Applying the Global Standard FAO LCCS to Map Land Cover of Rural Queensland

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Abstract

Production of land cover maps has developed rapidly with the introduction of satellite images. However, these mapping tasks face a common challenge in adopting an internationally accepted classification scheme. Classification schemes were generally tailored to match local conditions without a flexibility to apply in other parts of the world. Land cover mapping in Australia is also facing the same dilemma, "the lack of standard classification system" to classify its massive land mass and compare internally and internationally. To address this issue, the Food and Agriculture Organization (FAO) produced a widely acceptable land cover classification system (FAO LCCS) in year 2000, based on priori (pre-decided) approach to classify the land to match with any region of the world. In this study we classified rural Queensland land cover, using the hierarchical and the priori method used in FAO LCCS. Under the priori approach, all classes were determined before the classification start to maintain the standardization of categories. The hierarchical dichotomous approach was (divide into subcategories) applied afterward, to obtain classes without having any conflict between two given land cover types. We classified satellite images of two rural Queensland regions, Hughenden grasslands and semi-arid Mt Isa. After classifying regions into level 1 to level 3 (FAO pre-set classes), classifiers based on spectral values and field investigations were implemented to build the level 4. Primarily, SPOT 10m images were classified for land cover maps, however, all other available information were utilized for the classification process. Field investigations were carried out to verify uncertainties in spectral values and to collect ground truth information. Results of the study rendered well-classified two maps at 10m resolution with over 80% overall accuracy. The most significant outcome of the study is the successful implementation of FAO LCCS approach to local conditions of Queensland, which could serve as a guideline to map other regions in Queensland and other states of Australia.

Key words: FAO LCCS, Priori classification, Dichotomous Phase, Modular-Hierarchical Phase, Land cover classifiers. SPOT 10m data

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1. Introduction

When human interaction with the land increases, understanding the changes in the land becomes an integral part of any environmental plan. In general terms, "Land" is a part of the earth, or the ground, not covered by water. According to some law definitions, "Land" is described as a three-dimensional space consisting of land and space below and above it (Butt, 2001). But, environmental engineers are paying more attention to the land surface since investigating the land and its resources is critical to their work. The FAO document defines the land according to its contribution to productivity. The main resource controlling primary productivity for terrestrial ecosystems can be defined in terms of land: the area of available land, land quality and the soil moisture characteristics (Di Gregorio and Jansen, 2000). This main resource or the land further explains by its physical appearance as "Land Cover" and "Land Use". The Australian institute under the Natural Heritage Trust, the National Land and Water Resources Audit, agrees with the FAO definition of the land cover, which is described as observed biophysical cover on the earth's surface including vegetation and

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manmade surfaces (Di Gregorio, 2005). Further, the National Land and Water Resources Audit defines Land Use as the purpose to which the land cover is committed (National Land and Water Resources Audit, 2007).

This is explained further by the FAO definition; for example, "grassland" is a land cover type, while "rangeland" or "tennis court" refers to the "use" of respective "grassland". Hence, it's clear that the geographical feature of the land or land cover determines the land use. Also, ever increasing human interaction with the environment alters the land cover through dynamic changes in land use. Within last 50 years, the gross value of Australian agricultural sector expanded dramatically from $4.5 billion in 1960/61 to $46.5 billion in 2007/08 (Australian Bureau of Statistics, 2008). Due to its massive scale of activities, Australia has a significant obligation to act in this field of research to fulfill its local and global responsibilities in food production and environmental conservation. Table 01 shows few noteworthy features of Australian agriculture and land cover against world.

Land cover information is vital for the sustainable use of land. A standardized and up-to-date land cover dataset is required to; assess the condition of the natural resource base, modeling water quality, soil erosion, soil health and the sustainable production of food and fiber (DAFF, Australia, 2007). Data generation must be conducted to satisfy the logical approaches of standard land cover classification systems to compare with multi-temporal inter-state and international data. Here, the *priori Land Cover Classification System* (LCCS) adopted by the FAO can be used as the standard to build a local land cover classification system for Australia.

2. Constructing the Classification Scheme

Mapping the earth surface was achieved an explosive development with the introduction of earth observation satellites in 1972. Land cover and land use maps at various scales were generated to address specific needs or local areas; though none of the classification schemes became internationally recognized or standardized. Under this circumstance, the Land cover classification system (LCCS) adopted by the FAO can be considered as an approach with logical definitions which can be applied to different land cover types around the world (Di Gregorio and Jansen, 2000). FAO and UNEP gathered in 1993 to establish this new approach of land cover classification system to count a wider spectrum of global land cover types and by 2000 the FAO LCCS became fully operational.

