to be low-cost, time-efficient, inclusive, reliable, and participatory with a gender focus, enabling women to participate and gain recognition of their land rights.

Research question 3.2: *What is the ability of the proposed approach to support customary land administration?*
The proposed approach demonstrated that it is promising for customary land administration through local participation, coverage of all lands and local land rights, low cost, and flexibility for responsible land administration.

Research question 3.3: *What is the contribution of the proposed approach toward the security of women's land rights?*
Many factors work against the security of women's land rights in Ghana, mostly social and cultural factors, as enumerated under research question 1.2. The proposed approach is only a technological lens to help women gain recognition of their land rights. Alone, the approach may not directly provide tenure security, but it should be considered as an intervention for strengthening women's land rights. However, the existing legal and institutional frameworks provide hope for women's land tenure security since the three frameworks are required to build a functioning FFP-LA.

Research question 3.4: *What are the recommendations for future implementation?*
To further implement the proposed approach, steps should be taken to reach all landowners whose lands are also represented on the image in order to increase participation. In the acquisition of UAV imageries, Government approved surveyors should be consulted since the few private surveying companies are likely to exploit.

6.2. Recommendations for future research

This study explored the potential of including UAVs in customary land administration where women's land rights are given attention. For further research, the following are recommended:

The Nexus: UAVs, Women's land rights, and Food security
Mapping land rights goes beyond dividing the land. In the broader perspective, when women have secured land rights, the entire household benefits because food security and nutrition will be enhanced. Furthering the research, more empirical studies could be conducted to understand other dimensionalities of how

UAVs and low-cost land rights mapping approaches could enhance recognition of women's land rights towards improving food security.

Impacts of the intersection between literacy and gendered land rights

Towards SDG indicator 5.a.2, the intersection between literacy and gendered land rights could be explored further for empirical evidence in other parts of the country or even sub-Sahara Africa. Existing literature often emphasizes legal literature, but this study believes educational level and literacy impact how people interact with the existing land tenure system.

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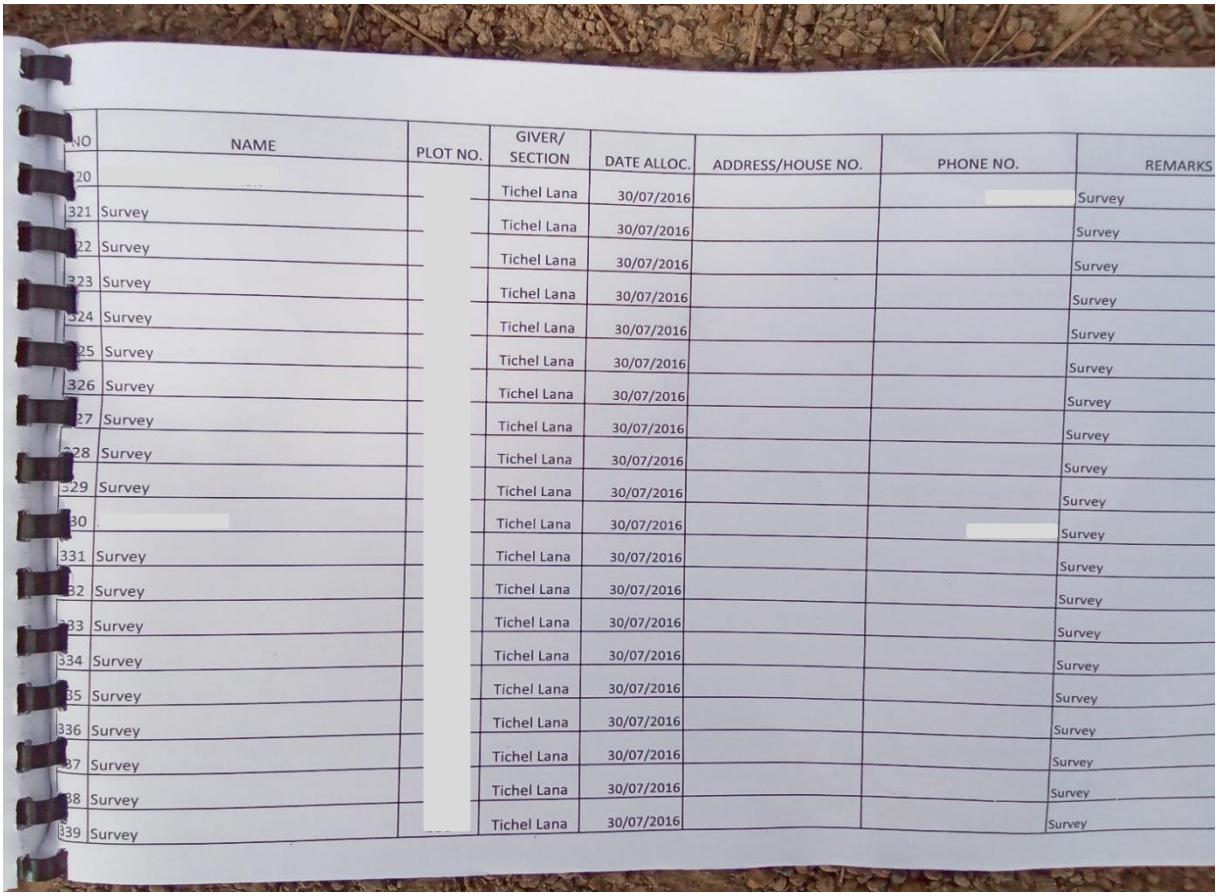
APPENDICES

