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Assessing the Contribution of Participatory Mapping Data Collection Methods in Detecting and Mitigating Land Boundary Conflicts on Farm Areas: A Methodological Framework

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ABSTRACT: Land conflict is a serious and sensitive issue in Africa. Disputes about land occur at all levels, which are: Conflicts between neighbors about field boundaries; between pastoralists and farmers; between states and indigenous peoples; etc (Wardell & Lund, 2006). These conflicts are a serious threat to agricultural and land productivity. Now our days there exist several methods of land data collection which facilitates land conflict mitigation, and each of these methods are been explained in various papers. However, none of these papers have compared these methods to bring out their unique contribution as a means to assist practitioners in identifying land conflicts prone areas. Our research is centered around the question: what is the distinctive contribution of each land data collection methods in identifying land conflict prone areas during participatory mapping? Using a case study of three villages in Mbalmayo (Cameroon), our research adopts an approach that combines farmland data from interviews, questionnaires, consultative meetings, field visits, demarcation of farm boundaries; recording of Ground Corner Points using Catalyst DA2, UAV flights, and participatory mapping. In this paper, we discuss the usefulness and limitation of each method, highlighting their unique contribution to the holistic understanding of the context of Mbalmayo and the mitigation of land conflicts. The study was conducted from June to October 2023. The results of our analysis shows that amongst the eight methods used to collect farmland data, six of these methods had a distinctive contribution that facilitated the mitigation process by precisely identifying the land boundary conflicts zones. The ideas provided by this paper can serve as guidelines for researchers and practitioners interested in mitigating land conflicts through participatory mapping approaches.

KEYWORDS: Participatory mapping; Land conflicts; Mitigation; Data collection methods.

ABBREVIATIONS

DSR – Design science research
GIS – Geographic Information Systems
GCPs – Ground Control Points
GNSS – Global Navigation Satellite System
IG – Indirect Georeferencing
LIS – Land Information Systems
PM – Participatory Mapping
QGIS – Quantum Geographic Information System
SDL – Spatial Data Layer
TMM – Trimble Mobile Manager
UAV – Unmanned Aerial Vehicle (Drones)
VGGT – Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security

1- INTRODUCTION

Now our days in Africa, people are now increasingly competing to get access to arable land and pastures, and open land conflicts are becoming more and more common across the continent. (Lund, Odgaard, & Sjaastad, 2006). Disputes and conflicts about land occur at all levels: Conflicts between neighbours about field boundaries; between men, women, and generations about their respective land rights; between pastoralists and farmers; etc. (Lund, Odgaard, & Sjaastad, 2006). Also, in sub-Saharan Africa, land conflicts have been increasing and are seriously affecting the wellbeing and safety of people and properties (Ringo, 2023). According to Micky THAMBIKENI land conflicts can be mitigated by improving the operations of Land Information Systems (LIS) thereby making land information and land services more available in support of urban and rural economic development for farmers and pastoralists (THAMBIKENI, 2015).

Participatory mapping is a group-based qualitative research method which is known to mitigate land conflicts (Evans, 2018) and this practice of land conflict mitigation is been used by many communities in the world and especially in Africa. Participatory mapping is based on the recognition that men and women in local communities are the main experts in the geography of their lands (Smith, Ibanez, & Herrera, 2017). The experienced I have acquired while working as Land Governance and Participatory Mapping Specialist for the African NGO named Youth Initiative for Land in Africa (YILAA), gave me the necessary knowledge I needed to conduct this research study. YILAA is a non-state actor involved in mitigating land conflicts in multi-cultural and multi-lingual contexts. Non-state actors are organizations and individuals that are not affiliated with, directed by, or funded through the government.

The voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT**)** give some recommendations to non-Sate actors. These recommendations stand as principles and good practices which every State and Non-State actor should implement in the activities as a means to promote and encourage the responsible governance of Tenure of Land, Fisheries and Forests in the world (FAO, 2012). The research we carried out in Mbalmayo was focused on the implementation and promotion of eight different principles and recommendations written in the VGGT. These eight principles are found in guideline number 6.9 on delivery of services; guidelines number 9.10 and 9.12 on community's customary tenure rights; guidelines number 12.13 on investments; guidelines number 22.2 on transboundary matters; guidelines number on 24.5 on natural disasters; guidelines number 25.1 and 25.3 on conflicts in respect to tenure of land, fisheries and forest; and guidelines number 26.5 on the promotion, implementation, monitoring and evaluation of these VGGT (FAO, 2012). Though all the above mentioned guidelines (6.9, 9.10, 9.12, 12.13, 22.2, 25.1, 25.3 and 26.5) are related to our research study, we placed more emphasis on implementing and promoting guideline numbers 9.10, 9.12, 12.13, 24.5, 25.1 and 25.3 when conducting our research work from June to October 2023 in Mbalmayo. So on this ground, I can say with assurance that our research on land conflicts mitigation in Mbalmayo contributed in improving community's customary tenure rights; contributed in guaranteeing the tenure rights of local people in the phase of large investments; and also contributed in reducing conflicts in respect to tenure of land, fisheries and forests as stipulated by the VGGT (FAO, 2012).

The problem this research wants to address is the lack of a comparative analysis which brings out the distinctive contribution of each data collection method used The most recent census, which was conducted in the previous two years, indicates that Mbalmayo has 125,616 people living there (Liliane, Romain, Caroline, Abigaelle, & Loic, 2022) during participatory mapping to detect land conflict prone areas in multi-cultural contexts. This research study was conducted from June to October 2023 in the villages of Zamakoue, Asanzoa and Medzong in Mbalmayo. Our research question is "what is the distinctive contribution of each land data collection method in identifying land conflict prone areas during participatory mapping?". This paper investigates the distinctive contribution of each data collection method used during participatory mapping to design a framework that will help participatory mapping practitioners to choose the best methods for identifying land conflict prone areas for land conflicts mitigation in multi-cultural contexts. To answer the above research question, our method will be based on a series of sequential steps which forms a funnel. These sequential steps are five steps that will convey us to the answer of our research question. These five steps are: the presentation of each method used for data collection (step 1); the outcome of the data collected by each method (step 2); the similarities between these methods (step 3); the differences between these methods (step 4); and the use of the DSR Knowledge Contribution Framework to establish the distinctive contribution of each method (step 5). These five steps constitute the generalized solution developed by our research to bring out the distinctive contribution of each data collection method used to identify land conflicts prone areas during participatory mapping. This generalized solution can serve as a framework for practitioners who because of limited resources have to choose a reduced number of data collection methods during participatory mapping to mitigate land conflicts by identifying land conflict prone areas in multi-cultural contexts.

2- Methods Used To Collect Data During Participatory Mapping To Detect Potential Land Conflict Prone Areas

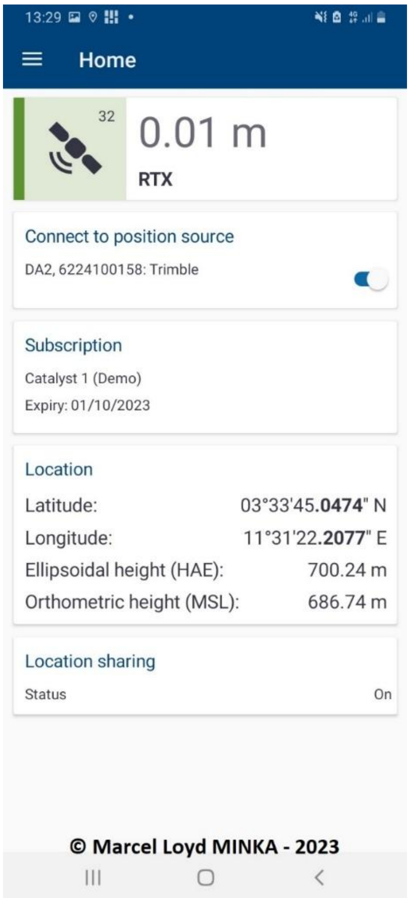
To mitigate these land conflicts amongst, I used eight methods to collected qualitative and quantitative data. These qualitative and quantitative data I collected enabled us to detect and show potential land conflict prone areas. These eight methods I used are in–depth Interviews (1), SW Maps (2), Trimble Catalyst DA2 Receiver (3), UAV Flights (4) Sketches on drone image (5), Kobo Collect (6), Map processing on QGIS (7) and Post–Participatory Mapping Interviews (8). Below are the explanation and details of these eight methods I used to collect qualitative and quantitative data during participatory mapping.

