

USE OF GIS IN CENSUS MANAGEMENT AND MAPPING: THE KENYAN EXPERIENCE
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By

JOSEPH NYANGAYA NDUBI

MINISTRY OF PLANNING AND NATIONAL DEVELOPMENT
KENYA NATIONAL BUREAU OF STATISTICS, P.O BOX 30266-00100, NAIROBI, KENYA
E-mail: nyangaya_j@yahoo.com

Introduction

The history of census taking in Kenya dates back to 1948 when the first population census was held. The subsequent censuses were held in 1962, 1969, 1979, 1989 and 1999. From 1969 to date, the censuses have been held during every ten years. The last of these decennial censuses was held in 1999.

The country is organized into 5 hierarchical levels of administration ranging from provinces, divisions, locations and sub locations. Provinces are large areas and are equivalent to regions whereas sub locations are the smallest administrative units. Villages are found within the sub locations and they are the units upon which the Enumeration Areas are based. The census maps are prepared based on sub locations. Thus a map is prepared for each sub location and the map carries all the villages and therefore all the Eas in the sub location.

Maps to facilitate a census in Kenya, and which were largely at small and medium scales were first used in the 1969 census. At those scales, the maps were suitable for that census since the country's population then was low. However in the subsequent censuses of 1979, 1989 and 1999, the population had increased quite substantially and there was a need to provide maps at medium and large scales to cover the rural parts of the high agricultural potential areas mainly found in Central, Western some parts of Eastern and Coastal regions. The semi arid North and North Eastern parts of the country, which are sparsely populated could adequately be covered by the 1: 250,000 topographical maps. This scenario will again apply during the current mapping for the 2009 population census.

Maps have proved to be indispensable products in conducting population censuses since they will ensure completeness of the coverage throughout the country and eliminate the possibility of double coverage of the population. Maps will also:

- a) Assist to delineate the country into small manageable counting units or Enumeration Areas (Eas)
- b) Facilitate in assigning areas of counting to enumerators during the census
- c) Enable the enumerators to plan their movement within the EA and identify households earmarked for call-backs especially in the urban areas
- d) Enable effective supervision
- e) Help in determining the personnel, materials and logistical requirements (budgeting)
- f) Help in presenting the results of a census

During the 1999 population census, there was a major shift during the mapping process when the country decided to adopt GIS technology to prepare and produce maps to facilitate that year's census taking. The GIS products were also to be used to disseminate the census results. The project however was not very successful due to various factors mentioned below. The facility could not produce maps for the whole country in time to enable the taking of the census - only about 40% of the maps were produced by the system whereas about 60% had to be drawn using traditional methods.

