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**Ghana's Spaced-based Land-cover/Land-use Mapping, its First Up-date and
Strategies for Customizing the Products for the Poverty-reduction Programmes.**

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ABSTRACT

Under the Ghana Environmental Resource management Programme (GERMP), five land and environmental data sets were produced in digital format, one of which was the Land-cover/Land-use Maps at 1/250,000 scale. The rest were the topographic maps, soil and soil suitability of indicator crops, land ownership and meteorological maps. After the GERMP continuity of the mapping programme was assured under the Natural Resources Management Programme (NRMP), which gave the job for up-dating the land-cover/land-use maps to the Remote Sensing Applications Unit (RSAU). The RSAU as a Project located within the Department of Geography and Resource Development, University of Ghana, undertook the baseline compilation of the land cover/land use maps using Land

sat TM data of 1990 dry season conditions. Based on the success of the base line compilation, the RSAU was transformed into a self-financing and self sustaining organization to use the funds for the First Update of the land cover/land use in order to establish itself as an autonomous center, named: the Centre for Remote Sensing and Geographic Information Services (CERSGIS).

CERSGIS is currently carrying out the up-dating exercise; using Land sat ETM data of 2001/2002 dry season conditions. This paper presents the methodology and the results with illustrations covering the ecological zones of the country. It also discusses the distribution of the image and the map products and the strategies for making the data available for widespread community-based planning at the third-tier level of government of the District Assemblies.

The First Land-cover/Land-use Compilation

In Ghana, the need for national land cover/land use information for addressing the concerns of socio-economically and environmentally sustainable use of land were recognized in the Environmental Action Plan, which was adopted by the Government in 1991 for implementation. The Ghana Environmental Resources Management Project (GERMP) was constituted as a major initiative to implement the plan.

Among other objectives, the GERMP sought to develop an Environmental Information System (EIS) for the management of Ghana's resources including land and its uses. Four other data sets, besides land cover and land use, were developed. These were topography, meteorology, soil and land suitability, and land ownership. The Remote Sensing Applications Unit (RSAU) established in the Department of Geography and Resource Development, University of Ghana Legon was charged with the task of producing land cover and land use maps.

The processes of land cover and land use mapping included the development of an appropriate classification scheme and a methodology. Mapping of a pilot area, the design and construction of a land cover and land use database. Both the classification scheme

and the methodology were presented at a national seminar attended by potential user-institutions, government departments, non-governmental organisations and individuals.

It was readily apparent that the most cost effective and convenient way of achieving this goal was through the application of remotely sensed imagery with field validation. The implementing agency of the GERMP, the then Environmental Protection Council, now Agency (EPA), was keen to promote the development of remote sensing skills within the country for future use rather than contract out the work. It was this idea, which gave birth to the establishment of the Remote Sensing Applications Unit in 1993.

The space images recommended were the Landsat Thematic Mapper scenes of the dry season of 1990/91. The scenes were georeferenced to the 1/250,000 topographic maps and formatted to the same map series. The sixteen full scenes covering the whole country were merged to form a countrywide coverage and then cut into 22 map scenes of the 1/250,000 series. The packaging was made in such a way that sub-setting to obtain Regional and District Administrative Image Maps for the political entities of the country. This packaging corresponded with the other EISD data sets thereby facilitating overlaying of the five datasets to provide supportive as well as collateral information for in-depth interpretation of the image data for different environmental studies.

The bulk of the image analysis and interpretation was carried out between June 1995 and August 1996 with 'ground truthing' initiated for the south of the country in early 1996 and completed in October 1997. Field verification of mapping accuracy was undertaken in early and mid 1998.

Quality assessment was conducted through field validation. The indication is that the map accuracy for the higher categories of the hierarchical classification. However the overall accuracy is likely to be over 70% since the validation tended to concentrate on areas where the accuracy was known to be lower and also since re-mapping after the fieldwork will have improved the overall accuracy.

Though the outcome land cover and land use map was by no means a perfect product, if indeed such a product would be feasible given the nature of the environment the map does however, for the first time, provide national information on land cover and land use, systematically obtained from data that have a definite base date and that could be obtained on a recurrent basis. On that basis the update was carried out using Land sat ETM of year 2000.

As part of the technical assistance, a staff from National Remote Sensing Centre (NRSC) in the UK was engaged to review the classification system and mapping methodologies. In the light of the reviews and also comments from the workshops, and results from field-testing, the final mapping scheme was arrived at.