2.1- Method 1: Pre Participatory Mapping Interviews (In–depth interviews)

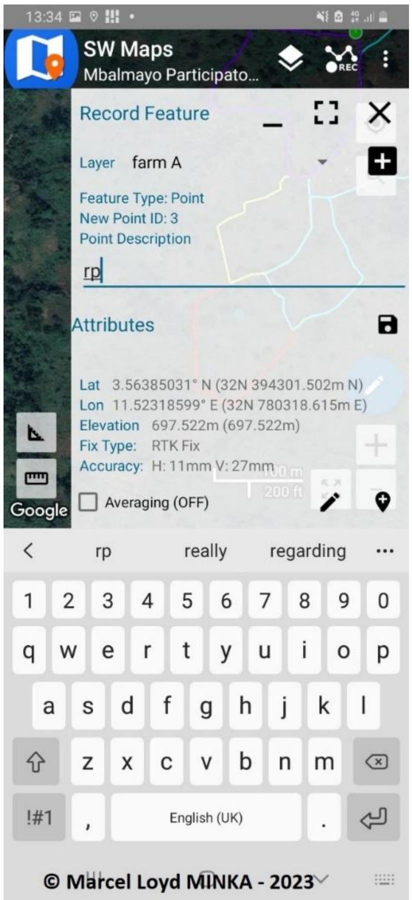
We conducted in-depth interviews with farmers over the course of a farm visit using a framework of questions to determine the intensity, seriousness and consequences of these land boundary conflicts. These interviews were carried out by me and each interview, lasted 30 to 40 minutes and were conducted with each of the farm owner or tender who felt comfortable participating in the interview. A total of twelve interviews were conducted. In-depth interviews were often the first step in gathering information with farmers and done in conjunction with a farm tour, and were conducted on farms that did not have UAV imagery from previous years. This farms did not have UAV images from previous years, because such a study had never been done before on these farms nor with these farmers. These interviews revealed the existence of land boundary conflicts which we will see in section 3 below.

2.2- Method 2: SW Maps with Trimble Catalyst DA2 Receiver for the delimitation of farms boundaries

The Trimble Catalyst DA2 is a GNSS receiver that collects spatial data with a centimetric accuracy ranging from 3 to 1 cm. It is compatible with Android and IOS systems. To collect this spatial data with Catalyst DA2, I used an Android terminal where I installed Trimble Mobile Manager (TMM) and SW Maps. TTM and SW Maps are two software's which helped me to collect all the GCPs. The android terminal (smart phone) was used as the main terminal coupled to the DA2 catalyst in order to operate and manage its signal in particular through the TMM and SW Maps applications. SW Maps is a GIS and topography application mainly used for real-time terrain data collection. Therefore, in order to collect the GCPs we when through the following process: we downloaded and installed the TMM application on our Android terminal, then created a TMM account through which we were able to subscribe to the Trimble 1 package, which gives us access to centimetric accuracy.



Picture 1: TMM interface showing the centimetric accuracy used in collecting the spatial data



Picture 2: SW maps interface showing the accuracy in GPS/GNSS measurements

In this way, we were able to share this precision with all the other location-aware applications on our Android terminal, including the SW Maps data collection application. Once in the field, we georeferenced the boundaries of the various plots using the SW Maps application, tracking them on foot around the 10 different farm plots. This enabled us to mark the delimitation of farms and place the ground control point.

Picture 3: Cameroon. Delimitation of farm limits using Trimble Catalyst DA2

Picture 4: Cameroon. Boundaries of farms delimitated on SW Maps

2.3- Method 3: Trimble Catalyst DA2 Receiver for placing Ground Control Points (GCP).

Once the different limits characterized, the next step was to place GCPs on the field that would serve as the physical boundaries between the farms and also serve as control points for the future drone missions. After placing the ground control points, we had to collect coordinates of their positions with the help of the Trimble catalyst DA2 so as to have very accurate data.

Picture 5: Cameroon. Placing of GCPs on each farm corner

Picture 6: Cameroon. Placing of GCPs on each farm corner

2.4- Method 4: UAV Flights

During these UAV flights, no farm was too large to be mapped by the drone in a single visit. After the UAV fights conducted by the drones, the images were formatted into a map layout in ArcMap (version 10.3) and printed on A3 paper. This data collection aimed at seeing the limits and boundaries of each farm on an orthophoto. This drone mapping activity provided exciting insights into the ability UAV to identify farms and farm boundaries. Relevant local government stakeholders were notified and informed about the data collection.

