The Effectiveness of Satellite Imagery Using GIS for Land Management and Administration in Myanmar

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Updating of cadastral maps were conducted using satellite image and the changes of ground features were observed in comparison with satellite image and ortho photo. The cadastral maps were evaluated on the basis of findings for effective land management and administration. The research tries to observe the effectiveness of satellite imagery using GIS for land management and administration in Myanmar.

***Key Words**: SLRD, GIS, Kwin Maps, Satellite Image, Ortho Photo*

1 Introduction

1-1 Introduction

The cadastral survey under Settlement and Land Records Department (SLRD) covered not only the agricultural land but also the town and village land across the country. Settlement and Land Records Department wants to increase information and easier access to all the cadastral maps and protocols through GIS technology in order to create an easy and effective usability for numerous applications, and especially for land management and administration. It has maintained all original cadastral map sheets for the agricultural land of most part of the country from its traditional cadastral survey since the establishment of the department in 1906. The cadastral maps and the corresponding parcel protocols are of great importance and interest to the peasants and farmers for their right to cultivate, the owners for their title and the employees of SLRD for the collection of agricultural statistics, and the management on land. These data describe the history of the landholder, the ownership, the course of the boundaries, and the land use type of all parcels. The cadastral maps are of three kinds depending on the scales. The cadastral survey at the scale of 1:3960 is for the agricultural land, 1:1980 for the mountainous areas of terraced cultivation and 1:990 for the block maps of town land. The sketch maps for the agricultural land are available to the public only for viewing, a copy of a specific location of the town land map are available to the persons concerned for the purposes of registration and property development through the form “LR 105” (LR= Land Records). The request for a copy of map has to be made according to the procedure, rules and directions.

1.2 Background

Settlement and Land Records Department was established in 1906. Large scale cadastral maps have since been produced for land management and administration. Manual survey methods with traditional surveying equipments were used to produce those maps to meet the requirements of the department. As the increased demand on the reliable and accurate information for land management and administration is urgent, the requirement on the updated maps is necessary. Settlement and Land Records Department has still to use traditional surveying equipments. It has currently been installed with modern equipments, Total Station Theodolite, GIS software Quantum GIS, work station computers and large format plotters. To successfully implement town land area expansion, village land area expansion and increase of agricultural production, it depends on good administration and management on land resources of Myanmar. Myanmar does not only enrich currently available land resources but also potential land resources to be explored. If Myanmar could apply modern technologies in land resources management, agricultural production of the country might be increased in near future. This research aims to set up advanced technology, Geographic Information System for a well set up mechanism in land management and administration.

The basic unit of data collection in Myanamr is a ***Kwin map***. A ***Kwin map*** is a cadastral survey unit which covers about 500 acres. The kwin map used in this research has a scale of 1:3960 which is produced for collection of agricultural land.

1-3 The History of Cadastral Survey and Mapping in Myanmar

In 1827 the British increased the collection of land revenue up to 10 baskets per acre. And then they collected the 20 percent of agricultural crop and the 25 percent of garden crops. Crop yield was estimated on the basis of agricultural implements and labour. The village head man collected land revenue, and got rupee 10 to 15 as their salary.

Land surveying started in 1826 for the purpose of collecting land revenue. In that year, Penan Governor came to Tanintharyi and discussed with the officials concerned on the prevailing rules and procedures and decided to conduct land surveying. According to the decision, the four military officers, Baker, Basis, Wilian and Bolderson (The actual spelling may be different because I translated these names from Myanmar into English) were sent to conduct land surveying. They were actually the first persons who carried out land surveying and settlement in Myanmar. However, Tanintharyi Division was transferred to India Government and land surveying was suspended for a time.

In 1842 the High Commissioner, colonel Bradford introduced land surveying by acre. After land surveying, land assessment was carried out by acre. The land revenue was rupee 2 to 5 per acre. In 1847 Sir Arthur Phalthar used "Kwin" as a basis of survey unit. So the term "Kwin" originated as the smallest survey unit. The land surveying system developed and the land assessment was carried out according to the land class, good, fair and poor. One rupee per acre was assessed for shifting cultivation, and two rupee per acre for other crops.

1-4 The purpose of land management

1-4-1 The Period of Ancient Myanmar Kings
The purpose is for collection of land revenue.

1-4-2 British Colonial Period
The purpose is for collection of land revenue.