Appendix 1: Research Matrix

Research Objective	**Research Question**	**Data Source/ Material**	**Method of Data Analysis**	**Anticipated Outcome**
1. To review the existing customary land administration practices and cadastral boundary acquisition techniques in Ghana	1.1 What are the existing practices, legal frameworks, and cadastral boundary techniques for administering customary lands in Ghana?	Books, Scientific literature, Journal articles, Reports, and Online webpages/ Key informants Interview	Desk review/ Content analysis/ Inferential analysis	Insight into Ghana's current customary land administration practices and cadastral boundary acquisition techniques.
	1.2 What are the effects of the current practices on women's land rights?	Literature, Focus Group Discussions, Key informants Interview	Desk review/ Content Analysis/ Inferential Analysis	Understanding the effects of the current practices on women's land rights.
2. To design a participatory boundary mapping approach using UAV imagery for administering customary lands	2.1 Which regulations and restrictions guide the acquisition of UAV imageries in Ghana?	Books, Scientific literature, and Online webpages/ Interviews	Desk review/ Content analysis	Regulations and restrictions for UAV data acquisition in Ghana
	2.2 Which procedures should be included in the proposed approach?	Books, Scientific literature, Journal articles, and Online webpages	Desk review	Steps and processes to design and experiment the proposed approach
	2.3 How should the boundaries be verified?	GNSS measurements and Layout scheme	Spatial Analysis	Validation of parcel diagrams and imagery
3. Evaluate the proposed approach	3.1 What are the strengths and limitations of the proposed approach?	Field observations, Key informants interviews (semi-structured), Focus Group discussions, Validation responses from the participatory mapping	Evaluation & SWOT Analysis	Identified strengths and weaknesses of the proposed approach
	3.2 What is the ability of the proposed approach to support customary land administration?		Descriptive, Relational, & Inferential analysis	Analysis of the potential of the approach for customary land administration
	3.3 What is the contribution of the proposed approach toward the security of women's land rights?		Descriptive, Relational, & Inferential analysis	Assessment of the security of women's land rights through the approach
	3.4 What are the recommendations for future implementation?			List of recommendations for future implementation

Appendix 2: Evidence of plots allocated to professionals in exchange for survey services



NO	NAME	PLOT NO.	GIVER/ SECTION	DATE ALLOC.	ADDRESS/HOUSE NO.	PHONE NO.	REMARKS
20			Tichel Lana	30/07/2016			Survey
321	Survey		Tichel Lana	30/07/2016			Survey
22	Survey		Tichel Lana	30/07/2016			Survey
323	Survey		Tichel Lana	30/07/2016			Survey
324	Survey		Tichel Lana	30/07/2016			Survey
325	Survey		Tichel Lana	30/07/2016			Survey
326	Survey		Tichel Lana	30/07/2016			Survey
327	Survey		Tichel Lana	30/07/2016			Survey
328	Survey		Tichel Lana	30/07/2016			Survey
329	Survey		Tichel Lana	30/07/2016			Survey
330			Tichel Lana	30/07/2016			Survey
331	Survey		Tichel Lana	30/07/2016			Survey
332	Survey		Tichel Lana	30/07/2016			Survey
333	Survey		Tichel Lana	30/07/2016			Survey
334	Survey		Tichel Lana	30/07/2016			Survey
335	Survey		Tichel Lana	30/07/2016			Survey
336	Survey		Tichel Lana	30/07/2016			Survey
337	Survey		Tichel Lana	30/07/2016			Survey
338	Survey		Tichel Lana	30/07/2016			Survey
339	Survey		Tichel Lana	30/07/2016			Survey

Appendix 3: Samples of existing customary land recordation

FORM A NAN/CLS/TICHELI/ 020 CERTIFIED BY...

