GEOGRAPHIC INFORMATION SYSTEM (GIS) IN IDENTIFYING AND MONITORING ROOT AND TUBER CROPS PRODUCTION AREAS IN SELECTED BARANGAYS IN THE PROVINCE OF BENGUET, CORDILLERA ADMINISTRATIVE REGION

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ABSTRACT

This study utilized Geographic Information System (GIS) to develop a methodology to generate spatial data in identifying and monitoring root and tuber crops (RTC) area to provide more accurate and timely information to government, non-government organization, and local government units in planning food security and crafting relevant policies. It determined the location and estimated the area planted with RTC. It used the participatory mapping approach to determine the traditional RTC production area at barangay level. It compared the GIS generated and the community participatory maps on estimating RTC production areas. Lastly, it integrated the results of GIS-based and community-based techniques in developing a database for root crops data.

The sources of information especially on root crops are limited or disaggregated. There are municipalities that have records of production data by municipality but none at barangay level. Among the provinces of Cordillera Administrative Region (CAR), only Abra and Benguet have provincial and municipal level data; however all of the provinces lack barangay level data. Based on DA-CAR data, Ifugao had the biggest production of sweet potato (7327.75MT) while Benguet had the biggest production area (792 Ha). In the province of Benguet based on Office of the Provincial Agriculturist 2011 data, the Municipality of Kabayan has the biggest area (146 Ha.) and production of sweet potato (6088 MT).

RTC database structure is organized in the Entity-Relationship (ER) Diagram using the MS Access software. The ER diagram is composed of entities namely province, municipality, barangay, farmers, facility, farm and crops.

It was observed that majority of the barangays did not have scaled barangay maps, only sketches and drawings. With this, Participatory Mapping methodology was conducted at barangay level. The study used printed satellite Google images in tarpaulin, where the community facilitated the transfer of information. There was a specific dimension in people's cognitive maps of their community and the GIS researchers' technical map. Both have its own cognition and perception of directions, scale, landmarks, slope, soil type, cropping pattern and social aspect.

The output of the participatory mapping is the RTC maps with location of RTC areas in the barangay. Using spatial analysis function of QGIS, the area of the polygons is determined.

Keywords: *root and tuber crops, participatory mapping, geographic information system*

INTRODUCTION

The Food and Agriculture Organization (FAO) defines roots and tubers as plants yielding starchy roots, tubers, rhizomes, corms and stems. Apart from their high water content, (70-80%), these crops contain mainly carbohydrates (largely starches that account for 16-24% of their total weight) with very little protein and fat (0-2 % each). As such, they provide a substantial part of the world's food supply and are also an important source of animal feed. On a global basis, approximately 55 percent of roots and tuber production is consumed as food; the remainder is used as planting material, as animal feed or in the production of starch, distilled spirits, alcohol and a range of other minor products (FAO). This approximation uses data on patterns of utilization, consumption rate, production area and volume of harvest to generate statistical information.

According to the FAO, there are seven classifications of primary crop namely, a.) potatoes (Irish potato): *Solanum tuberosum,* b.) sweet potatoes: *Ipomoea batatas,* c.) cassava (manioc, mandioca, yuca): *Manihot esculenta, utilissima and dulcis,* d.) yautia ("Chou caraibes"): *Xanthosoma,* e.) taro (Cocoyam, old cocoyam, colocasse): *Colocasia esculenta,* f.) yam: *Dioscorea,* and g.) other roots and tubers.

In dealing with agricultural statistics of root and tuber crops, there are efforts to have a common definition and basis of root crop statistical data at a global level. However, root crop productions in the tropics are very poorly documented and few estimates of these measures of productivity are available (FAO, 1997). In the Philippines, the existing agricultural data on crop and tubers from the actual field production is limited and scarce; root crops have not been given priority attention on a national scale and scientific studies on root crops have been carried out so far only on a piecemeal and uncoordinated basis; (PD1107). Even the BAS website has detailed the concepts and methods of rice and corn data statistics but only few for root crops.

The national banner programs implemented by DA are also concentrated on rice, corn and selected high value crops production for food security. All the other root crops have long been ignored or neglected such that 65 percent of its budget is spent on rice and corn, and practically nothing on root crops. (Manila Bulletin 23 June 2011). However, PhilRoots (Leyte) is the government agencies mandated for research and statistics for root and tuber crops.

Agricultural statistics, such as crop production are important in the implementation of research and development projects. They are crucial in decision making to benefit the population of a target region. FAO (2003) points out that in order to plan agricultural research and rural development strategies, it is absolutely necessary to have an information system that provides reliable data on the total area cultivated under a specific crop, the size of production units, the agro ecological areas where the crops are found, soil and climate characteristics, the socioeconomic condition of the producers and the cropping schedule, among others. (P. Zorogastúa et al, 2007)

In the principle of crops statistics, the concepts of area, yield and production are clearly defined. Keita (2003) defines area as horizontal projection of a particular extent of earth's surface. The area has two types: gross area and net area. Gross area is the total area including uncultivated patches, bunds, footpaths, etc., while the net area excludes the above elements. However, in estimating the area relevant to root crops, there are conceptual and operational issues such as continuing planting/harvesting and mixed or associated cropping. FAO defines yield as the average amount obtained per unit of area while production is the total amount produced. The production/yield data for root and tuber crops must be reported in terms of clean weight, i.e. free of earth and mud. In comparison, Bureau of Agricultural Statistics (BAS) defines area planted as the actual physical area planted to a permanent crop. This generally applies to area reported for permanent crops (crops which occupy the land for a long period of time and do not need to be replaced after each harvest such as fruit trees, shrubs, nuts, etc.). Area harvested, on the other hand, is the actual area from which harvests are realized. This excludes crop areas that are totally damaged and may be smaller than area planted. In crop statistics, this applies to temporary crops that are grown seasonally and whose growing cycle is less than one year and which must be sown and planted again for production after each harvest. In addition, Effective Crop Area Harvested is the actual area from which harvests are realized which is counted as many times as it was planted and harvested to same crops or different crops during the reference period. This concept applies to the harvest area reported for temporary crops such as rice, corn, vegetables, root crops and tubers and temporary fruit crops.