1-4-3 The present-day activities
The primary purpose is for collection and compilation of agricultural statistics, and the secondary purpose is for collection of land revenue.

1-5. Problem Statement and Objectives

Settlement and Land Records Department has been carrying out collection and compilation of agricultural statistics. Manual survey methods have been used to produce large scale cadastral maps. SLRD has to prepare the timely report on the crop statistics. This requires updating of cadastral maps for the reliable and accurate information. As the basic element of the statistical system is cadastral maps, it is important the maps should be updated according to the changes of ground features. The Department is now transforming paper maps into digital forms and establish a geographic information system for compilation of agricultural production statistics. As the Department conducts exploration of new agricultural land, using geographic information system will be an advantage for exploring available land resources.

- To update them by using low altitude aerial photographs and available satellite images.

- To compile agricultural production statistics by application of Geographic Information System for a better land record and management system.
- To explore available land resources for agricultural purpose in remote areas of Myanmar.
- To raise land productivity by utilization of available land resources such as cultivable land, waste land and fallow land in Myanmar.

Thus the main objective of this thesis is to establish and evaluate an efficient method of updating of cadastral maps for effective land management and administration.

2. Methodology

Settlement and Land Records Department has maintained and continued to use large-scale cadastral maps for land management and administration for many decades.

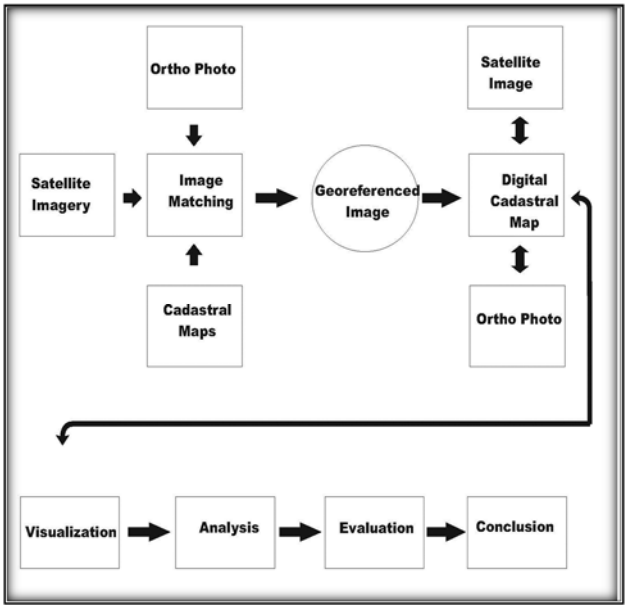


Figure_1 Structure of Processing

To transform paper maps into digital form and update them according to the changes of ground features, these maps need to be digitized (Figure 1).

Table_1 Basic Information about the data sets

Name	Satellite Imagery	Ortho Photo	Kwin 1661	Kwin 1664	Kwin 1651	Kwin 1650
Item Type	Tif File	Tif File	Tif File	Tif File	Tif File	Tif File
Year Acquired	2013	2001	2012	2012	2012	2012
Size	296 MB	171 MB	46.7 MB	53.5 MB	47.3 MB	182 MB
Dimension	10170*10172 px	11430*11395 px	9798*13240 px	9808*13240pxls	9804*13240px	13240*14470px

satellite image = 25km^2, scale = 1:57383 , Censor-GeoEye-1
aerial photo = 12.96 km^2, scale=1:50,000,Suntac Technologies

-production of digital cadastral maps (for the area of interest)
-conducting overlay operations to update ground features using digitized maps.
-processing of satellite image for updated land use and land cover information.
-creating a geo-information system for crop databases.
-conducting an analysis of ground features using digitized maps.
-evaluating the digitized maps on the basis of findings.