DAGBON LANDS
ALLOCATION OF LANDS

TOWN TICHELI/NANTON BLOCK B
LAYOUT/BLOCK/WARD TICHELI RSS. AREA, BLK 'B'
PLOT NUMBER 368
Following a request received from
TELEPHONE NUMBER
1. I have today the 30 of JULY 2016 recommended the allocation of the above-mentioned land described above and shown pink-edge on the attached site plan to him/her/them for commercial/residential/industrial use.
2. The applicant has complied with all the customary requirements for the grant of the land under Dagbon custom. The applicant is therefore advised to obtain a grant of this plot from the Divisional Chief.

SIGNED WITNESSED BY
OFFICIAL STAMP 30 JUL 2016 SIGNATURE

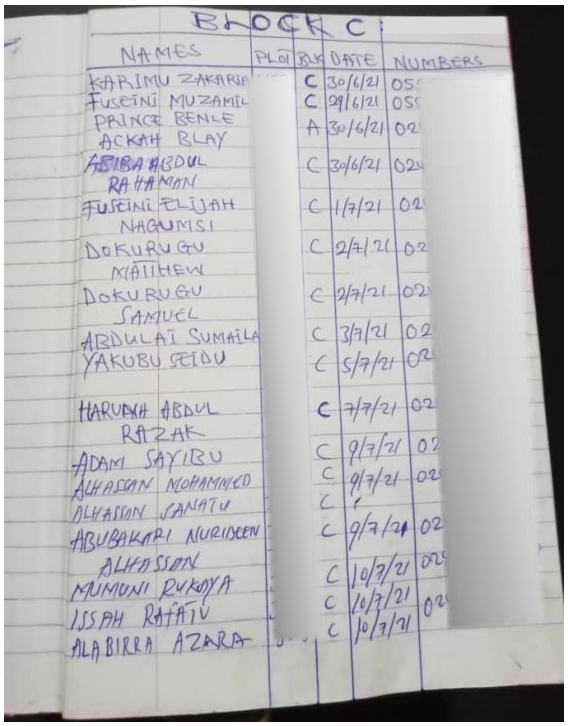
FORM B

CONFIRMATION OF ALLOCATION

TOWN BLOCK
LAYOUT/BLOCK/WARD
PLOT NUMBER(S)
ALLOCATED TO:

1. I have examined the above mentioned recommendation in the light of Dagbon Customary Law and hereby grant the above land to him/her/them.
2. This grant is given subject to the grantee entering into formal lease agreement with the Ya-Naa and myself within six (6) months from this grant on terms mutually agreed upon.
3. The grantee is further advised to seek advice from lands commission secretariat on the registration of the lease to be executed.
4. The grantee is further advised that this grant shall be used ONLY FOR THE PURPOSE(S) for which it was granted, and be operational not less than two (2) years from the date the grant was assigned. Failure to comply with this mandates will result in the land reverting back to the grantor for renegotiation or reassignment.

PARAMOUNT CHIEF WITNESSED
OFFICIAL STAMP SIGNATURE



BLOCK C

NAMES	PLOT	BLK	DATE	NUMBERS
KARIMU ZAKARIA		C	30/6/21	05
FUSEINI MUZAMIL		C	29/6/21	05
PRINCE BENLE		A	30/6/21	02
ACKAH BLAY				
ABIBA ABDUL RAHAMAN		C	30/6/21	02
FUSEINI ELIJAH NAGUMSI		C	1/7/21	02
DOKURUGU MATTHEW		C	2/7/21	02
DOKURUGU SAMUEL		C	2/7/21	02
ABDULAI SUMAILA		C	3/7/21	02
YAKUBU SEIDU		C	5/7/21	02
HARUNA ABDUL RAZAK		C	7/7/21	02
ADAM SAYIBU		C	9/7/21	02
ALHASSAN MOHAMMED		C	9/7/21	02
ALHASSAN SANATU		C		
ABUBAKARI NURIDEEN ALHASSAN		C	9/7/21	02
MUMUNI RUKAYA		C	10/7/21	02
ISSAH RAFIU		C	10/7/21	02
ALABIRA AZARA		C	10/7/21	