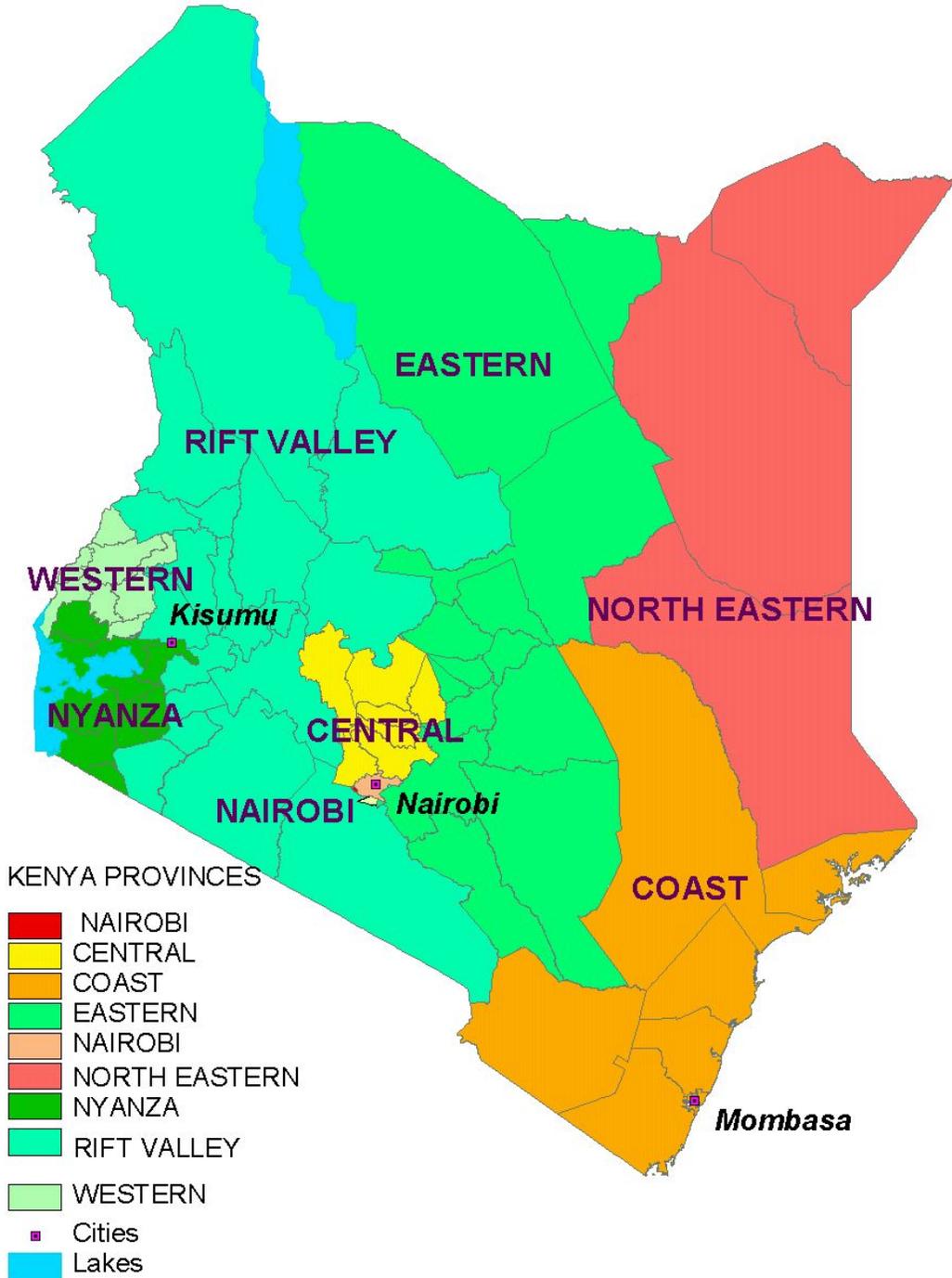
The cartographic mapping for the 2009 population census in Kenya is earmarked to be accomplished fully in GIS. Great effort has therefore been made to address and overcome the constraints which affected the project in 1999. Some of these constraints are:

- a) Late acquisition and installation of the GIS facility
- b) Inadequate software user licenses
- c) Poor maintenance of the GIS facility
- d) High cost of maintenance service contract
- e) Lack of adequate personnel with appropriate skills

Having drawn from the experiences of the 1999 census, there is great optimism that the current cartographic mapping for 2009 will be fully achieved using the GIS and the output products will be of much higher quality. And to this end, the Kenyan government with the support of the development partners (the USAID, DFID, UNFPA) have continued to provide resources to support the project and make it a success.

The collection of social economic statistics in Kenya and conducting of national censuses and sample surveys are carried out under the statistics act of the country's laws. The Kenya National Bureau of Statistics (KNBS) is mandated to be the official custodian of all the statistical information in the country and is therefore the organization charged with the responsibility of carrying out censuses and sample surveys.

KENYA: Administrative Provinces



THE 2009 POPULATION AND HOUSING CENSUS

In planning for the 2009 Kenya Population and Housing Census, a lot of experience has been drawn from the previous censuses. Consideration for training of the personnel, requirements of materials and equipment and the overall budgeting was done making close references to the 1999 census. Considering the challenges faced in mapping the urban areas with inadequate base map resources, a decision had to be taken early enough to incorporate usage of modern geo-spatial technology to overcome the challenges.