The project was funded by the by the government of Ghana, the government of Denmark through DANIDA and the International Development Association (IDA) of the World Bank. The Environmental Information Systems Development (EISD) project, of which the land cover and land use mapping is a component was implemented by five institutions; the Survey Department, the Soil Research Institute (SRI) of the CSIR, the Meteorological Services Department (MSD), the Lands Commission and the Remote Sensing Applications Unit (RSAU) at the Department of Geography and Resource Development at the University of Ghana.

The Environmental Protection Agency (EPA) co-ordinated the execution of the GERMP. While the technical facilitation was by the EISD consultants from Ramboll and Kampsax of Denmark, the twinning support from the National Remote Sensing Centre (NRSC) of the UK and administrative co-ordination by the Executive Director and staff of the EPA scored the success of the GERMP's EISD.

The Land Cover and Land Use Classification System Used

The term Land cover was used to refer to the cover of the terrain surface, such as vegetation (forest, grassland, shrub-thicket), bare soil, water body and so on, without

reference to how that cover is used. Land use was used to refer to the actual economic and/or cultural activity for which the land is used, such as razing, farming, logging, housing and others.

In many cases land cover and land use are directly related; for example grassland seen as land cover becomes grazing land when used by livestock. However the same grassland could also be used to support wildlife and thereby become a land use of tourism.

The classification system adopted for Ghana is hierarchical in that, it accommodates different levels of information starting at the broad-level classes of major land cover, proceeding downward into more detailed sub-classes levels were used. The first two levels corresponding to the land cover categories and the second and third reflecting land use categories.

Level I:	Principal vegetation and non-vegetation landscape cover e.g.
Level II:	Sub-categories of the principal vegetation and non-vegetation covers defined in terms of the major management systems e.g.
Level III:	Land use defined in terms of the major management systems e.g.
Level IV:	Land use categories defined in terms of products and services e.g.

The coding system adopted also reflects the hierarchical structure of the scheme. The first figure represented the major land cover, the second, the sub-category of the first, the third numeral stood for major land use (management) system and the fourth a sub-category of the management type.

The Terminology Used

The terminology referred more to the land management types of the land covers. They were the following:

Bush fallow cropping, compound farming, gathering, mixed cropping, open access land, reserved or protected, mosaic of covers and uses forest, woodlands water body, base land, fire scars, settlement (built-up) etc. The details were as follows:

Bush Fallow Cropping

The system of farming in which the farmer relies on the natural re-growth fallow to restore the fertility of the soil including the control of weeds. The degree of restoration of fertility depends upon the length of the fallow period and the composition of the fallow. “Land rotation” and “recurrent cultivation” are other terms used to describe the system while “shifting cultivation” is a variant of the system where the farmer moves to cultivate fresh areas and may not come back to the abandoned field.

The intensity of cultivation was indicated by the length of the period of the fallow. *Short fallows* are associated under a cultivation factor of <33% while the *long fallows* have a factor of >33-66%. The cultivation factor was calculated as the ratio of the years under cropping and the total length of the cropping and the fallow cycle. Whereas Nye and Greenland (1960) suggested that adequate fallow periods in the forest and savanna ecological areas should be 5 and 15 years respectively. The classification system took 3 years as the cut-off between short and long fallows. Short fallows therefore generally indicate pressure on the land.

Compound Farming

This is permanent cultivation of crops immediately around dwelling units and groups of dwelling units known as “compounds”. Cultivation is intensive, made possible by the use of household refuse for manure, particularly in the dispersed settlement areas of the northern parts of Ghana (Wills, 1960), and in much of the savanna area of West Africa.

Gathering/Hunting

This is a common form of land use activity in Ghana, in which a wide variety of wild produce and wildlife are collected from forests, savannas, wetlands and water bodies often for subsistence use, but increasingly becoming commercial pursuits. The products involved include fuel-wood, honey, medicinal herbs, fodder, thatch and meat, mushroom wild fruits.

Gathering is done primarily in the “open access” areas, but may be extended to statutory reserved or traditionally designated and controlled areas.

Mixed Cropping

The cultivation of more than one crop on the same piece of land, visually in a complex mixture. Mixed cropping may involve arable crops, (maize, cassava, vegetables) and tree crops (oil palm, citrus, mango). Some of these may be natural growth but tended by the farmer, for instance fruit trees, or they may be ratoon such as sugar cane and plantain or unharvested crops.

Open Access

Open access describes areas that are not subject to restrictions as to entry and the exploitation of products and resources by members of the community. Resources exploited include wood for fuel and construction, wildlife, medicinal herbs, fodder etc.

Reserved

In contrast to “open access” these are areas that have been gazetted and designated as reserves with restrictions on use. They are usually forest but also include areas of savanna woodland and shrub thicket. In the mapping exercise, areas of reserved land with the natural cover removed use mapped according to the image cover type.