Picture 7: Cameroon. UAV flight for mapping the potential land conflicting farms identified during the delimitation of farm boundaries

2.5- Method 5: Sketches and drawings on drone image

These sketches done with a visible, bold marker are overlayed property lines on drone images, making it easier to reorganize farm boundaries. These drawings help to increase the visibility of each farm's boundary lines, enabling for the detection of the boundary conflict lines for an effective mitigation of the land conflicts caused by unclear and invisible boundaries. The spatial and temporal resolution of the background orthophoto is a very important aspect to consider when creating the map. The older the orthophoto is, the more problems the community might have in recognising specific objects which helps them do the sketching. Similarly, the season can also play a role in certain areas, as the landscape can look very different in the rainy and dry seasons or in summer and winter (Dr. Claudia Stöcker & Kaspar Kundert, 2022). The spatial resolution (pixel size) of the orthophoto is also crucial.

Picture 8: Cameroon. Sketches on drone images for the participatory drawing of each farm boundary to mitigate the existing land boundary conflicts

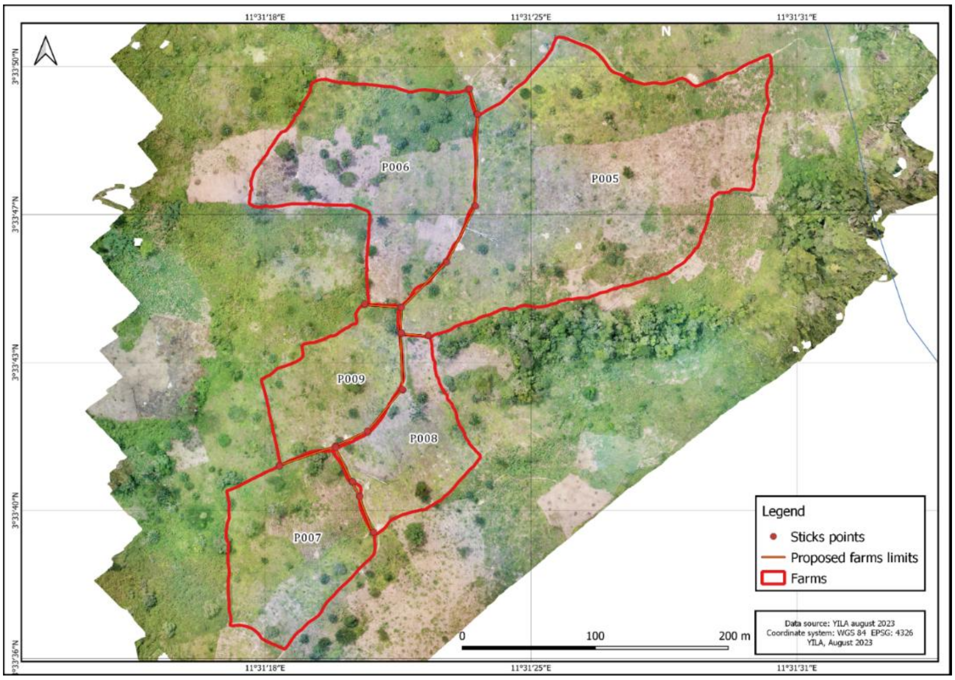
Picture 9: Cameroon. Sketches on drone images for the participatory drawing of each farm boundary to mitigate the existing land boundary conflicts

2.6- Method 6: Kobo Collect

With this this method, I collected attribute data to help mitigate the boundary land conflicts. These attribute data are paramount knowledge in land administration and might or might not have caused the land boundary conflict. On Kobo tool I built a questionnaire, then later I deployed to mobile devices from which the survey was made. Through this questionnaire, I was able to collect data on land ownership, land rights, land use. The questions on kobo tool were primarily closed questions for which I provided propositions to guide the farmers and avoid them from feeling the weight of the many questions. This questionnaire helped to gather data which could have been left out through the interviews. The Questions were separated into four categories, which included: questions on the demography; questions on the agriculture practices; questions on the Land ownership, land rights and land use; and questions on of the nature of conflicts.