2.1 Geographical Location of Myanmar

Location

Latitudes - 9° 30′ to 28° 31′
Longitudes -92° 10′ to 101° 10′

Area

Total Land Area - 676,577 km^2
Length (North to South) - 2090 km
Maximum Width (West to East) - 805 km

Figure_2 the location of the research area

3. Results

3-1 Processing for image matching

The cadastral maps were scanned into Tiff files using a large scanner in the spatial analysis laboratory. Some places of distinguishing marks on the maps corresponding to the respective ortho photo and the satellite imagery were used to geo-reference the scanned images of cadastral maps. These were used as ground control points. These scanned maps were brought into ArcMap. The satellite image was projected into UTM coordinates during the preparation period of the intensive program in Asia Aero Survey Company. The ortho photo and cadastral maps are image-matched with satellite imagery for the purpose of necessary operation and analysis. So 1:50,000 maps are very important to the operation of transforming paper maps into digital form. The ortho photo was only used for this purpose, and it is not intended to produce topographic map. But the processing of aerial photo for an ortho photo was necessary for image matching, digitizing operation and georeferencing. This process was conducted during the intensive program. The scale of cadastral maps is 1:3,960. So georeferencing was conducted to get the accurate scale and location. Firstly the scanned images were geo-referenced through the overlay of the satellite imagery and ortho photo. The digitizing operation was conducted for the purpose of analysis of changes of ground features.

3-2 Building of necessary data sets

The required data for the research was collected from the Kan Oo village tract in the Pyinmana Township of Nay Pyi Taw, Myanmar. The satellite image, the Ortho photo and the four kwin maps were prepared for geoprocessing.

3-3 Georeferencing

Georeferencing started with the kwin number 1661. The locations on the kwin map corresponding to the respective locations on the base map were chosen and points were tied for image rectification. The other three kwin maps-1664,1651 and 1650 were also done similar to kwin number 1661.

Satellite Image

Figure-3 Kwin No 1661 after georeferencing

Ortho Photo

Figure-4 Kwin No 1661 after georeferencing

And then all the maps were checked for the accuracy of position. The distance on the kwin map and the distance on the digitized map were observed to compare the difference of the distance between the digitized map and the map done by manual procedure.

Figure-5 Distance check of kwin no 1661 (Satellite Image)

The difference in the first check between the digitized map and the scanned image is 7.2 meters according to the scale. So the percentage of the difference is 0.69%. The second check is 5.99 meters different. So it is 0.87% different.

Figure-6 Distance check of kwin no 1661 (Ortho photo)

The difference in the first check between the digitized map and the scanned image is 1.04 meters according to the scale. So the percentage of the difference is 0.10%. The second check is 3.47 meters different. So it is 0.50% different.

Kwin No `664

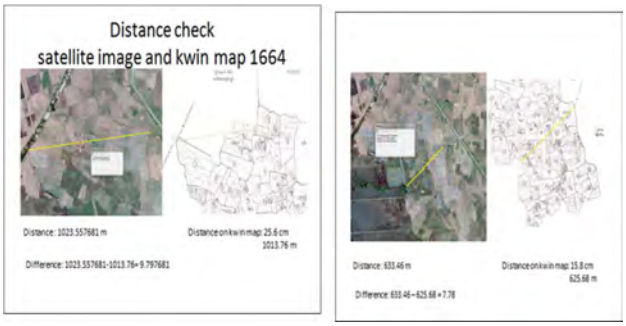


Figure-7 Distance Check of Kwin No 1664 (Satellite Image)

The difference in the first check between the digitized map and the scanned image is 9.79 meters according to the scale. So the percentage of the difference is 0.95%. The second check is 7.78 meters different. So it is 1.22% different.

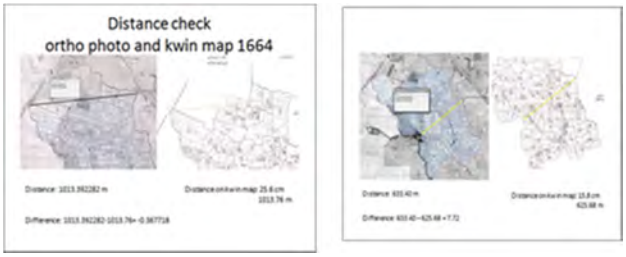


Figure-8 Distance Check of Kwin No 1664 (Ortho Photo)

The difference in the first check between the digitized map and the scanned image is 0.36 meters according to the scale. So the percentage of the difference is 0.03%. The second check is 7.72 meters different. So it is 1.21% different.

The Other kwin maps 1651 and 1650 are also checked in comparison with the satellite image and ortho photo, and it was found that the location was quite accurate. The results can be observed in the following.

Kwin 1651 (kwin map and satellite image)

The difference in the first check between the digitized map and the scanned image is 0.20 meters according to the scale. So the percentage of the difference is 0.02%. The second check is 0.76 meters different. So it is 0.09% different.