The Geographic Frame

As in the previous censuses, the results of the 2009 census will be reported based on the country's hierarchical administrative structure, which ranges from provinces, divisions, locations and sub locations. As reported earlier, the provinces are large regional entities whereas sub locations are the smallest administrative units. The census results are therefore usually published based on the above structure although the processed data is at EA levels. The unpublished data at EA/Village level can be accessed by the users from the KNBS offices. It is therefore important that during the mapping process, a complete inventory of all the administrative areas together with the villages and enumeration areas is compiled. The areas are then assigned unique identifiers or geographical codes which are latter used during data processing, in tracking and cross checking of the census records.

Due to rapid changes in population growth, the government continuously reviews the sizes of the administrative units and subdivides them to ease administration and improve service delivery to the citizenry. It is therefore necessary that during the mapping for census, these changes are captured and the census geographic frame updated accordingly. The updating of the administrative areas is done with the assistance of the provincial administration officials who administer their respective units. The sub location is the focal point during the exercise, and the assistant chief assisted by the village elders/estate chairmen plays a crucial role in providing the information about the changes as well as showing the boundaries of the villages and the enumeration areas. The table below shows the changes that have taken place in the last four censuses. In the 2009 census, number of Eas is expected to rise to about 100,000.

Table 1. Changes in the number of administrative units in the last four censuses

Administrative Units	Administrator	Number of Administrative Units and Eas			
		1969	1979	1989	1999
Kenya	President	1	1	1	1
Provinces	Provincial Commissioner	8	8	8	8
Districts	District Commissioner	41	41	45	69
Divisions	District Officer	154	184	260	497
Locations	Chief	567	618	1,099	2,427
Sub Locations	Assistant Chief	2,410	3,111	3,553	6,612
Enumeration Areas		20,000	25,000	36,979	61,921

Geographic Coding

This is a process of assigning unique identifiers or codes to all the administrative units and enumeration areas in the country during census mapping to help in census management. The geo-codes are particularly useful during data processing in tracking and cross checking of census records. After the tabulation of census results, the geo-code makes it easy to retrieve, analyze and manipulate data. It is therefore important to ensure that the geo-coding is done carefully and is sound.

Fig 3. Geo-coding for the 2009 census is done based on the frame shown below

Administrative Unit	No of Digits
Province	2
District	2
Division	2
Location	2
Sub Location	2
EA	4
Total	14

Sample code for one peri urban EA

Administrative Unit	Codes
Nyanza	06
Bondo	02
Maranda	01
Bondo Township	01
Ajigo	01
Misinjiro	0043
Complete EA code	06020101010043

PREPARATORY ACTIVITIES FOR THE 2009 KENYA POPULATION AND HOUSING CENSUS

Overall Planning:

The preparatory activities for the 2009 Kenya Population and housing census started by preparing a 2009 census project proposal paper that gave a summary of activities which will lead to the conduct and the production of outputs from that census. The proposal paper deals with issues of the overall census management and preparatory tasks, the enumeration phase, the post enumeration phase, quality assurance, the budget and the work plan. The paper also deals with the creation of various offices and committees to manage the whole census process. The paper was presented to the government and approved in July 2006 for implementation.

Planning for the cartographic census mapping

The government of Kenya has recognized the fact that the cartographic field mapping for the 2009 population census is a key activity, which if properly implemented will ensure the success of the census. Measures have therefore been put in place to enable a successful completion of the exercise that was launched in March this year following a pilot mapping which had been conducted in November 2006 in Kisumu, western Kenya. The following activities have been carried out in readiness for the exercise.

Procurement of materials and equipment

Early in the planning stages for the 2009 census, it was realized that there existed lots of materials and equipment from the past censuses within the cartography/GIS section. Some of the materials and equipment could be salvaged and used for the coming census. An inventory therefore had to be done of all the available materials and equipment and ascertain their conditions. Then a final list of the required materials was compiled together with a budget for their procurement. The list of the required items included the following:

1. 4 wheel drive Vehicles
2. Computers
3. GPSs
4. Upgrading of the ArcGIS software
5. printers – Large formats
- Medium size format
6. Map Storage Cabinets
7. Scanners
8. Topographical maps
9. Satellite/Aerial photographs
10. Stationery
11. Field gear (Boots, Tshirts and rain coats)
12. File servers

From the above list, some of the items have been procured whereas others have not. Those that been procured include:

- Computers
- GPSs
- Topographical maps
- Satellite Images (for a few towns)
- Upgrade of the ArcGIS software
- Stationery
- Printers (one has procured)

And the following items have not been procured:

- Scanners
- Vehicles
- Satellite Images (for majority of towns)
- Map storage cabinets
- Printers (some)
- File Servers

Problems encountered in procurement of the above items.