2.7- Method 7: Map processing on QGIS

Once farm boundaries are sketched and that the questionnaires on kobo collect are filled, the farmers had to agree with the sketches on the orthophoto which enabled us to draw on QGIS the final farm boundary lines for the mitigation of the land conflicts. These agreed boundary lines on the orthophoto was traced by the mapping assistant on top of the ballpoint pen lines with a black marker with a line width of 1 mm - 2 mm to yield reliable results in the automatic line extraction process. To process the maps on QGIS in order to have the final shape and size of the farms, we photographed the sketched orthophoto map using the SmartLandMaps Digitizer application (Claudia, Auriol, Gergely, Kaspar, & Angela, 2023). Here the orthophoto maps needs to be aligned in a landscape format on a flat surface such as a big table or a tiled floor. It is recommended to tape the edges of the map to the ground to ensure that it is completely flat. Ideally, pictures are taken in passive daylight conditions and without shadows on the sketched map. Once the mobile device is connected to the internet, all pictures will be uploaded automatically to the SmartLandMaps cloud and the automatic processing of the Map on QGIS will start.



Picture 10 (orthophoto): Final sizes, shapes and boundaries of farms processed on QGIS after agreeing with the participatory farm boundary lines drawn on the drone image

2.8- Method 8: Post–Participatory Mapping Interviews

These interviews where done after the participatory mapping sessions, and aimed at determining the level satisfaction of farmers with regards to the strategy I used to mitigate the boundary land conflicts. These interviews I did lasted between 20 to 40 minutes. These interviews which were done one month after we had finished the participatory mapping session with the new farm boundary lines agreed by all the farmers. One of the major changes declared by every farmer was the easy access to each farm due to the creation of a road which separates five farms. The implementation of this road path was a mitigation strategy which I proposed to the farmers to reduce the outbreak of future land boundary conflicts.

Pictures 11: Cameroon. Presentation of the final farm boundaries to the conflicting parties for an evaluation of the participatory mapping exercise used a strategy to mitigate land conflicts

Pictures 12: Cameroon. Presentation of the final farm boundaries to the conflicting parties for an evaluation of the participatory mapping exercise used a strategy to mitigate land conflicts

3- DESCRIPTION OF THE QUALITATIVE AND QUANTITATIVE DATA COLLECTED BY THESE EIGHT METHODS

Below is a table listing and describing the data collected by each of the eight methods. Each of these qualitative and quantitative data help us to detect potential land conflict prone areas.

Table 1: Table Describing the qualitative and quantitative data collect by each of the eight methods

Methods used to Data Collect	**Spatial Data Layer (SDL) types**	**Data Collected**	**Description of Data**
In–Depth Interviews	- Croplands. - Natural habitats - Agroforestry	Existence of Land conflicts (verbal affirmations of farms boundaries deficiencies which causes land conflicts)	These are qualitative data which confirms the presence of boundary land conflicts amongst majority of the neighboring farmers, with an 90% YES to the answer on the existence of land conflicts and a frequency of 9 YES amongst the 10 respondents.
SW Maps with Trimble Catalyst DA2 Receiver	- Croplands. - Natural habitats - Agroforestry	Shapes and boundaries of farms (farm boundaries detection lines)	These are quantitative geographic data which when collected appears in the form of maps on the SW Maps software. (see picture 4 above)
Trimble Catalyst DA2 Receiver	- Croplands. - Natural habitats	GCPs	GCPs are specific places on the earth's surface with known referenced locations that are used to georeferenced an area. GCPs can be used as reference data for a farmland.