In the concept of yield and production, FAO has three main concepts of production namely biological production (production still on the plants), production actually harvested (excludes harvesting losses and production not harvested for various reason), and marketed production (production for sale, excludes own consumption by farmers and post-harvest losses). BAS defines yield as indicator of productivity derived by dividing total production by the area. Production is the quantity produced and actually harvested for a particular crop during the reference period. It includes those harvested but damaged, stolen, given away, consumed, given as harvester’s share, reserved, etc. Excluded are those produced but not harvested due to low price, lack of demand and force majeure or fortuitous events, etc. The data published and documented by BAS are crop estimates (actual harvest for the previous quarter)/ crop forecasts (harvests for the next two quarters) on production, area harvested and yield using stratified sampling methods at barangay level.

In the past years, investments in agriculture are declining (Jatta, cited in Manila Bulletin 23 June 2011). Thus, investments in agriculture by small-scale entrepreneurs are most welcome. They are more effective in achieving food security among a bigger number of the population. Jatta (2011) added that if more households will undertake food production projects, access to food by more people would be ensured.

Dr. Gelia Castillo (cited in Manila Bulletin 23 June 2011), national scientist and rural sociologist, batted for food security through crop diversification. People should not only grow rice. They should grow other crops and livestock at the same time. She particularly mentioned the potentials of camote roots as well as its tender tops as source of a healthy diet. Root crops are good substitutes to rice and corn as food in terms of carbohydrate and fiber content. Tuber contains no saturated fats or cholesterol but is rich source of dietary fiber, anti-oxidants, vitamins, and minerals. The nutritional content of root and tuber crops can help improve the malnutrition in impoverished communities; however awareness on its nutritional value and its potential as substitute for rice are not being given attention. In Asia, International Potato Center (CIP) has accorded priority to working in countries and regions where poverty levels are high and where potato and/or sweet potato play an important role in the food and agricultural system to increase the impact of research on poverty alleviation (Fuglie, 2010).

Initial fieldwork in 2012, revealed that there are different government agencies handling and storing data. The local government units (LGUs) in the municipal and provincial levels independently handle and share the data even though they are autonomous from each other. At the national and regional levels, the Bureau of Agricultural Statistics (BAS) under the Department of Agriculture (DA) is the agency mandated to collect, compile, and release official agricultural statistics. The DA regional offices consolidate data from provincial LGUs, while BAS uses statistical process to estimate data which serve as one of the basis for implementing banner programs. The data are available in tabular formats and lacks spatial map representation. There are efforts to produce various maps. Some LGUs hired the service of private consulting firm to produce digital maps in image format but the database and information are mostly not included. Hence, the maps produced do not present actual agricultural information. At the national level, several agencies under DA have digital maps repository such as Bureau of Agricultural Research (BAR) and Bureau of Soil and Water Management (BSWM). However, map information is concentrated in rice, corn, and other high value crops (fruits) while root and tubers crops are seldom available.

Maps and statistical information are essential elements in planning development programs (Food Agriculture Organization (FAO), 2003). The information is mapped out with the community in order to identify their felt needs rather than those of technical experts through participatory or community-based mapping. It is widely practiced globally and in the Philippines, it is being used in various community development programs and projects. Among these were mapping ancestral domains in Northern Mindanao Philippine –International Fund for Agricultural Development (PAFID-IFAD) project in 2006 (IFAD, 2009); mitigate disaster prevention for day care children (mb.com.ph, March 19, 2012); and indigenous people (de Vera, 2007).

The BAS agricultural data are available on line through their website portal (www.bas.gov.ph) under cropstat link. The tabular data are consolidated per commodity in regional and provincial level, but there is no data linkage-using map. Initial fieldwork revealed that majority of LGUs lack thematic map to represent production and area. Most of the maps are sketches of the barangay which are based on their perceived shape, road network and many others. There are only few who use the Google earth map. Moreover, the information reflected in the maps was provided by only a few and not by the community.

Based on WaterAid Guide (2005), when communities carry out survey of their area and build an accurate knowledge of what their community looks like, the process itself can reinforce and build capacity within the community. It enables the community to work out problems it faces, and begin to look for and implement solutions.

In the Philippines, Environmental Science for Social Change carries out community mapping in different fields such as agroforestry projects in 2007. The objective of the project is to retain the value of both maps so that the government can appreciate the community's understanding, as well as their potential responsibility for managing the area.

Root and tuber crops (RTC), the so-called “underground treasures” (CIP-IFAD) are very versatile commodity that they are batted for food security through crop diversification. RTC are more effective in achieving food security among a bigger number of the population; they provide livelihood and healthy diet (Jatta, 2011 cited in Manila Bulletin 23 June). However, there is a huge need to systematize the documentation and organization of data on RTC. Utilizing GIS to generate spatial data in identifying and monitoring root and tuber crops area can provide more accurate and timely information to government agencies & LGUs in planning food security program and crafting relevant policies. This research will explore community mapping for agricultural use particularly on mapping root crops for future project planning.

MATERIALS AND METHODS

The research methodology was divided into four parts: 1.) Literature Review and Reconnaissance Survey 2.) Database System Development using MS Acess, 3.) Data Collection Technique used Participatory Mapping and 4.) Base Map Generation. The study used open source GIS (QGIS software).

RESULTS AND DISCUSSION

The following discussion focused on developing a methodology in identifying and monitoring Root and Tuber Crops (RTC) production areas to facilitate building a GIS-based Decision Support System. This is particularly useful in creating RTC Database and Base Maps to determine the location and estimate the area using participatory mapping approach through the use of open source GIS. The discussion also presents the results of initial field data gathering from different government offices and the conduct of community mapping in different barangay. A discussion on the resulting map from overlaying RTC production, malnutrition and percentage of poor households is likewise included.