The above items have not been procured because of:

- 1) Late disbursement of funds
- 2) Bureaucracy in the procurement process

USE OF GIS AND GEO-SPATIAL TECHNOLOGY IN MANAGING AND MAPPING FOR THE 2009 CENSUS

A review of digital mapping in the 1999 census was done to assess the strengths and weaknesses of the system. It was realized that it had not been possible to produce all maps for census as it had been envisaged because of the following constraints:

- f) Late acquisition and installation of the GIS facility
- g) Inadequate software user licenses
- h) Poor maintenance of the GIS facility
- i) High cost of maintenance service contract
- j) Lack of adequate personnel with appropriate skills

However it was realized that if well managed the GIS technology has great potential in offering solutions to the problems caused by lack of current base maps with suitable scales to map both rural and urban areas. With the technology, it is possible to incorporate the satellite images, aerial photographs and GPS in the mapping process. These products easily overcome the problems constraining conventional base maps.

To address the above shortcomings and ensure that use of the technology is executed smoothly and efficiently, the following has been put in place:

Training

Arrangements have been made to offer sufficient training to the personnel in the section. Eight staff members have already had training in cartography and GIS in our local training institutions. In addition, a local firm, who are representatives of Esri, the suppliers of ArcGIS software in the Eastern African Region are also already on board to offer in house training on the use of the upgraded ArcGIS 9.2 to the members of staff in the section.

Upgrading of the GIS facility

The GIS facility in the department was established in 1997 and had not been upgraded since 2002. Through a recent initiative, the facility has been supplied with 12 new computers, a modern plotter and the ArcGIS 8.2 mapping software has been upgraded to version 9.2 with over 12 licenses. A bigger file server has also been acquired. But still optimum number computers and user licenses of 25 has not been achieved.

Maintenance and service contract with Oaker Services

KNBS has secured a maintenance and service contract with the local suppliers of the ArcGIS software – Oaker Services and this will ensure that the system runs smoothly.

Use of Satellite images, Aerial Photographs and GPS

Mapping for censuses in Kenya has always relied on the topographical maps provided by the Survey of Kenya (SoK) who are our national mapping Agency. Whilst census undertaking requires maps that are suitable in terms of scales and currency so as to enable delineation of Eas even in heavily settled areas, the available maps do not always meet these requirements. However Kenya is one of the countries in the world with huge urban slums which require very large scale maps if they have to be adequately mapped. To address this problem, census mapping for the 2009 census is making use of modern GIS tools such as

- Satellite images
- Aerial Photographs
- And GPSs

SOK has also produced a digital map of Nairobi City in 2004 using aerial photography acquired in 2003. But given that census will be done in 2009, the digital map will be more than 6 years old and it will need to be supplemented with data from the sources mentioned above to make it more useful in mapping areas where changes in settlement patterns take place quite rapidly.

Preparation of census mapping Instruments

Five Mapping manuals were prepared prior to the launching of the cartographic mapping exercise. The manuals will be used by the mapping teams to provide guidelines in cartographic field mapping and in the preparation and production of the final EA maps. The manuals completed in September, 2006 are as follows:

- Cartographic Field Mapping Manual
- Manual on use of GPS, Satellite Images and Aerial Photographs in Census Mapping
- Manual on Editing of Census maps, Control Forms and generation of Area Geographical Codes.
- Manual on Preparation and production of Census maps

Training for mapping assistants and Launch of 2009 pilot census mapping

A training session was mounted for Mapping Assistants in Kisumu City, which lies in Western Kenya, in early October 2006. The training session which lasted for one week was to induct the 50 mapping assistants who had been selected from all the KNBS field offices into census field mapping process. The District Statistical Officers who will be coordinating the exercise in their respective areas also attended the session. The training was one of the strategies designed to improve quality in the mapping process and a successful census.