Kwin 1651 (kwin map and ortho photo)

The difference in the first check between the digitized map and the scanned image is 8.2 meters according to the scale. So the percentage of the difference is 1.12%. The second check is 2.06 meters different. So it is 0.26% different.

Kwin 1650 was checked as the same way to kwin 1651.

3-4 Visualization of Kwin Map, Ortho Photo and Satellite Images

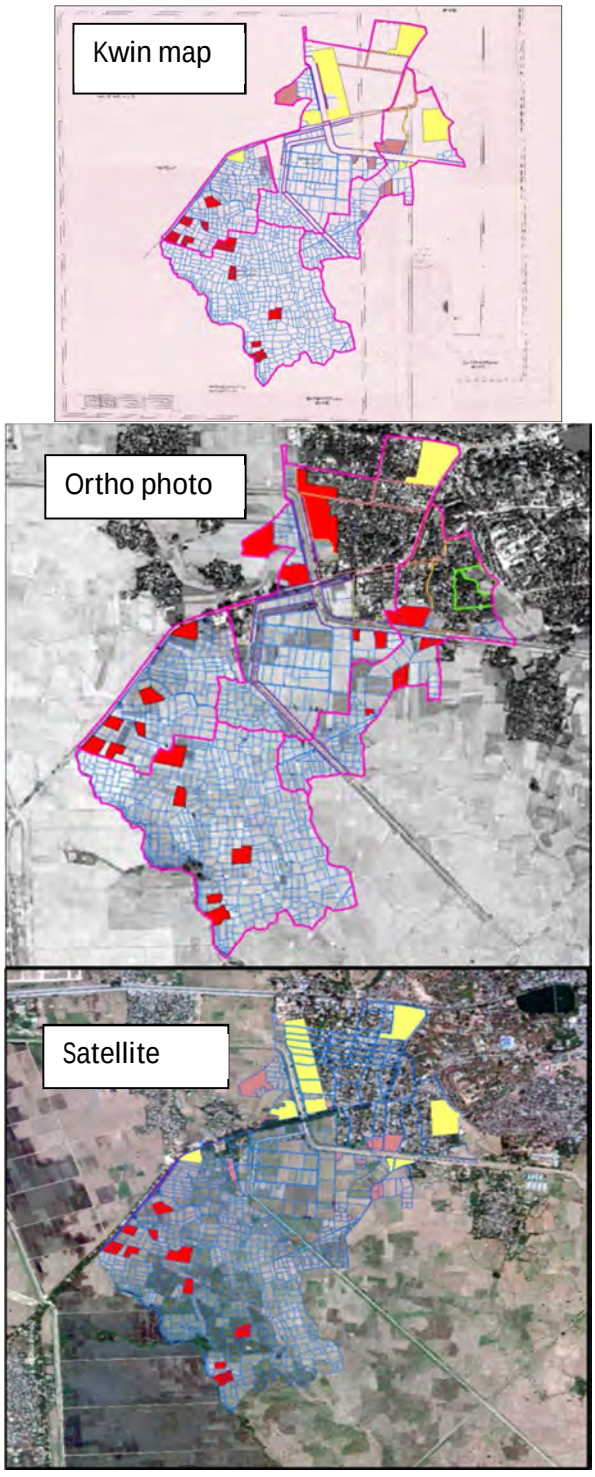


Figure_9 visualization of kwin map, ortho photo and satellite image

The georeferenced kwin maps, ortho photo and satellite image were visualized, and through these images, we can observe the differences. in figure 2, the red represents agricultural land, the yellow the residential land and the dark red the other uses of the land.

3-5 Analysis of Changes

The boundary parcel features were compared between the digitized cadastral map and the ortho photo and the satellite imagery.

According to the time series data, the parcel boundary features were highly significant between the cadastral map and the Ortho photo. The parcel boundary features between the cadastral map and satellite imagery were also highly significant. It was also found between the Ortho photo and the satellite imagery. The five locations of each cadastral map which were highly significant were randomly checked. The highly significant parcels were shown in red circles in the images. The cadastral maps were updated according to the changes of ground features.

All parcels of each kwin map were checked to be able to calculate the percentage of the parcel changes of ground features for each kwin map. In figure 10, the left image is kwin map and the right image is the digitized map of satellite image. Apart from the significant five locations, all other parcels were checked, and the parcels of difference were highlighted. In figure 11, the left image is kwin map and the right image is the digitized map of ortho photo.