	- Agroforestry		
UAV Flights	- Croplands. - Natural habitats - Agroforestry	Georeferenced drone Images of the farms	These are hundreds of slightly overlapping pictures that covers every square inch of the farms, from the property edges to the tops of trees. Each of these pictures are georeferenced. That is every time a drone takes a picture, it records the precise coordinates (i.e. longitude, latitude, and relative altitude) in the image's EXIF data.
Sketches on drone image	- Croplands. - Natural habitats - Agroforestry	Sketches and drawings of farm boundaries on drone images (provisional farms shapes and sizes)	These sketches and drawings of farm boundaries on drone images are overlaying property lines which helps to better visualize and rearrange the farm boundaries on a drone image. These drawings are done with a visible bold marker. These drawings help to improve the visibility of the boundary lines of each farm in order to detect and mitigate potential land conflicts which arose because of unclear and invisible boundaries. It's a form of reorganization of farm boundaries to mitigate the land conflict.
Kobo Collect	- Croplands. - Agroforestry	Attribute data (Land ownership, Land rights, Land use etc.)	Attribute data are used to describe vector features. These attributes don't have to be visible things, but they can describe things we don't know about the farmlands, such as the name of the owner, the legal aspects of the farm, the year the farming activity started, etc. The attribute data revealed that majority of the farmers are tenants and only a few of they are owners of the farmland
Map processing on QGIS	- Croplands. - Natural habitats - Agroforestry	Final farms shapes and sizes	These farm shape and sizes are vector data whose shapes are represented using geometry. within the GIS environment. The geometry is made up of one or more interconnected vertices (vertex). The data of these maps on QGIS are made up of the following detailed elements: The Title in detail; the Map Border in detail; the Map Legend in detail; the North arrow in detail; the map Acknowledgment in detail; the Graticule in detail; and the Name of the map projection in detail.
Post–Participatory Mapping Interviews	- Croplands. - Natural habitats - Agroforestry	Satisfaction level of farmers about the mitigation strategy used in this study	These are qualitative data obtained from farmers through interviews. This data assesses the effectiveness of the mitigation process by given the satisfaction level of farmers three months after the new boundary lines had been drawn on the field. Added to these new boundary lines was the creation of a small road path which separates the five farms.

4- SIMILARITIES BETWEEN THESE DATA COLLECTION METHODS IN DETECTING LAND CONFLICT PRONE AREAS FOR EFFECTIVE MITIGATION

In this section 4 of my paper, I will use the data collected to detect land conflicts prone areas (4.1) and the implementation process (4.2) to outline the similarities between the above eight methods of data collection.

4.1- Similarities in data collected

Methods 2, 5 and 7 collected similar data during the participatory mapping. This data collected was the shape and sizes of the five farms, which can be seen in picture 4 and 10 above. These data on the shape and sizes of farms were derived through the recording of points and lines of farm boundaries on SW Maps and also through Sketches of farm boundaries on drone images. This data enabled us to identify the land conflicting neighboring farms by detecting the error in the boundary lines of these neighboring farms.

More so, methods 3 and 4 collected similar qualitative data. This data collected was georeferenced drone images with GCPs. This combination of GCPs on geo georeferenced drone images gives rise to what is called Indirect Georeferencing (IG). IG is a precise technique for georeferencing aerial photography. It uses Ground Control Points (GCPs) to assist Aero-Triangulation (AT) and achieves accuracies of 0.02 m (Joan-Cristian, Francisco-Javier, Jordi, & Xavier, 2019). To better visualize the similarities and interconnection between these two data, please check figure 5 below.

4.2- Similarities in the implementation process

In this sub-section, I will explain the similarities which exist between the different methods with regards to the implementation process I followed to implement these methods on the field in Mbalmayo. For example, in this research study, methods 2 and 3 have the same implementation process because to implement these methods on the field, I used the same boundary detection software and the same measuring tool. The software I used to implement these two methods was SW Maps (see picture 2 above). And the measuring tool I used was Trimble Catalyst DA2 Receiver (see picture 1 above) which gave us an accuracy of 0.01 m for each farm boundary line.

Also, methods 5 and 7 have the same implementation process because to implement these methods on the field, I used the same settings. These settings were a drone image and an orthophoto on which the farmers could do the participatory drawing of each farm parcel in order for these farmers to agree on each farm boundary line. The unanimous agreement on the participatory drawing of farm boundary lines mitigated the land conflict by giving rise to the final boundaries of each farm.

Finally, methods 1, 6 and 8 are similar in the implementation process, because the implementation of these methods demanded the presence of all the farmers (involved in the land conflict) who had to answer to a questionnaire in the form of an interview.

5- DIFFERENCES BETWEEN THESE DATA COLLECTION METHODS IN DETECTING LAND CONFLICT PRONE AREAS FOR EFFECTIVE MITIGATION

Apart from the above similarities, these eight methods of data collection also have some differences when applied during participatory mapping. So, in this section 5, I will use the data collected to detect land conflicts prone areas (5.1) and the implementation process (5.2) to outline the differences between these eight methods of data collection.