Appendix 4.: Areas with indeterminate boundaries

Appendix 5.: Cost Estimate of UAV image acquisition from private Survey Firm

24/02/2022

SERVICES IN SURVEY,ICT AND GENERAL BUSINESS

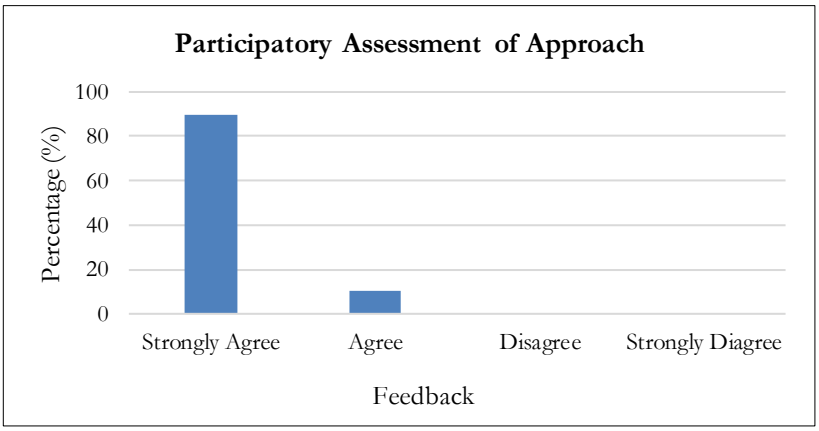
Bill To:
Name:DORA DADEY
Company: RESEARCH
ACCRA
GHANA

ITEM	JOB DESCRIPTION	UNIT (Ghc)	TOTAL ACRES (Ghc)	AMOUNT
1	ORTHOPOHOTOS OF TICHELI IN THE NORTHERN REGION OF GHANA WITH ELEVATION DATA	90.00	527.00	47,430.00
2	ORTHOPOHOTOS OF ZUO IN THE NORTHERN REGION OF GHANA WITH ELEVATION DATA	90.00	443.00	39,870.00
			-	-
3			-	-
				87,300.00

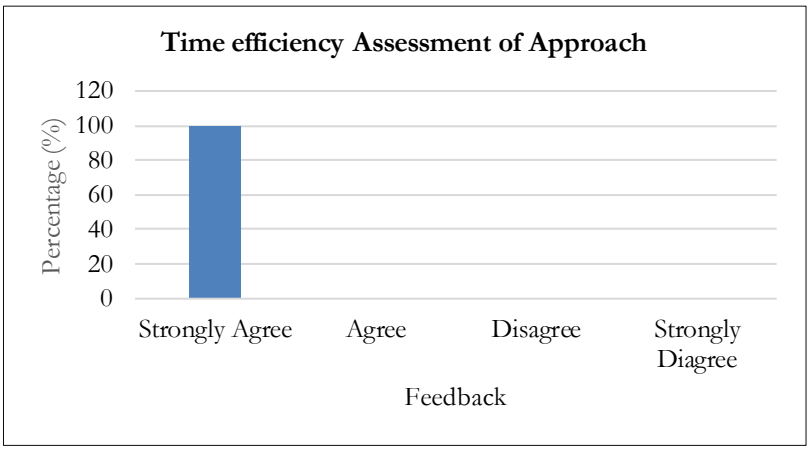
Make all cash/checks payable to .....

THANK YOU FOR YOUR BUSINESS!

Appendix 6: Participatory assessment of the proposed approach



Appendix 7.: Time-efficiency feedback from Participants



GUIDE FOR STRUCTURED AND SEMI-STRUCTURED INTERVIEWS WITH KEY INFORMANTS

Introduction

Thank you for accepting to participate in this interview on the research topic, ***"Exploring UAVs for participatory mapping to understand women's land right"***. My name is Dora Dadey, an MSc student at the University of Twente, Faculty of ITC, Netherlands. The interview aims to seek your expert opinion on some key issues covering different dimensions of the research and therefore, no answer is right or wrong. Feel free to express your opinion.