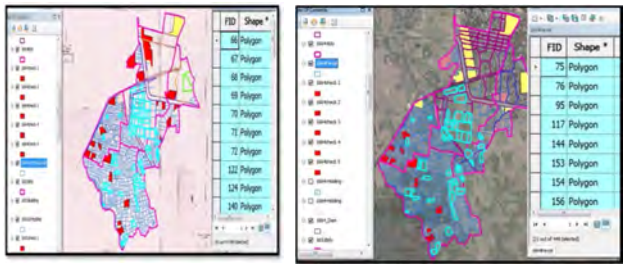


Figure_10 comparison of changes between kwin map and satellite image

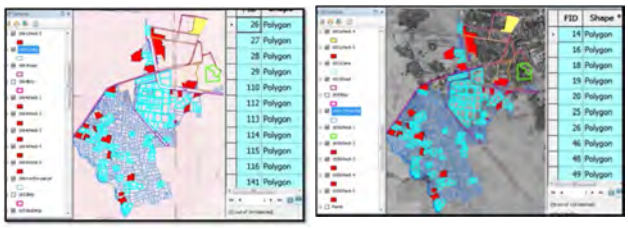


Figure_11 comparison of changes between kwin map and ortho photo

Table 2 . Percentage of changes of ground features

kwin map number	total number of parcels	number of parcels changed compared to Ortho Photo	number of parcels changed compared to Satellite Image	percentage of change compared to Ortho Photo	percentage of change compared to Satellite Image
1661	194	36	11	18.56%	5.67%
1664	500	75	47	15%	9.4%
1651	155	65	42	41.94%	27.09 %
1650	134	34	24	25.37%	17.91 %

The above table is the percentage of changes of ground features of each kwin map including the significant five locations. The first column is the kwin number for each kwin map. The second column represents the total number of parcels of each kwin map. The third column shows the number of parcels changed for each kwin map compared to Ortho Photo. The fourth column indicates the number of parcels changed compared to Satellite Image. The fifth column calculates the percentage of change of ground features of each kwin map compared to Ortho Photo. The sixth column shows the percentage of changes of ground features of each kwin map compared to Satellite Image.

In figure 10, the highlighted parcels show the changes of ground feature between Kwin map and satellite image. In kwin 1661, the total number of parcels is 194. The number of parcels changed compared to satellite image is 11. So it is 5.67%. So also kwin 1664 is 9.4%, kwin 1651 is 27.09% and kwin 1650 is 17.91% respectively as is shown in table 1.

In figure 11, the highlighted parcels show the changes of ground feature between Kwin map and Ortho photo. In kwin 1661, the total number of parcels is 194. The number of parcels changed compared to Ortho photo is 36. So it is 18.56%. So also kwin 1664 is 15%. Kwin 1651 is 41.94% and kwin 1650 is 25.37% respectively as is shown in table 2.

From technical point of view, the resolution of satellite image is higher than the resolution of ortho photo. So the digitizing operation is easier in satellite imagery than in ortho photo. The changes of parcel boundary features can also be clearly observed in satellite image. The parcel boundary features are not quite clear in ortho photo. As a result, it is very difficult to precisely digitize the accurate parcel boundary to be able to compare the existing kwin maps.

Due to the high resolution, the digitizing operation can be easily done with satellite imagery. As a result, the existing kwin maps can be updated easily to get the information on land use status. The parcel boundary features can be checked easily whether it is merged or split or changed. The land utilization statistics can be analyzed for effective land management and administration. The manual procedures which is a burden for data processing can be replaced by geographic information system using satellite imagery.

Table 3. The Change Pattern of Ground Features between Kwin Map and Ortho Photo Compared to Satellite Image focusing on the significant five locations

Kwin No	Parcel Check No	Parcel No	No Change		Merge		Split		Land Use Change	
			Kwin Map	Ortho Photo	Kwin Map	Ortho Photo	Kwin Map	Ortho Photo	Kwin Map	Ortho Photo
1661	1	102								
	2	13								
	3	124,145, 148								
	4	163								
	5	6								
1664	1	152								
	2	415								
	3	399								
	4	74								
	5	304								
1651	1	193								
	2	201								
	3	180								
	4	131								
	5	223,225								
1650	1	3								
	2	11								
	3	19								
	4	35								
	5	53								

Merge **No Change**

Split **Land Use Change**

As can be seen in table 2, the percentage of change compared to Ortho photo is much higher than that compared to satellite image. This is because the Ortho photo is produced in 2001 , the satellite image is created in 2013 whereas the cadastral maps were created in 2012 according to the time series data. So it will be highly significant between Ortho photo and satellite image when compared to the cadastral kwin maps.