Root and Tuber Crops Primary Data

Agricultural statistics are important for decision making in planning development activities that will benefit the people. However, the sources of information especially on root crops are limited or disaggregated. For the study, initial data collection was conducted from different offices in the local government unit (LGU) such as Provincial Agriculture Office, Provincial Planning and Development Office, and Municipal Agriculture Office (Table 1). The data includes production area (Hectare) and volume (MT) of RTC.

Based on field observation, there are municipalities that have records of production data by municipality but none at barangay level. Among the provinces in the Cordillera Administrative Region, only Abra and Benguet have provincial and municipal level data, however all of them lack data at the barangay level.

Table 1. Availability of RTC data in Cordillera Administrative Region (2011)

Province	Province level	province by crop	Municipal level	Barangay level
IFUGAO	✖	✖	✖	✖
KALINGA	✔	✖	✖	✖
ABRA	✔	✔	✔	Incomplete
BENGUET	✔	✔	✔	✖
MOUNTAIN PROVINCE	✖	✖	✖	✖

Using the data from the Department of Agriculture- Cordillera Administrative Region (DA-CAR), a thematic cartography map was generated based on available environmental, social and economic data (primary data). The thematic map (Figure 1) indicates that in 2011, Ifugao province had the biggest production (7327.75MT) of sweet potato followed by the province of Benguet (6005.7MT). However, Benguet had the biggest production area of sweet potato (792 ha).

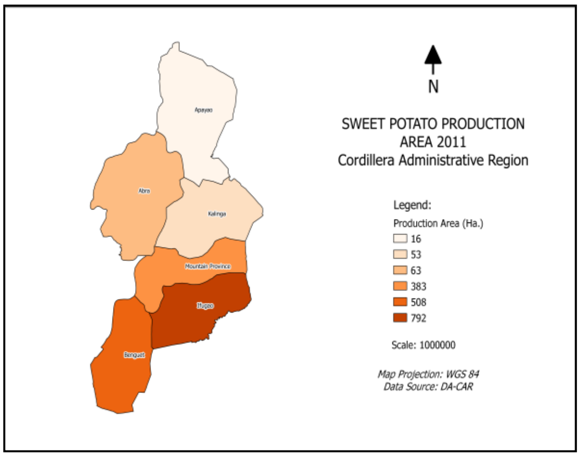

Figure 1. Sweet Potato Production Area

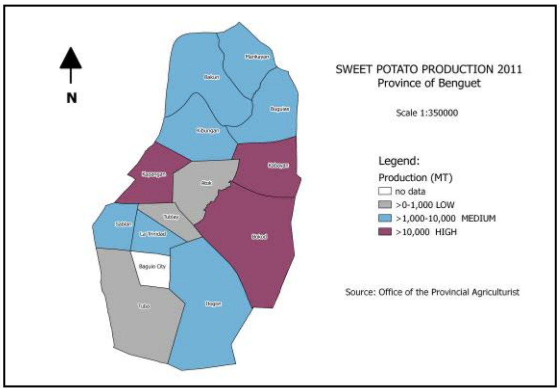

Figure 2. Sweet Potato Production Classification Map

In the province of Benguet, the Office of the Provincial Agriculturist consolidated production data of various agricultural commodities per municipality for the last 3 years including RTC. In 2011, the Municipality of Kabayan had the biggest sweet potato area (146 Ha.) and production (6088 MT).

The graduated color shown in the thematic maps shows the range of values corresponds to different levels such as Low, Medium/Moderate and High. In Figure 2, the municipalities of Atok, Tublay, and Tuba were classified as low producing municipalities while Bokod, Kabayan and Kapangan had high production.

Aside from production data, socio-economic data (Malnutrition and Poverty) of Benguet were also included. There were several measures of malnutrition (Figure 3 & 4) depending on parameters used. This study used the percent of underweight children with ages (0-5 years old). The Municipality of Bakun had the highest percentage of underweight children, while Itogon had the lowest. The entire municipality was classified as low or within the 0-15% range.

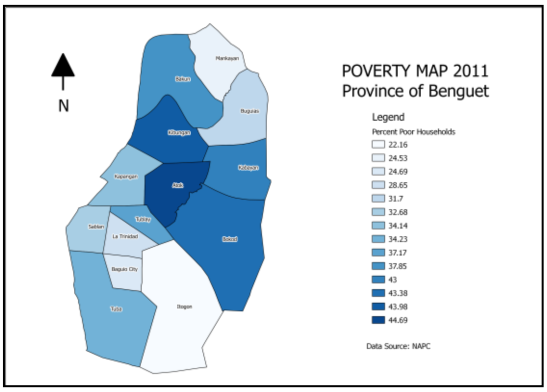

Figure 5. Poverty Map

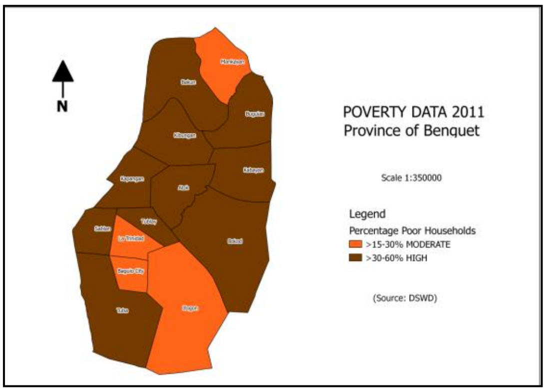

Figure 6. Poverty Classification Map

Poverty, like malnutrition, has several dimensions depending on the parameters used. The study used the percentage of households below poverty threshold or earning less than one dollar per day (Figure 5 & 6). The Municipality of Atok had the highest percentage of households living below the poverty line. The municipalities classified as moderate (>15-30%) were Itogon, La Trinidad and Mankayan while the rest were classified as having high percentage of poor households.