2.1 Basics Considered in FAO LCCS

The FAO LCCS system is considered as the only such approach available today which can be applied to any region of the world regardless of the economic conditions and data source. Initially, the FAO method is a "*priori*" classification system, which defines all the classes before the classification is conducted. The advantage of this approach is the possibility to maintain standardisation of classes. For this proposes, LCCS developed pre-defined classification criteria, or *classifier* to identify each class, instead of identifying the class itself. This concept is based on the idea that a land cover class can be defined without considering its location or its type, using a set of pre-selected classifiers. Therefore, when the user requires a large number of classes, a large number of classifiers are required. To organize the

Table 1. Some characteristics of Australian agriculture and land cover (source: Agro data, 2006)

Component	Australia	World
Per Capita Cereal Production (tons per person), 1999 - 2001	1794	343
Percent change of Cereal production since, 1979-81	62%	32%
Hectares of Cropland per 1,000 population, 1999	2547	251
Forest area as a percent of total land area, 2000	20%	29%

Table 2. Dichotomous approach to build primary classes in FAO LCCS

First level	Second level	Third level
A. Primarily vegetated	**A1.** Terrestrial	**A11.** Cultivated and managed terrestrial areas
		A12. Natural and semi-natural terrestrial vegetation
	A2. Aquatic or regularly flooded	**A23.** Cultivated aquatic or regularly flooded
		A24. Natural and semi-natural aquatic or regularly flooded
B. Primarily non-vegetated	**B1.** Terrestrial	**B15.** Artificial Surfaces and Associated Areas
		B16. Bare Areas
	B2. Aquatic or regularly flooded	**B27.** Artificial water bodies, snow and ice
		B28. Natural water bodies, snow and ice

classification more easily, FAO system used a *dichotomous* (divide into sub categories), approach in hierarchical levels and used eight classifiers to group all land cover types at the third level. In other words, any location on the earth surface can be categorized into one of the eight classes without having a conflict. Up to this third level, FAO used the presence of vegetation, edaphic (plant conditions generated by soil and not by climate), and artificiality of land cover for classification. Additionally, the third level of FAO classification can be considered as a concept based on visual classification, which uses the directly visible and knowledge based components on the ground.

In practical conditions, a further breakdown of the third level eight classes must be conducted to obtain a detailed level of land cover classes. For that purpose, FAO uses a *hierarchical approach*, or the *Modular-Hierarchical Phase*, to build additional classifiers, but strictly within one of eight classes identified in third level of the dichotomous phase. Under this 4th phase, the system uses a set of pre-defined pure land cover classifiers, different from the eight classes in the dichotomous phase presented in Table 02.

The pure land cover classifiers are defined by **Environmental Attributes** (e.g., climate, soil, and etc) or by **Specific Technical Attributes** (specific details like crop type, soil type) (africover, 2003). In both cases, the user gets the freedom to add these classifiers according to, research interests, scale of the classification, and the physical and climatological conditions of the field. The FAO LCCS document presents a large number of classifiers to use at this level and the user can use only a selected set from the list to match with the scope of their own mapping project.

2.2 Australian Vegetation and Its Recent Changes

The Australian flora and fauna is a composite of Gondwanan elements, and has evolutionary lines shared with South America. About 80% of the flora of Australia is endemic to the country and most of the species are extremely restricted in geographic and climatic range. For example, 53% of the about 800 species of eucalypts have climatic ranges spanning less than 3˚C mean annual temperature, and 25% span less than 1˚C (Hughes, 2003). Also, about 23% have adapted to less than 20% of mean annual rainfall changes (Barrie, 2003). The recent global warming may have influenced these flora (and fauna), since the largely flat Australian geography offers only a little space to escape naturally.

The millions of years old unique Australian landscape met a drastic change within last two centuries after the arrival of European settlers. Loss of native vegetation continues to be one of the greatest threats to Australia's biodiversity. Historically, most clearing has been for agricultural production, with the result that around 13 per cent of the original vegetation has been removed since European settlement (State of Environment, 2006). Most of the native forest change has occurred through clearing of forests and woodlands, which originally covered 54% of the country and now covers only 42%. Within this period, an excessive loss occurred in rainforest and vine thickets, eucalyptus woodland, Mellee woodlands, and low closed forest categories by over 30%. According to overall assessments, about 22% of the forest and woodland have been lost due to burning and farming by settlers (State of Environment, 2006). These recent manmade and other climatic influences on the land surface have attracted the attention of researchers.