In the table 3, the first column describes each kwin number. The second column shows the parcel check number of each kwin. In the third column, the parcel number of each kwin checked are entered according to the parcel check number.

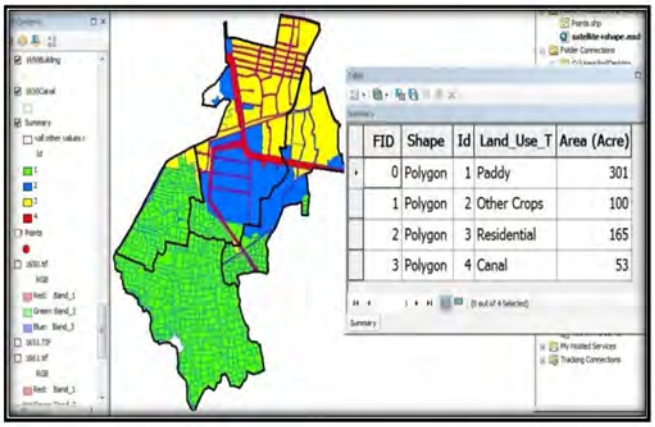
There are a lot of merged area in kwin map rather than Ortho photo when compared to satellite image. A lot of split parcels occur in Ortho photo. Land use change occurs mostly in Ortho photo.

In the columns of no change, merge, split and land use change, the ground features of kwin maps and ortho photo were observed compared to satellite image.

Each column for parcel feature includes kwin map and ortho .

4. Evaluation

This paper presents how to update the cadastral maps, transforming paper maps into digital forms. The area of Pyinmana in Nay Pyi Taw was chosen for data collection. The four kwins of cadastral maps were digitized, and compared to the geographic features of Ortho Photo and Satellite Imagery of the same location. The four kwin maps produced in 2012-2013 were used for digitalization, and the Ortho photo of 2001-2002 and the satellite image of 2013-2014 were processed to be able to make a comparative study for the changes of ground features. According to the time series data, there is highly significance between the Ortho photo and kwin maps or satellite image. It is also significant between the kwin map and the satellite image. The research shows that the residential area or urban area increased over time. In some places, the agricultural area has



FID	Shape	Id	Land_Use_T	Area (Acre)
0	Polygon	1	Paddy	301
1	Polygon	2	Other Crops	100
2	Polygon	3	Residential	165
3	Polygon	4	Canal	53

Figure 12 Land Use Map

been used for other purposes. Parcel boundaries have changed greatly in Kwin 1661 and Kwin 1664. The residential area has dramatically increased in Kwin 1651 and Kwin 1650.

The figure 12 shows the total area of all four kwin maps by land use type; paddy, other crops, residential and canal land.

Figure 13 is updated kwin map after analysis of the changes of ground feature. The green colour represents paddy land. The blue represents land of other crops. The yellow represents the residential land and the red represents canal land. It is described in detail in figure 13.

The cadastral maps need to be updated according to the changes of ground features. Data structuralization is required for the changes of parcel boundaries. The existing cadastral maps can be used for digitizing operations. The parcel boundary change was clearly visible in the satellite image.

The area by land use type can be observed on the map. The land utilization statistics can be known by land use type. Land management by land use type can be easily conducted for various purposes.