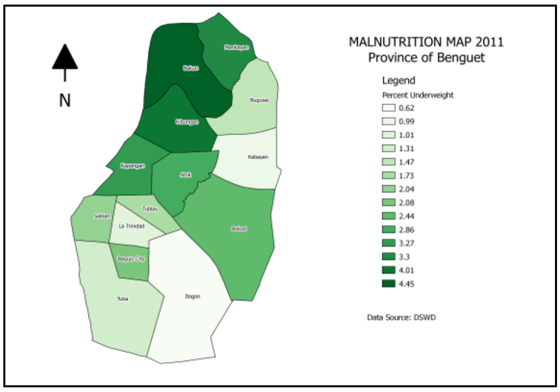

Figure 3. Malnutrition Map

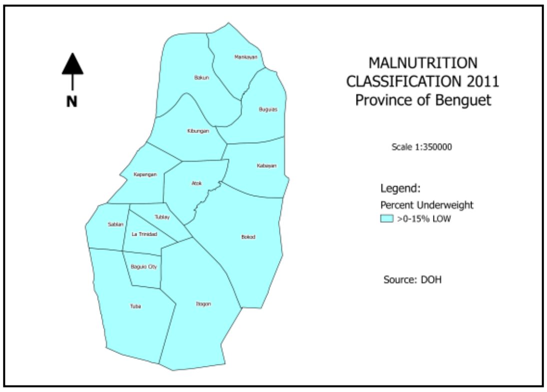

Figure 4. Malnutrition Classification Map

Cross tabulating the data on production and malnutrition, the municipality of Atok, Tublay and Tuba showed low production and low malnutrition, while Kabayan, Bokod and Kapangan showed high production and low malnutrition (Figure 7). Cross tabulating production and poverty, the municipalities of Atok, Tublay, and Tuba had low production and high poverty while Kabayan, Bokod and Kapangan had high production and high poverty (Figure 8).

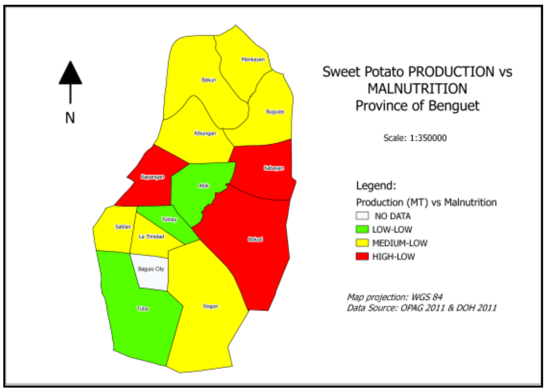

Figure 7. production vs. malnutrition

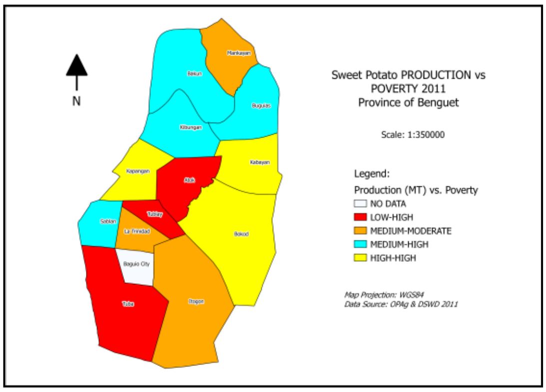

Figure 8. production vs. poverty

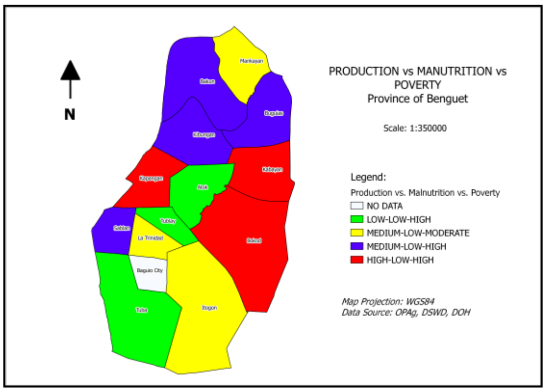

Figure 9. production vs. malnutrition vs. poverty

Cross tabulation of the three parameters showed the municipalities of Atok, Tublay and Tuba with low production, low malnutrition and high poverty while the municipalities of Kabayan, Bokod and Kapangan had high production, low malnutrition and high poverty (Figure 9).

Root and Tuber Crops Database

The primary data is composed of RTC production and area per municipality. The data are tabulated in table format such that organizing, querying and updating are executed easily. However, adding the barangay level data needs a database structure to systematize RTC data. The RTC database is organized in the Entity-Relationship (ER) Diagram (Figure 10) using MS Access software. The ER diagram is composed of entities namely province, municipality, barangay, farmers, facility, farm and crops. The database can be expanded to suit project objective (i.e. value adding). In the ER diagram, a province is composed of one-to-many municipality. A municipality is composed of one-to-many barangay, barangay is composed of one-to-many farmers, and farmer farmed one-to-many RTC farm and a farm is planted with one-to-many root and tuber crops. In addition, barangay has one-to-many facilities. The database can query which farmer planted what RTC and its corresponding location. The facilities can also be selected depending on the nature of service (i.e. multipurpose hall, loading shed, barangay hall, school etc.)

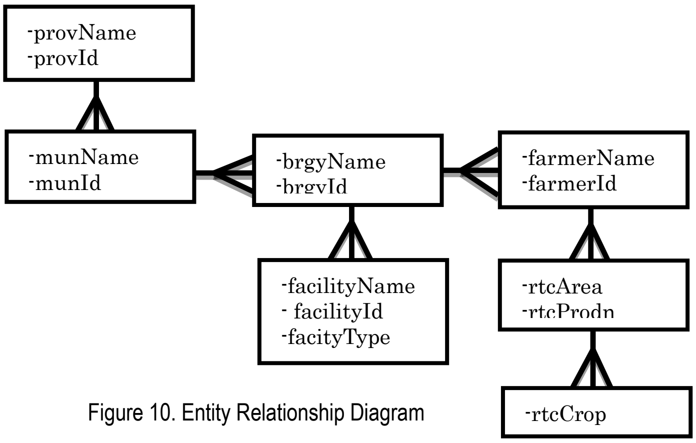

Figure 10. Entity Relationship Diagram

In Figure 11, there are seven entities. The province table is connected to municipal. Municipal is connected to barangay. Barangay table has two connections - farmer and facility. Farmer table is connected to RTC area wherein crop is connected.