Kindly note that every information collected will be treated as confidential and limited for academic purposes. Your identity is highly respected and will not be disclosed in the report. In order not to leave out important part of this interview during the report's compilation, I would like to record it. However, if this is not comfortable with you, we can proceed without recording.

A. SEMI-STRUCTURED INTERVIEW GUIDE FOR OFFICIALS AT CUSTOMARY LAND SECRETARIAT (CLS) AND CHIEFS

Section 1: Customary Land Administration Practices

1. What is the structure of the land ownership system in this customary area?
   - Are there any hierarchies or subgroups within the land ownership structure?

2. What are the procedures for land acquisition in this customary area?

3. Which interests/ rights does this customary area grant for allocation of lands? E.g leasehold etc

Section 2: Women's Land rights

4. How do women access land in this area?

5. What type of land rights can women access?

6. Are women involved in land management or decision-making involving land?
   - If no, what reasons account for it?

Section 3: Customary Land Recordation/ Cadastral Boundary Mapping

7. How do you record allocated land transactions?

Prompts

- On paper or digital?
- Do you attach spatial information to the recording?

If yes, how do you acquire the spatial info and how is it recorded?

- How long does it take for the recordation process (acquisition & registration)?
- Have you heard of UAVs(drones)? Have you used drones for cadastre data recordation?

8. Who bears the cost of the land recordation?
   - If it is fully borne by the people, how much do they pay for the services?

9. In your opinion how does the cost of recording affect the people's ability to acquire land or regularize their interest?

B. SEMI-STRUCTURED INTERVIEW GUIDE FOR OFFICIALS AT LANDS COMMISSION

(Land Registration Division/Public and Vested Lands Management Division of Lands Comm)

1. In practice, how do you collaborate with the CLS in the management of customary lands?

2. On the average, how long does it take to register customary lands (average turnaround time)?

3. How much does it cost to complete registration of a normal one plot of land within the Municipality?

4. In your opinion does the cost have any effect on the people's ability to register their lands? Explain.

5. Have you had any projects or plans on alternative land registration for local land administration?
If yes provide further details.

C. SEMI-STRUCTURED INTERVIEW GUIDE FOR OFFICIALS AT SURVEY AND MAPPING DIVISION OF THE LANDS COMMISSION

1. a) What technique do you use in the acquisition of Cadastral boundary data? E.g., GNSS etc
   b) Any other alternative technique(s)?

2. What are the processes for acquiring cadastral boundary data with the technique in (1)?

3. What is the unit cost of surveying a regular plot of land using the technique in (1) and how long does it take to complete a survey request?

4. What challenges do you face regarding the use of the technique in (1)?

5. What are the effects of the technique (1) on the people's willingness to register their lands?

6. Has the Lands Commission considered the use of UAVs for cadastral data capturing?
   - If yes, what reasons could be influencing the need to consider UAV for cadastral purposes?
   - What preparations has the institution made towards the use of UAV technique?

7. What are the regulations concerning the use of UAVs for surveying and mapping in Ghana?

8. Have you used UAV for data capturing?
   - What do you perceive to be the advantages and limitations of using UAV over the technique in (1) or vice versa in terms of cost, accuracy, and efficiency?

D. HOUSEHOLD INTERVIEWS FOR INDIGENOUS COMMUNITY (TOWN NAME:…..)

This questionnaire is related to the research topic, ***"Exploring UAVs for participatory mapping to understand women's land right".*** I am Dora Dadey, a Master student at the University of Twente, Faculty ITC in the Netherlands. The interview is solely for academic purpose. The privacy of respondents is highly respected and acknowledged.

Details of the Respondent

1. Gender: ☐ Male ☐ Female

2. Age: ☐ Below 30 ☐ 31- 40 ☐ 41-50 ☐ Above 50

3. Marital Status: ☐ Single ☐ Married ☐ Separated ☐ Widow/Widower ☐Co-habiting

4. Occupation:

☐ Formal
☐ Business/Trade
☐ Crop Farming
☐ Livestock Rearing
☐ Retired
☐ Unemployed
☐ Other …….....