5.1- Differences in data collected

To mitigate these land boundary conflicts between these five farms, we collected two different types of data, which were qualitative and quantitative data. It's through these different types of data collected that I will illustrate the differences between our eight data collection methods. Methods 1, 6 and 8 were used to collect qualitative data in the form of verbal affirmations of farms boundaries deficiencies; and in the form of attribute data on land ownership and land rights. Whereas methods 2, 3, 4, 5, and 7 were used to collect quantitative data in the form of farm shapes; farm sizes; GCPs; georeferenced UAV images; and farm boundaries detection lines. (see Table 1 above)

5.2- Differences in the implementation process

In this sub-section, I will illustrate the differences which exist between the methods with regards to the implementation process I followed to implement these methods in Mbalmayo–Cameroon. At the level of the step needed to implement each method, the steps of methods 2, 3, 5, and 7 where longer than the steps of methods 1, 6 and 8.

Another implementation difference was at the level of the software and measuring tools I used when implementing these methods. This was the case when implementing methods 2, 3 and 7. To implement these methods, I did not use the same software nor measuring tool for the boundary detection, shape configuration and size determination of the five conflicting farms. In method 7, I used the Geodesic Measure Tool icon on QGIS by doing a left-mouse click on the map to get measurements between corner points to define the map size and boundaries. Whereas in method 2 and 3 I used SW Maps and Trimble Catalyst DA2 to get the farm corner points for the boundary detection, shape configuration and size determination.

Finally, I observed and noted a significant implementation difference between methods 2, 3, 5 and 7 at the level of the settings put in place to carry out these methods on the field in Mbalmayo. The settings of method 2 and 3 were farm settings where we did farm tours for placing GCPs, whereas the setting of method 5 and 7 were drone images and orthophotos on which we did the participatory drawing of each farm boundary line.

6- THE DISTINCTIVE CONTRIBUTION OF THE ABOVE DATA COLLECTION METHODS IN DETECTING POTENTIAL CONFLICTING BOUNDARY LINES FOR MITIGATION

In this sixth and last section, I will discuss the distinctive contribution of the above data collection methods in detecting and mitigating land conflicts during participatory mapping. To determine and bring out the distinctive contribution of these methods I used the DSR Knowledge Contribution Framework (Gregor & Hevner, 2013). The application of the DSR Knowledge Contribution Framework as seen in figure 1 below, revealed that only six methods out the eight methods above had a distinctive contribution in detecting potential conflicting boundary lines for an effective mitigation of the land conflict.