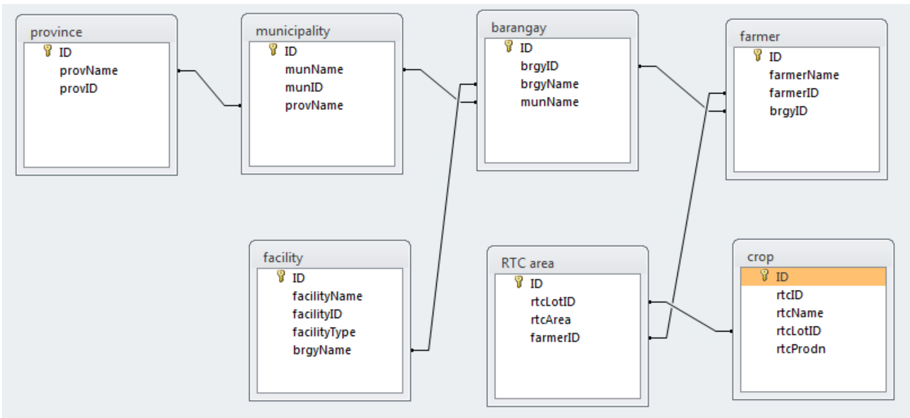

Figure 11. Entity Relationship Diagram

Participatory Mapping

The study conducted an inventory of RTC production, particularly sweet potato, through GIS and with the participation of the community members in selected barangays in Benguet province. The 12 barangays selected in this study were the beneficiaries of the DA-CHARMP and CIP FoodSTART (Food Security Through Asian Root and Tuber Crops) Project. The barangays are project partners in RTC production and enterprise development such as value adding. Moreover, the community organizers of the project and the leaders of the barangay openly expressed their cooperation in the study. Given these considerations, a community mapping activity was conducted.

The community mapping methodology was adapted from various institutions such as Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA); International Fund for Agricultural Development (IFAD); Environmental Science for Social Change (ESSC, 1998) and WaterAid-for Life (2005). The study started with initial consultation and meetings with International Potato Center (CIP), Department of Agriculture-Cordillera Highlands and Agricultural Resource Management Project (DA-CHARMP) and Benguet State University. The leader of the community (barangay chairman), community organizers (DA-CHAMP field staff), and farmers were consulted and initial arrangement was agreed in the conduct of participatory mapping. Data preparation like sourcing of available base maps and primary data (RTC data) from the LGUs and DA was also done. The activities were in accordance with the Environmental Science for Social Change (ESSC) (1998) methodology. The community-mapping methodology involved seven phases, the first three phases of which were: (1) initial consultation with leaders and networking, (2) data preparation and (3) initial consultation with the community and site analysis.

The study used open source GIS (QGIS) to generate RTC area. In preparation to community mapping, Google® images were downloaded using the Google Image Downloader applications and printed in large tarpaulins. In addition, initial information on barangay location, existing school and other pertinent landmarks were gathered from wikimapia.org.

The fourth phase was the community mapping activity (ESSC, 1998), which was conducted in a friendly and open atmosphere. Wider representation of different sectors of the community was ensured such that community officials, farmer leaders, elders and women also participated. There were times when representatives from the municipal agriculture and municipal planning and development office, also joined as process observers. It was also ensured that all those involved in the mapping process would have a higher level of acceptance, a deep sense of ownership of the activity, and the commitment to bring the activity into fruition. The activity started with an introduction on the objective of the community mapping. However, due to language barrier, the Community Organizer interpreted in local dialect.

In the conduct of community mapping, the study added tools and processes from the traditional method. The traditional method starts with a ground map that is transferred to paper maps. However, this study used paper map, then transferred the information in large printed satellite Google images in tarpaulin. The satellite image gave technical value to community-drawn maps. The community was asked to draw in paper the households, streets, landmarks and the location of RTC areas. From the paper, the RTC areas were located in the satellite image. Chambers (2006) recommends doing both, by ground mapping first, then paper mapping after. With this method, no information is lost since when a ground map is transferred to a paper map the details are enriched.

According to Orban (2011), it is better to invite indigenous people to draw their perceptions and expectations on a blank sheet rather than start with a satellite image or an ancient map. Indeed, any pre-printed map/image may prevaricate their message. Even if the expert is tempted to gain time and money by providing the community a preprinted map/image, attention must be given in the possibility of reducing and limiting the impact of such a practice in terms of participation. The practice also proved that providing people a plastic blank sheet facilitated the transfer and digital encoding of data for future easy use within a GIS.

During the community mapping, it was observed that majority of the barangays did not have barangay map. The present barangay maps were sketches/drawings based on their perceived location of roads, rivers and sitios surrounded by mountainous areas. To prevent preemptive perception, the printed tarpaulin was shown to the participants after they have drawn the paper maps. The initial reaction of the people based on their mixed facial expression was that they cannot interpret the image and perceived it as an abstract picture. It was their first time to see a satellite image of their barangay. Thus, the satellite image was explained in layman terms, “as a picture taken from an airplane flying above their barangay”. From this perspective, the community was amazed and appreciated to see the whole barangay from the top view. From here, they start to approach and scrutinize the satellite image. The location of barangay hall, school, churches, road intersection and rivers that were previously located, including the present location of the mapping activity was pinpointed in the satellite image. Moreover, the community members were eager to locate their houses and their neighbors.