Mosaic

Mosaic was applied to a cover of shrub thicket and grassland where neither cover be mapped separately at the scale of mapping.

Tree Density and Canopy Cover

Forest and woodland trees vary in densities. Field estimates of the tree densities and canopy cover were considered for identifying sub-categories of the vegetative classes.

Density ranges used are fewer than 10; 10-75; 75-150 and greater than 150 trees per hectare.

Description of Level 1 categories:

Agricultural Land (code 1000)

This is Land where over 50% of any defined area is used for agriculture. This may be currently cropped or in fallow and may include areas for grazing of livestock. Agricultural land has been sub-divided at level II according to the vegetative cover within which the agriculture takes place.

Forest

Continuous, multi-storied stand of trees at least 5m high with interlocking crowns, usually lacking a grass ground cover. Forest is sub-divided at level II into “closed” where the canopy cover is more than 60%, and “open” where canopy is less than 60%. Riverine forest is distinguished in the Savanna zone.

3000 Savanna

An area of land comprising a mixture of woodland (a single storied stand of trees less than 5m high), and/or bushes (woody plant with multiple stems, usually over 2m tall), and/or grassland with or without scattered cultivation. Savanna woodland is sub-divided at level II into closed (.150 trees/ha) and open (150 trees/ha), grassland and riverine vegetation.

4000 Shrub thicket

Areas dominated by dense shrubs in association with grassland.

5000 Non-biotic constructed surfaces

Areas, which have an artificial cover modified by human activity. Sub-divided at lower levels into settlement and transport.

6000 Bare land

Areas which are devoid of vegetative cover either naturally (rock, sand) or through the results of human activity (erosion, mining).

7000 Water bodies

Broad river channels, reservoirs, lakes and lagoons.

8000 Wetland

Vegetated areas where the water table is at or near the surface for a significant part of most years.

9000 Unclassified

Some areas were unclassified which were over cast by clouds or exposed as burnt surface/fire scars.

Up-dating and using the outputs for the planning activities

When the GERMP ended in 1998, it was followed by the Natural Resources Management Project (NRMP). There was a land use component of the NRMP which was for up-dating the map derived from the 1990 Landsat TM images. The updating was to be undertaken with year 2000 Landsat ETM images. The updating exercise is in progress.

Whereas the interpretation for compilation of the base line maps was based on on-screen interpretation of the false-color composite version of the 1990 images, the current exercise has adopted some automation by classifying both the 1990 and 2000 sets, using a common classification and color scheme. This facilitates comparison between the two dates. In addition, the vector layer of the land cover/land use map units has been overlaid on both the 1990 and 2000 images. The output is a composite of the land cover/land use layer and the corresponding land cover image. It facilitates the use of one as collateral for the interpretation of the other. This will encourage lay-users to use the outputs without elaborate references.

By adopting this strategy of the layman's use of the images the Centre recognizes that one of the most pressing needs in capacity development for enhanced environmental resource management relates to the inadequate information base for improve decision-making. The image maps should serve as part of the information base for quick decision making. The image the land cover types associated with the forest/woodland sub-sector, water resources sub-sector and agricultural resources sub-sector are the same the information base for determining visually the investment possibilities for developing natural resource-based enterprises within the area. The poverty-oriented approach of Ghana's development framework has to recognize the space images and the existing geographic data sets as part of the essential information base for planning.