5. Educational Level:
   ☐ Basic Education (Primary)
   ☐ Junior Secondary Education
   ☐ Senior Secondary Education
   ☐ Tertiary Education
   ☐ No formal education

6. Literacy level: ☐ Can Read ☐ Can Read and Write ☐ Cannot Read or Write

7. Are you the sole owner of this land? ☐ Yes ☐ No

8. If No, indicate your relation to the land ownership?
   ☐ Tenant or relative
   ☐ Part owner, by virtue of family relation or investment partnership
   ☐ Joint owner, by virtue of being a spouse to the owner
   ☐ Caretaker

Other……

9. Land Use: ☐Residential ☐Farmland ☐ Livestock rearing (ranch) ☐other

10. Tick the type of Right / Interest you have on the land

☐ Freehold ☐ Leasehold ☐ Usufructuary ☐ Customary tenancy/share cropping

Rights

☐ Right of ownership
☐ Right of Use and Access e.g. Farming, picking firewood
☐ Right to change use e.g. Build
☐ Right to Transfer e.g. bequeath, sell, mortgage etc
☐ Right of Occupancy
☐ Do not have any interest or the right to access land
☐ Other ……..

11. How did you acquire the land?

☐ Purchase ☐ Inheritance ☐ Gift ☐ Allocation from Chief/family ☐ Other …….

12. From whom did you acquire the land

☐ Chief ☐ Family ☐ Individual ☐ Government ☐ Other …….

13. Was the allocation recorded at the customary level, or lands commission or both?

☐ Customary level ☐ Lands Commission ☐ Both ☐ Not recorded (Oral grant)

14. If answer to (13) above is **Yes**, how much did you pay for the recording?

……

15. How long did it take to obtain the allocation document from the customary (CLS)?

☐ Less than 1 Month ☐ Between 1-3 Months ☐ More than 3 Months

16. How would you rank how difficult or easy it was to have your interest recorded locally?

☐ Very Easy ☐ Easy ☐ Difficult ☐ Very Difficult

17. If answer to Qn 13 is **No**, give reasons:

☐ Cannot afford the cost of documentation

☐ Am a family member/usufruct, I do not deem it important, I feel secured

☐ It's a mere short-term interest/right of use, I do not see the need for documentation

☐ Tradition does not allow documentation of the type of right/interest I have

☐ Other: give details……

18. Do you have a cadastral plan for your land?

☐Yes ☐ No

19. If yes to Qn 23, how much Survey fee did you pay?

☐ GHs…….

☐ No official payment was made

☐ Survey service was exchanged with plot (s) of land

☐ Other unofficial arrangement ……

20. How long did the survey and preparation of the cadastral plans take?

☐ Less than 1 Month ☐ Between 1-3 Months ☐ More than 3 Months

For Women

21. How do you access land to build, farm or do business?

☐ Purchase

☐ Inheritance

☐ Marriage /Family Relation

☐ Allocation from Chiefs/Family heads

☐ Allocation from State/Government

22. How would you rank the security of your tenure on the land?

☐ Insecure (can be ejected any anytime or may lose the land when ties with the partner is broken)

☐ Secured (self-perceived security, cannot be easily disposed under a trivial circumstance)

☐ Highly Secured (confident about ownership either by *de jure or de facto)*

23. What effect do the limitations have on your economic life and empowerment as a woman in terms of development?

☐ No effect, I am comfortable with the existing practices

☐ Low productivity

☐ Demotivated to develop

☐ Unemployment
☐ Other ……

VALIDATION SESSION

1. How easy were you able to identify the boundary of your land on the imagery?

☐ Very Easy ☐ Easy ☐ Difficult ☐ Very Difficult

2. How were you able to identify your boundary?

……

3. To what extend do agree to the efficiency of the approach regarding the following:

(i) The approach was **Participatory**

☐ Strongly Agree ☐ Agree ☐ Disagree ☐Strongly disagree

(ii) The approach is **Flexible**

☐ Strongly Agree ☐ Agree ☐ Disagree ☐Strongly disagree

(iii) The approach is **Transparent**

☐ Strongly Agree ☐ Agree ☐ Disagree ☐Strongly disagree

(iv) The approach is **Time-efficient**

☐ Strongly Agree ☐ Agree ☐ Disagree ☐Strongly disagree

(v) The approach is **Not Complicated**

☐ Strongly Agree ☐ Agree ☐ Disagree ☐Strongly disagree

4. How likely are you to recommend the approach for future implementation in customary land administration?

☐ Very likely ☐ Likely ☐ Unlikely ☐ Very Unlikely