From the image, the community traced the roads, sitios, actual barangay boundary, landmarks and RTC areas from the paper map; however it took time for them to get oriented with the image in terms of direction and ground distance. One of the reasons was direction orientation or how they perceived the location of adjacent sitios. For instance, in their paper map Sitio A was situated at the left of Sitio B but in the satellite image, it was located at the bottom. Considering the mountainous and rugged terrain of the area, the direction of sunrise and sunset was the accurate reference used. According to

Orban (2010), the community expressed its views and perspectives by way of mental (cognitive) maps. In addition to this, there are other factors such as (1) actual barangay boundary was different from the reference boundary (http://www.gadm.org/) used in the study, (2) year of the Google image and the (3) image resolution which add difficulties to locate recently constructed structures and changes in the area (i.e. kaingin areas).

The study observed that there were dimensions of participatory mapping between the communities and GIS researchers. There was a specific dimension in people's cognitive maps of their community and the GIS researcher's technical maps. Figure 12 shows a comparison between community's sketch/paper map and GIS researcher's satellite image. Both have its own cognition and perception of different dimensions of mapping. Note that the community has an ethnographic classification or physical basis of common reference features in finding direction, scale (ground distance), landmarks, determination of boundaries (i.e. sitios), slope, soil type, cropping pattern and social aspect (database); i.e. who owns the farm; suitable crop planted. The GIS researchers put technical geospatial reference method of determining direction (northing), scale (map scale to ground distance), slope (contours), soil type (image classification), cropping pattern (temporal analysis) and database (data gathering and survey). The community cognitive map is rich in information that the GIS researcher can integrate to generate community map. This was done through participatory mapping. Since the value of a technically integrated community resource map is in the presence of community information in a technical reference, it is of great importance for a community to find their data on this hybrid map, which attempts to geolocate community-identified features onto a technical reference. The result is a community geographic information map as basis for planning and management decision-making.

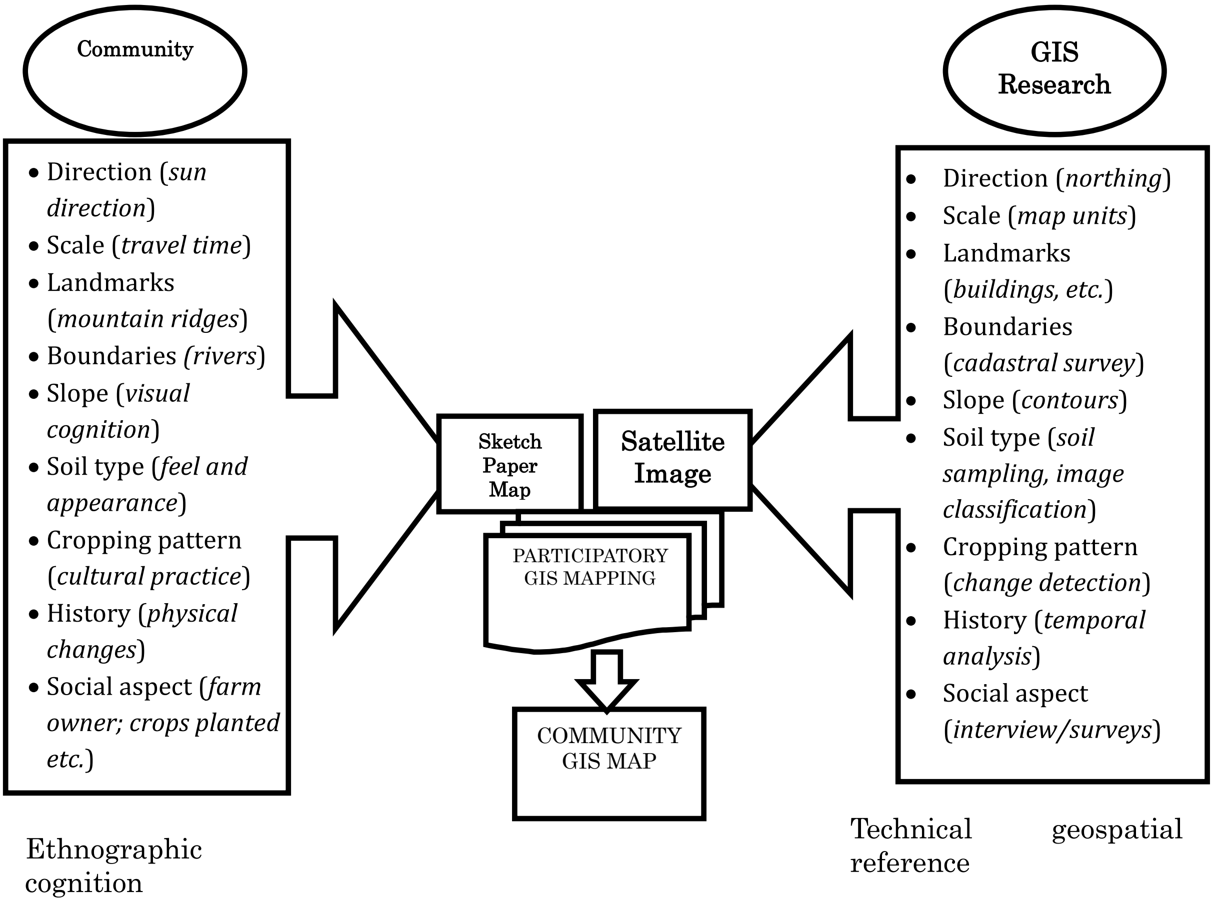

Figure 12. Dimensions of Participatory GIS

Familiarization with satellite images takes time. According to Rambaldi et al. (2002), the code of ethics for a good Participatory GIS (PGIS) practice is: "do not rush; be considerate in taking people' time". Hence, additional methodology was added in this study, such as the use of laptop and LCD to improve resolution of satellite image. However, it was limited to barangays with electricity. In some instances, the participants transferred the image posted from the wall to the floor to facilitate aligning the image in actual direction. In this method, road networks and RTC areas were drawn clearly. The list of RTC farmers was utilized to facilitate and complete the RTC area location. This activity coincided with database encoding of RTC while digitizing the RTC area.