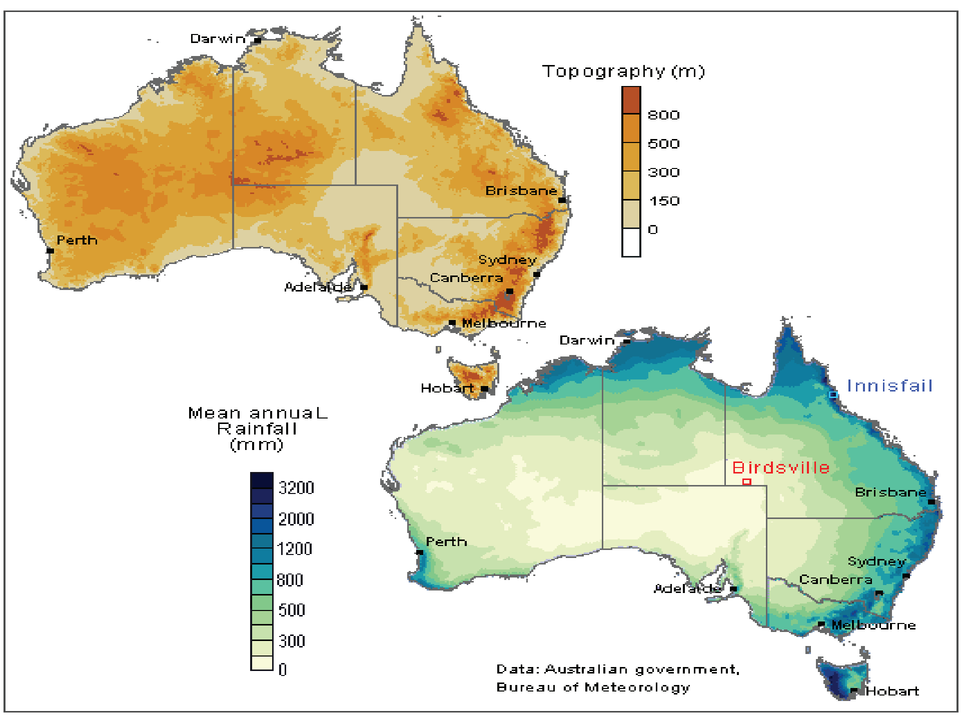

Figure 1. Elevation and annual rainfall of Australia (source: Climate Data Online 2009)

2.3 Applicability of FAO LCCS System in Australian Terrain

Australian land cover is greatly influence by climate rather than it's near flat terrain with 99% of its land area below 1000m (Hughes 2005). Figure 1 compares the annual rainfall and topography of the country, which shows heavy rainfall along the east and north coastal areas. Within Queensland, the central region receives extremely low rainfall (Birdsville, mean annual rainfall is less than 200mm), while northeast coast receives heavy monsoon rains (Innisfail, mean annual is over 3200mm) (see locations on Figure 1). Vegetation types throughout the state have adapted to these climatic variations. When classifying land cover of Australia, the priori classification approach of FAO LCCS provides a logical approach to separate land cover types. It helps to ignore differences in land surface of Australia at the initial three levels of the classification (see Table 02). However, for the construction of the 4th level of the classification system, regional environmental features and field information must be considered.

When building the land cover map through these four levels of FAO LCCS, the near-flat terrain of Australia requires a focus on climate and soil characters rather than topology. The other elements to consider for the classification are spectral characteristics and the resolution of original data, final mapping resolution and the quality of supporting data (including ground truth data). In this study we used SPOT 10m satellite data and a set of GIS data for the mapping. Also extensive ground surveys and SPOT 2.5m color composite images were used to build the classifiers.

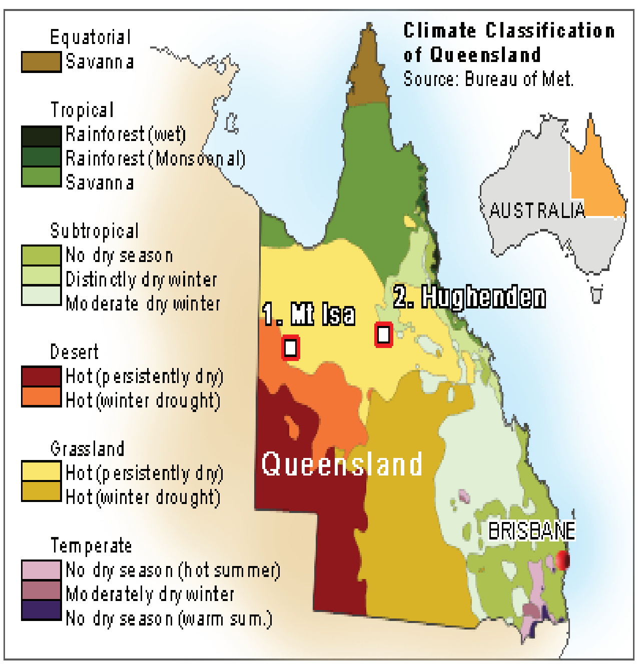

Figure 2. Locations of study areas on QLD Climatic Zone map (data source: Climatemap 2010)