After the training, a pilot in census mapping was immediately launched in the lake side of Kisumu. The pilot mapping was to test the suitability of the mapping manuals, the base maps which had been acquired from various sources, the applicability of the quick Bird Satellite Image in slum mapping and the use of GPS in aligning boundaries and picking the positions of major land mark features and updating the old topographical maps.

The results from this exercise were quite impressive. The mapping teams were able to produce better maps for the whole of Kisumu District. The city has quite expansive slums covering Nyalenda, Migosi, Manyatta, Nyawita and Obunga. The teams were able to map all these areas and come up with Eas of average sizes as expected with Households ranging from 49 – 150. This was possible because the satellite image used was fairly recent (2004) and at large scales of at least 1: 1000. At this scale, one could easily locate tiny structures measuring about 10 by 10 feet.

From the results of the pilot, it was recommended that modern geo-spatial tools mentioned above be used extensively through out the country carrying out the 2009 census mapping. Arrangements are now under way to acquire satellite images or aerial photography covering all the urban areas to facilitate the mapping.

CARTOGRAPHIC FIELD MAPPING

Composition of mapping teams

In early March 2006, a training session was held in Kisumu City, Western Kenya on census mapping and it involved the senior members of the department, the cartography/GIS staff and 50 mapping assistants who had been selected from the department's field offices. After the training, nine mapping teams were composed, each comprising of a team leader, an assistant team leader and four mapping assistants. The fieldwork is assigned to teams on basis of districts and each team is wholly responsible for all the work within their district. This strategy is meant to eliminate or minimize problems arising from mismatches along common boundaries of areas being done by different teams. However large cities and municipalities which require structure listing and are more involving because of the high population and the presence of slums, are tackled by a combination of many teams.

The Concept of Household and Structure Listing

The concepts of household and structure listing mooted in the 1989 population as a basis for creating Eas, and again used during the 1999 census will continue being used in the current census mapping. In this concepts, for the rural areas, house hold listing forms are sent to the administrators of the sub locations in advance, who with the help of the village administrators prepare a list of all the house holds resident in each village. The lists are then used latter by the mapping teams when they visit the sub location to map the Eas. Each EA should have between 49 and 150 households. And in the urban areas, the mapping teams accompanied by the village elders/chairmen visit every structure within the village or a residential estate to establish the resident households and then create Eas based on the above household range. In the two last censuses (1989 and 1999), these concepts proved to be very useful in determining the desired size of Eas. It is for this reason that the concepts are still being used in the current mapping exercise.

Mapping Rural Areas

The administrative structure indicated above provides a frame for carrying out census field mapping both for rural and urban areas through out the country. The mapping teams visit every sub location, having briefed the higher hierarchs of the provincial administration and carry out the mapping by updating the sub location boundary, marking the village boundaries and then creating the enumeration areas in reference to the household listings done earlier by the area assistant chief assisted by the village elders. As mentioned earlier, in both urban and rural areas, each EA will have an average of 100 households (they will range between 49 and 150 households). The boundaries of the sub location, the village and the enumeration areas are clearly marked on the base maps. The base maps being used are topographical sheets from our national mapping agency, The Survey of Kenya, the previous census maps, the urban topo cadastral and town development plans. Where boundaries do not follow well defined features e.g. rivers, roads, tracks or footpaths, GPS is used to capture the boundaries which will latter be transferred to the base maps or incorporated into the digitized shape files of features and boundaries.

Numbering of EAs

Once the team leader is certified that the mapping of the sub location is completed, he or she assigns EA numbers to all the Eas in the sub location in a clock wise and systematic format starting from the top right hand corner. This procedure of EA numbering is applied in all categories of Eas both in rural and urban. The EA number written on the map manuscript is a four-figure number the fourth digit being the EA type. There are three EA types: 1 for a rural EA, 2 for a pure urban EA and 3 for a peri-urban EA. Thus the fourth EA that falls in a pure urban setting will be numbered as 0042.

Mapping of slums areas

In the previous censuses, mapping of slums in Kenya has not been done satisfactorily because of lack of suitable maps. Mapping of slums require current and large scale maps since the areas densely populated and experience rapid changes in settlement patterns. Such maps however cannot be availed by our national mapping agency. It has therefore been difficult to provide accurate data on slums to the users. During the current mapping, satellite images, aerial photographs and GPSs are being used to address this problem. The

Geo-coding has been designed so that all the slums can easily identified and their populations aggregated. Informal settlements (slums) are assigned digit 4 and formal settlements 9. These two digit codes are not indicated on the maps but they are recorded on the EA summary forms and in the database of the geo codes.