The study observed that most of the participants in community mapping were women. Based from interviews with the locals, in the Benguet culture, women attend the meetings while men work in the farm. Moreover, planting RTC particularly sweet potato is a women's job.

Root and Tuber Crop Maps

The final map is not the be-all and end-all of a mapping activity, though it is also considered a significant output. Rambaldi et al. (2006), considered map making and the maps as a means or a practice, and not an end. The map itself is actually seen as just instrumental to the marriage between the scientific/technical knowledge and the indigenous knowledge toward a more holistic characterization of the environment and in coming up with more informed decisions in its management. The threads that link the two knowledge systems can be generated from the interaction between the researcher and the community.

The RTC map shows the location and distribution of RTC area in different locations in the barangay. Based from field verification, these were areas with high elevation, gentle slope and less irrigation. On the other hand, the areas with rolling slope, irrigated, and low lying, were for rice and vegetables cultivation.

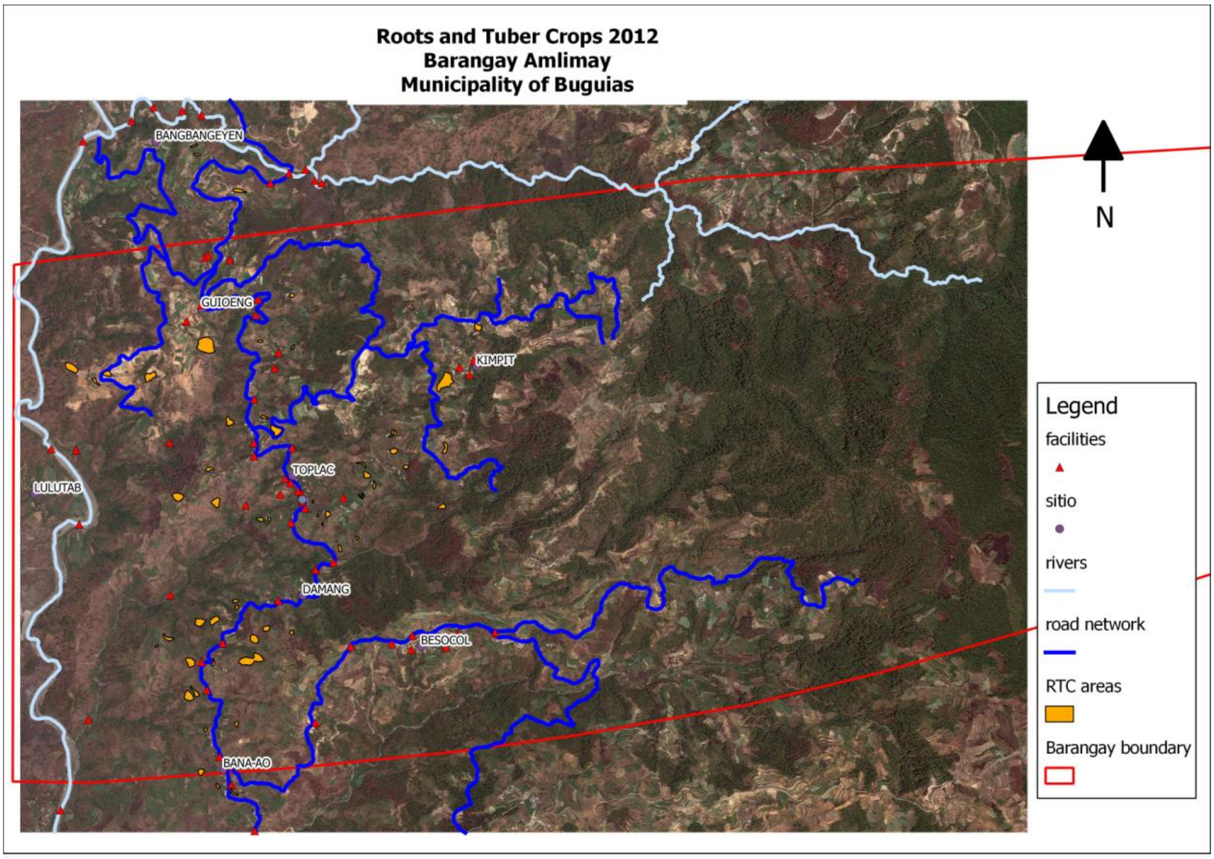

Figure 13. Barangay Amlimay RTC Map

Based from interview with the community, the areas identified for RTC practiced intercropping and crop rotation. In all the studied barangays, RTC especially sweet potatoes were intercropped with corn and vegetables, except in Amlimay (Buguias), Kayapa (Bakun) and Bayabas (Sablan). It was observed that the cropping pattern and size of the RTC area, sweet potato for instance, was relative to their culture.

During the interview conducted in 2013, some barangays such as Amlimay and Catlubong locals cooked sweet potato on special occasions such as weddings. In Ekip and Kayapa, it was considered as staple food. In these barangays, sweet potatoes were not considered as major commodity for trade unlike vegetables and potatoes. In Barangay Bayabas, ube or yam production was considered as a source of income. The farmers sell the yam produce to a monastery in Baguio City that makes processed yam products.

Based on the map, RTC production especially sweet potato is planted only in small areas as compared to the total productive areas of the barangays. Using the area determination function, the estimated and average area of RTC was computed (Table 2). However, the method was dependent on the resolution, date of the satellite image used and cognition of the farmers to identify their RTC area.

The small area planted to RTC depends on which crop gives high economic value, as compared with vegetable in the trading post. However, based on interview, farmers can easily shift their cropping pattern to RTC production if value adding will be done. Accordingly, it is cheaper to grow RTC due to less agricultural inputs needed, low incidence of insect infestation and pest attack, less labor intensive, can be planted throughout the year and less prone to typhoon damage and cold temperature.