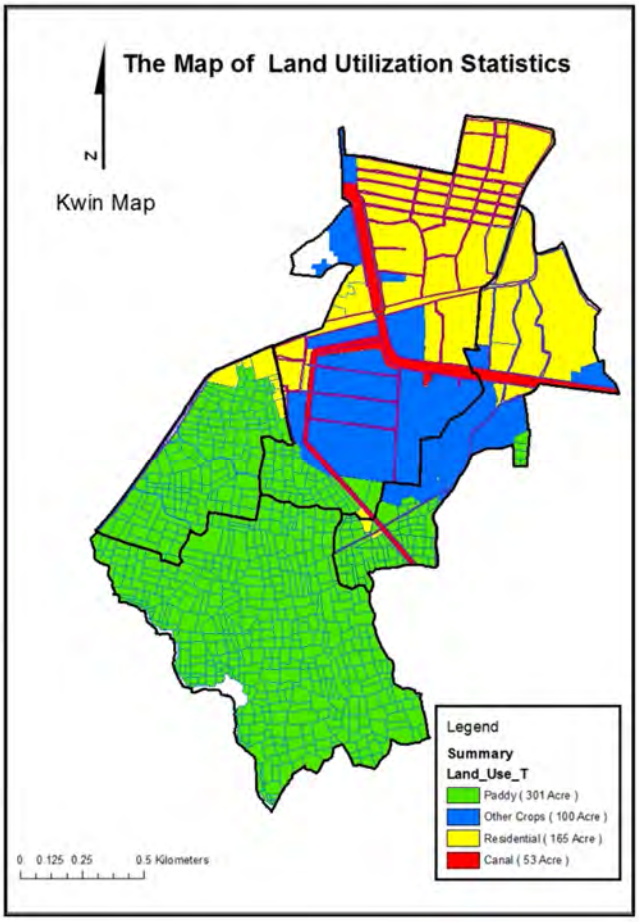


Figure-13 Updated Land Use Map

In the figure 13, the crop growing area was analysed to be able to know the land utilization statistics. According to the analysis, the paddy area was 301 acre. The area of other crops was 100 acre. The residential area was 165 acre. The canal area was 53 acre. These statistics can be provided to policy makers for the agricultural area expansion or regional planning or urban planning for effective land management and administration.

5. Conclusion

SLRD's main responsibility involves in the two systems:
1 Agricultural Statistical System
2 Land Management and Registration System

-Agricultural Statistical System

Agricultural Statistical System includes information on annual crop production statistics such as planted area, harvested area, yield and production for all kinds of crops, irrigated area and

irrigable area for each type of irrigation and protected area by embankments.

-Land Registration System
Land registration system includes land utilization information by land use type, town land registration and registration of deeds for transferring immoveable properties. Assessment of land tax and water tax for irrigated areas. Support to policy makers in management of land resources.

It is very important to update cadastral maps to carry out these two systems effectively for land management and administration. The research shows the effectiveness of satellite imagery to successfully conduct updating of cadastral maps and the system of digita cadastre.

According to the analysis of ground features using digitized maps with satellite imagery, the satellite images play an important role in updating of cadastral maps. The use of time series data shows that the updated satellite images are required for digitalization of cadastral maps as can be seen the changes of ground features in this analysis. Manual procedures which are a burden to updating of cadastral maps can be replaced by the modern technology for effective land management and administration. The updating of cadastral maps is faster and much more effective by using the satellite images.

According to the comparative study between kwin map, ortho photo and satellite imagery, the ground feature changes can be clearly observed. The residential area dramatically increased over time. The analysis of time series data indicates that many

acres of agricultural land will definitely be replaced by the residential area in the next ten years. Data structuralization as well as the updated maps is required to get the accurate

information on land both for the purposes of collection of agricultural statistics and land revenue. This clearly shows that the digitized maps using satellite images should be created on the basis of existing kwin maps in order to update and observe the changes of ground features. On the other hand the research shows the usefulness of the existing kwin maps in transforming paper maps into digital form, and the importance of these maps in realization of updating of cadastral maps and creating crop databases for an effective land management and administration.

The Department will be able to establish a geo-information system for crop databases as well as updating of cadastral maps, thus helping to maintain a complete coverage of maps for a better land management and administration. . The Department can strengthen the statistical capability for the offices at all levels in data collection, processing, analysis and dissemination. The Department can utilize geo-information system for the timely and reliable statistics to data users, planners and policy makers. Integration of geo-information system with the conventional collection of field data will provide the required information for planning the appropriate strategy for development of the country. Geographical information system will greatly enhance the capabilities of mapping and monitoring of crops and land utilization statistics. Outcome of better land resources management system can be expected.

By transforming paper maps into digital form, the analysis of land utilization statistics will become easy. The cadastral maps and registers will be integrated, and it will not be time-consuming to search maps and registers. In the traditional system, the maps and registers are separated each other. Updating of cadastral maps is difficult. In the digital cadastre, updating of cadastral maps are easy. Data processing will be faster.

It is expected that the digitized maps using satellite imagery and the associated databases will be used widely and effectively for planning various development plans, contributing to the development of Myanmar.

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