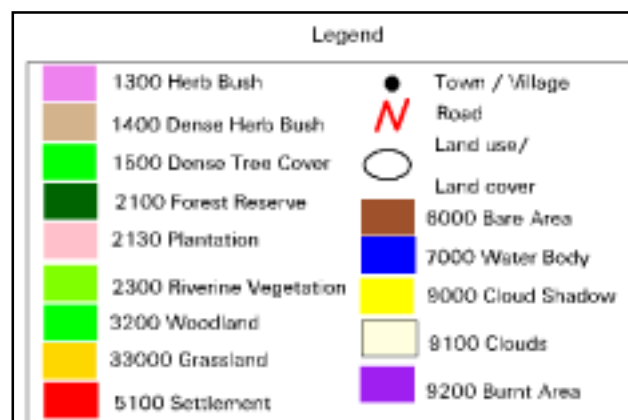
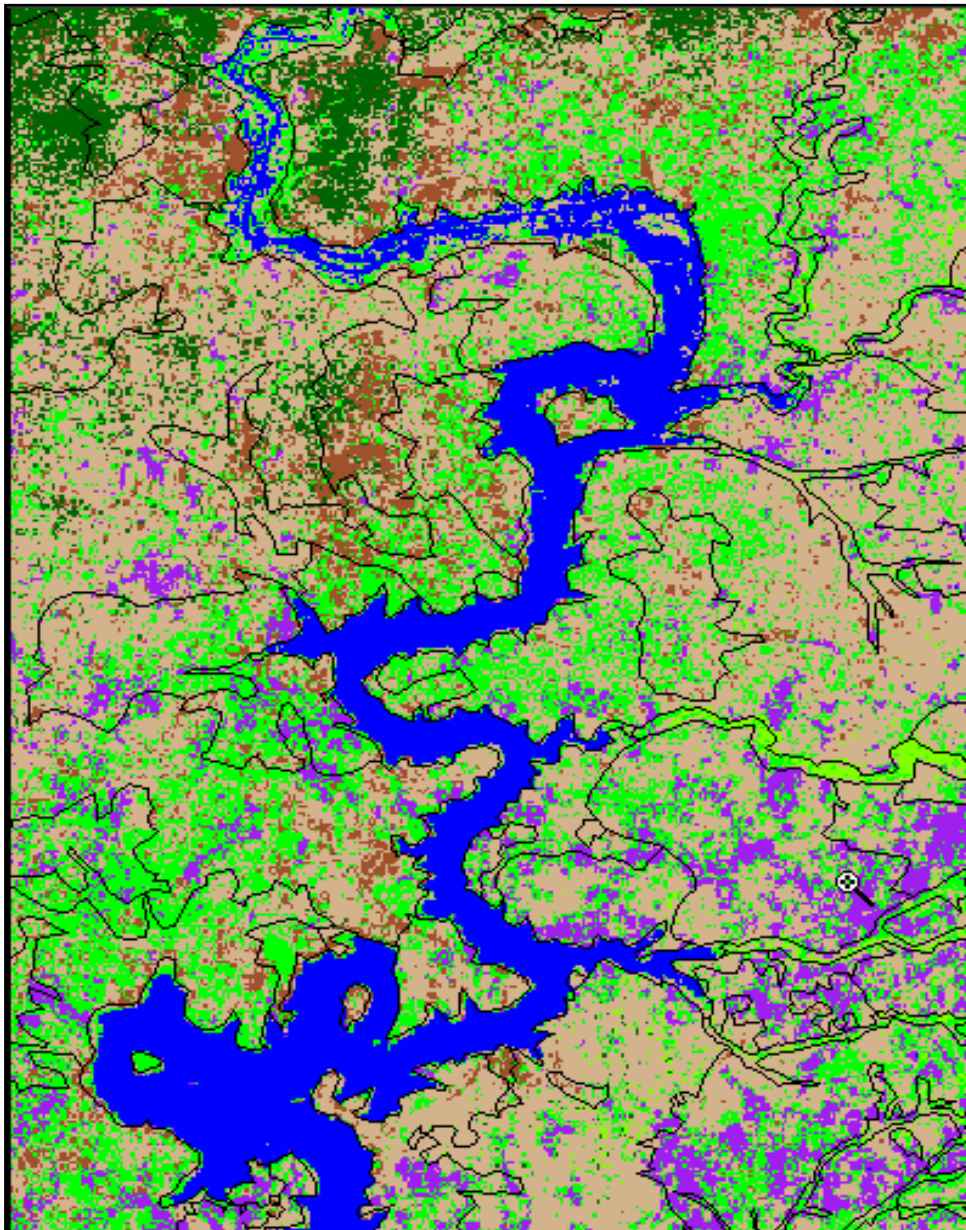
It has been recognized that a key constraint that underlies the weaknesses in the development planning and environmental management is the weak culture of science and application of technology in many areas of the socio-economic activity. The land cover/land use maps and images are products from science and technology for planning, monitoring and evaluating the poverty-alleviation projects.

In relation to this philosophy images would be re-packed to convey community level display the natural resource-base information to assist investors looking for such information on the Forest/Woodland, Water, Agricultural soils, etc.

Currently, the country is administratively organized into one hundred and ten (110) District Assemblies (DAs). Each DA is an entity as a local government. The image maps and the land cover maps are to re-packaged together with the topographic, the soil and soil suitability, the meteorological and the geological layers to serve as the set of "Environmental Resource Data sets (ERDS)" at 1/250,000 scale except the topographic map layer, which would be at 1.50,000. This packaging presumes that the digital version is to be used actively by the DA-Planning Committees.

The UNDP-Ghana Capacity 21 Project has succeeded in putting District Environmental Resource Information System (DERIS) in eight pilot DAs. These DAs are currently using the ERDs to generate part of the critical information for planning.

Annex 1: Classified Image of Ghana Topographic Map Sheet 800 (Year 2000)



Annex 2: Classified Image of Ghana Topographic Map Sheet 800 (Year 1990)