Table 2. Tabulated Area Computation of Root and Tuber Crops from Participatory Mapping

Barangay	Total estimated RTC area Ha. (polygon area)	Ave. RTC area (sq.m.)
Amlimay	6.9	1,139
Ballay	25.75	6,439
Banengbeng	6.6	1,083
Bangao	8.44	1,407
Bayabas	18.44	2,795
Beleng-belis	12.42	3,550
Catlubong	5.27	1,599
Ekip	79	28,409
Gaswiling	31.58	6,192
Pudong	5.2	474
Poblacion	11.1	2,995

The PGIS process, because of its highly grounded nature on the actual farmers working the land, was validated by the GIS researchers at the local scale (ground-truthing). It had been observed that there was an inverse relationship between the technical accuracy of the output integrated maps and the RTC area based from farmers' estimate. It is clear from this example that the method has its limitations in terms of technical accuracy of area estimation, which is less likely to be technically acceptable. This is particularly understandable and true, as it was also observed that a garden or RTC area was composed of several parcels with different elevation.

CONCLUSION

The use of geographic information system (GIS) in identifying and monitoring root and tuber crops in selected Barangays in Cordillera Administrative Region, through participatory mapping approach was proven to be relevant. It provided a more scientific and responsive means in addressing barangay RTC information by creating a database structure and identifying the location of RTC area in the community through the participatory data and GIS maps generated. Besides determining the location of RTC area in the community it also presented information overlaying poverty and malnutrition. It also identified a list of priorities by cross tabulating malnutrition and poverty with RTC production or area. These show that GIS practice is an effective tool for planning and design of development intervention programs. It is a reliable basis for participatory decision-making on the part of major stakeholders' vis-à-vis the overall goal of poverty reduction in the community.

GIS becomes relevant in community development only if it is operationalized within a participatory framework. Its sustainability largely depends on the strength of collaborative engagement between the community and academic institutions and agencies, which have GIS technology and the will to make it participatory (PGIS), as well as the other stakeholders such as the business sector, NGOs and people's organizations.

The experiences of RTC mapping in 12 Barangays using PGIS showed how access to a technology-based system such as GIS can be democratized for the wider use of the public such as communities. It also showed how it can contribute to the process of strengthening democratic systems in the design and implementation of community development programs aimed at reducing the incidence of poverty, especially in poor marginalized rural communities.

The methodology for community mapping proved to be an effective way of engaging the community from the start to end in determining the RTC areas in the Barangay. It provided a lot of opportunities for the community members from the sitio level to be actively involved not only in the drawing of the map but also in interacting with the researcher and each other in field validation or map validation. The activity was also successful because of the active participation and support from the members of the barangay council, farmer leader, farmers, and other community mapping participants.

Community mapping helps to identify the location and distribution of RTC areas in the barangay. As compared with table data, the barangay RTC production was presented with location and relative distribution in the whole barangay boundary. The clustering and distribution of RTC areas with respect to road proximity and other support facilities such as road, tramline and multipurpose building was likewise identified. The maps can help planners to create a development plan and assess the needed infrastructure in the barangay.

Database facilitated the storage, querying and updating of farmers information relative to RTC production. Information such as historical pattern of RTC farmers, change of RTC area production, volume, variety preference and the potential area for expansion can also be processed.

Root and Tuber Crops production can significantly contribute in alleviating poverty in the community. The farmers' RTC productions are market driven, and partly cultural, however they are willing to expand their area. The cropping pattern can be changed favoring root crop if market increases and value adding will be done.

The study conducted a rapid estimate of RTC mapping applying community mapping approach and utilizing open source software and available satellite image from Google earth. Although this was an initial attempt at a technical integration of community resource maps, it gave acceptable outputs with community data being geolocated onto technical maps used by government in planning efforts. The output technically integrated community resource maps that served an important role in community-government dialogue in resource management. In future researches, it is suggested to conduct Barangay Resource Accounting using high resolution, updated satellite image and capacitate the community on the use of Global Positioning System (GPS). The accuracy of RTC location, extent of area, roads, facilities (school, barangay hall, households) and infrastructure (bridges) will be increased. Furthermore, linking the tables with the Community-Based Monitoring System (CBMS) data at the households' level (data) in terms of nutrition and poverty can be a valuable source of information. The use of geographic information system (GIS) in community development research such as in the case of poverty mapping is recommended. It provides a more scientific and responsive means in addressing poverty by identifying immediate and priority needs of the community through the participatory data and maps generated.

The output map of RTC when integrated with the community map was used for the preparation of a more comprehensive barangay development plan or business enterprise development. It also has practical uses for other sectors such as environment, water resources, nutrition, health, and addressing poverty problems. Indeed, the map did not just stay hung on the wall of the barangay hall as decoration. It served the people especially in barangay planning, implementing development projects, crafting policies and helping resolve issues affecting the community. This brought deep satisfaction to the researcher, knowing that many benefited from the process and the output of participatory GIS.

The impact of GIS community mapping generated different results for the community. Some barangays did not fully appreciate the tool. This can be attributed to the lack of awareness building and exposure to GIS of the community. However in other barangays, the process truly empowered them and facilitated their involvement in the process of map making. It gave them a sense of power, authority and control over their knowledge and aspirations for themselves and their community.

As GIS specialists, important lessons were gained, most especially in the need to truly focus on social relationships in the conduct of the process. The involvement of technical people must be confined in assisting the community in facilitating information and thus, can make no claim on authority or control. In terms of the programs, the sustainability of the program is dependent on the initiative of the community and so, planning tools must be consistent with their present needs and conditions. There was a great challenge in attaining the balance between technical soundness and social acceptability in all PGIS involvement of the technicians. The skill in creating this balance can only be gained through constant working with communities. It was also realized that PGIS as a technology will not be significant if the social perspective of the technician is not developed. As GIS technicians, also it is also important to learn to develop one's knowledge of social realities and dynamics in the study area.

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