Integrating the political and administrative boundaries.

Also lacking in the previous census mapping was a way of integrating political and administrative areas because the two do not always conform. In this current exercise, the mapping teams are collecting information on wards and constituencies and mapping them accordingly. These entities will also be assigned codes but again the codes will not appear on the maps but they will be kept in geo-code database.

Mapping Urban Areas

As in the rural areas, the mapping teams will follow the same procedure and finally map either the village or the residential estate. Accompanied by the village elder/estate chairman, they will visit every structure in the mapped area to establish the number of households residing there in and create the EAs accordingly. Again as in the rural areas, each EA will have an average of 100 households (they will range between 49 and 150 households). The boundaries of the sub location, the village and the enumeration areas will clearly be marked on the base maps which will include satellite images and aerial photographs. Again where boundaries do not follow well defined features e.g. rivers, roads, tracks or footpaths, GPS is used to capture the boundaries which will latter be transferred to the base maps or incorporated into the digitized shape files. In addition to marking the boundaries on the imageries, all the visited structures are assigned numbers on a serial sequence. The same numbers are marked on the gates or doors of buildings/structures visited and written on the prescribed forms with the accompanying household sizes indicated. This makes it possible for an aggregate of households in each area to be done.

Mapping of Arid and Semi Arid Areas

The procedure for mapping the arid and semi arid areas will be slightly different from the other areas whose description is offered above. In the arid and semi arid areas, the settlement patterns are both nomadic and permanent and they are also very sparsely populated. In these regions, there aren't clearly marked boundaries for the sub locations. So the teams will visit the settlements and mark them on 1: 250,000 topographical base maps and use GPS to get their positions. Where the settlement is large, and since it may not be possible to map it on the small scale base maps, a sketch map will be prepared to enable EA boundaries to be marked and at the same time the whole settlement will be mapped using GPS.

Like in the rest of the country and due to the problems mentions earlier, the medium and large urban centers in these regions will be mapped using satellite images, aerial photographs and GPS.

Mapping of National Parks, Forest and other Special Areas

National parks, forests and other special areas are mapped as separate entities in the districts where they exist and are assigned enumeration numbers. Special areas are areas such as army camps, police stations, prisons, large educational institutions and hospitals.

WORKSHEDULE UP TO JUNE 2009

a) The whole field mapping process has been broken into 12 phases and each phase is targeted to cover a given region. According to the work plan, the first and second phases were supposed to run from March – June 2007 but due to delays in the disbursement of funds and other logistical issues, the commencement of the second phase had to be rescheduled from mid September will be completed mid November 2007. The transport problem has partly been aggravated by the fact that the census project has not acquired vehicles of its own but instead relay on vehicles acquired earlier for other projects. This clearly shows that the work is already lagging behind by 4 months.

As mentioned above, the delay has been caused by:

- Delay in disbursement of funds.
- Lack of vehicles - vehicles meant for the project are diverted and deployed in other assignments.
- Delay in getting the imageries for the urban areas in the targeted districts.

b) By end of June 2008, the teams should be completing the 8th phase covering the Coastal Region. The capital of Nairobi, Central and North Eastern Regions will be covered in the remaining 4 phases. The field mapping exercise is supposed to be completed by April 2009 and map verification and call backs by June 2009.

DATA CAPTURE, MAP PREPARATION AND PRODUCTION

The implementation of this process has been rather slow because it is being handled by the same personnel who are carrying out the field mapping exercise. Most of the work for Nyanza Region has been digitized but very little map composition has been done. Recognizing that this process is lagging behind, arrangements have been completed to hire a team of 20 well qualified GIS Officers/Cartographers who will hasten the process. The team carrying out the map production is expected to also generate Area Measurements.

7) PRINTING, PACKAGING AND DISPATCHING OF MAPS FOR THE MAIN CENSUS

This activity is scheduled to be implemented starting early in 2009 and end in June the same year.