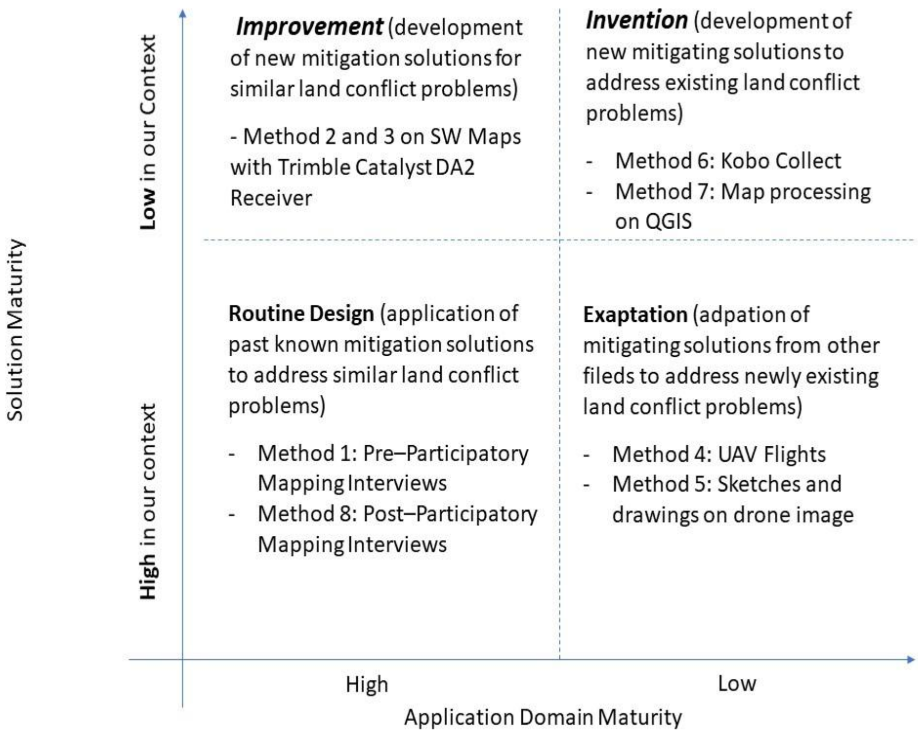


Figure 1: The Design Science Research (DSR) Knowledge Contribution Framework (Gregor & Hevner, 2013) showing the distinctive contribution of the data collection methods

6.1- Distinctive contribution of methods 2 and 3 in fostering improvements for mitigating land boundary conflicts

The Trimble Catalyst DA2 (Trimble, 2021) is a different type of low-cost GNSS receiver developed in 2021 as a new solution to foster the improvements of participatory mapping in mitigating land conflicts. The distinctive contribution was that it helped to survey each farm parcel boundary lines by 0.01 cm accuracy for an effective mitigation of this land boundaries conflict between the five farm parcels. Also during the mitigation process, Trimble Catalyst DA2 makes it easy to observe the proximity between the ground markers and GNSS derived GCPs coordinates (Israel, Sunday, & Matthew, 2023).

6.2- Distinctive contribution of methods 6 and 7 in promoting innovative Inventions for land boundary conflicts mitigation

Methods 6 and 7 are innovative methods which helps to identify double allocation of land. Double allocation of land is an important factor which causes land conflicts. This problem greatly exists as two or more people find to be claiming on plot of land each with a valid certificate right of occupancy (THAMBIKENI, 2015). So the use of kobo collects to obtain data on land ownership and the formalization of this land ownership on a QGIS software to produce the map for land titling is an effective mitigation strategy which we used in Mbalmayo to prevent these problems of double allocation of land.

6.3- Distinctive contribution of Methods 4 and 5 in the reimagining (re-appropriation) existing solutions for land boundary conflicts mitigation

Method 4 on UAV flights is significant in determining the type of land use in an area. Drones (UAV) are a unique tool which helps to visualize what activities are been carryout on a land. UAV flights are therefore crucial for land use planning and management. Land use planning is used as a land conflict mitigation strategy by certain communities in Cameroon. So the combination of UAV flights with sketches on drone images helps to clearly define and visualize the boundary lines of each land parcel even if they have the same land use or not. “Land use” is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place (EPA, 2024).

CONCLUSION

In conclusion, this paper outlines a comprehensive framework for determining the unique and distinctive contribution of participatory mapping data collection methods in mitigating land conflicts. In this paper we place an emphasis on the pivotal role played by each of these eight methods in mitigating existing land boundary conflicts amongst farmers. The type of data layers present in these farms were significant in determining which method have similar data with another. The similarities between these methods of data collection clearly shows that to mitigate land boundary conflicts these methods cannot be dissociated from one another, thereby showing their inter-linkages. But even though these inter-linkages exist, with the support of the differences these methods portray in the data collected, we used the Design Science Research Knowledge Contribution Framework (Gregor & Hevner, 2013) to regroup them into four categories in order to bring fort their distinctive contribution in the land boundary conflict mitigation process. As its seen in figure 1 above, these four categories are improvement, invention, routine design and exaptation. Methods 2 and 3 distinctive contributions are that the data they collect help to enrich the mitigation process by giving a virtual representation of the boundary lines which are inexistent on the field. Meanwhile the data obtained from methods 4 and 5 showed to the conflicting parties a visual (image on paper) of what their farms look like without boundaries thereby identifying the root cause of the conflict. And finally, the peculiar contribution of methods 6 and 7 in the mitigation process was the detection of boundaries deficiencies. The identification and combination of all these distinctive, unique and peculiar contributions enables us to understand the role played by each of these data collection methods when using participatory mapping to mitigate land boundary conflicts. With this appropriate understanding outline in our research paper, we hope that this paper can serve as guidelines for researchers and practitioners interested in mitigating land conflicts through participatory mapping approaches.

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INFORMED CONSENT STATEMENT

Informed consent was obtained from participants involved in the data collection process.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; nor in the collection, analyses, nor in the interpretation of data; nor in the writing of the manuscript.

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