3. The Case Study

The land cover of Queensland varies from semi-desert barren lands and huge farm lands in the vast hinterland to some of Australia's largest remnant tropical rainforests including a world heritage site (Department of the Environment, 2008) and urban environments in east coast. Mapping the land cover characteristics covering all these land cover diversities is a challenging task. The present study focuses on the classification of two selected locations of Queensland (see Figure 2) that represent significantly different rural land cover types of the state. This paper presents two selected areas from originally classified full scenes of SPOT, with one area (area No. 1, Mt. Isa) in details.

The locations of study sites are over 650 kilometres apart from each other (Figure 2). The selected study areas are located in semi-desert or arid Mt Isa region and in grassland dominant subtropical Hughenden region. The land cover classification of these locations with contrasting geo-climatic characteristics makes the approach suitable to apply most of other Australian regions with appropriate modifications. As tabulated in Table 03, the two selected study areas are considerably distinct from each other by distance and geo-climatic aspects. The 1st area (around Mt Isa city in central Australia) has arid climate with relatively unproductive soil layer for farming (Michael and *et al*, 2005). Hughenden area (2nd study area) in central-northeast Queensland is in the massive Mitchell grasslands and closer to subtropical conditions of the state. For this study, we focused on 1000 km^2 sections from each region. Population density is very low and less than 2 people per 1 sq km (Australian Bureau of Statistics, 2008).

4. Data and Data Processing

4.1 Used Data

Land cover maps were produced with SPOT 10m data, but number of other satellite images was utilized as supporting data. The Table 04 summarized the data sets used in the study.

4.2 Building the Classification for Study Areas

The methodology of building the classification scheme focuses on one of the mapped areas, Mt Isa in north-west Queensland, in order to limit the length of the paper. For all the aspects of image processing, Micro Image TNT software package (TNTmips 2008:74) was used. The construction of first three levels of the classification was completed by strictly following the FAO LCCS structure. For these initial three levels, spectral characteristics of SPOT images and vegetation index image were used extensively. Different levels of spectral information were also used to isolate broad classes at each level of the LCCS. A new set of training sites was selected from each level to perform the next level of the classification. Those training sites were selected with the

Table 3. Main features of study areas (sources: Climatemap 2010, Climate Data Online 2009, Desert Knowledge CRC, 2006)

Element	**1. Mt. Isa**	**2. Hughenden**
1. Covered area	1000 km²	1000 km²
2. Mean annual rainfall	389.75mm	492.4mm
3. Mean annual maximum temperature	32.3˚C (at post office)	31.6˚C (at post office)
4. Climatic zone (based on KÖppen Classification) (bom.gov.au/climate/environ/other/kpn_all.shtml)	Semi-arid, hot climate (winter drought)	Grassland - Hot (winter drought)
5. Main soil types (cazr.csiro.au/connect/resources.htm)	Cd (predominantly physical limitations; soils with periodic subsurface) Cf (predominantly physical limitations; shallow soils)	Cb (predominantly physical limitations; cracking clays)
6. Elevation (approx. range)	530 - 300 m	400 - 270 m
7. Main land cover feature	Woodlands and bare lands with grass	Grasslands

Table 4. Used data in the study

Location / data type	Data set identifier	Date
Mt. Isa		
SPOT 2.5m	sthn_gulf_2p5m_nc.tif	Not known
SPOT 10m	sp5xi10_358391_30072005.tif sp5xi10_358392_30072005.tif	30072005 30072005
ASTER	1397_203_130900.img	16102006
Landsat	l5tmre_mtis_20051005_ba7m4.img	05102005
Field Survey		Dec/Jan 2008
Hughenden		
SPOT 10m	sp5xi10_367390_16072005.tif sp5xi10_367391_16072005.tif	16072005 16072005
ASTER	1437_205_240900.img	16102006
Landsat	l5tmre_hugh_20050728_ba7m4.img l5tmre_oakv_20050813_ba7m5.img	28072005 13082005
Field Survey		Jan 2008

help of, 2.5m SPOT images, field investigations, different image indexes of SPOT, Landsat images, ASTER images, and general knowledge of the region. Under the dichotomous approach (see Table 2) of FAO LCCS, the accuracy of each initial level permanently is affected to the accuracy of following levels of the classification.

4.2.1 Classification Level I: A supervised classification to isolate non-vegetated lands was conducted through careful selection of training sites from 100% non-vegetated areas. Spectral values of each SPOT band and NDVI image together with 2.5m SPOT images were used to identify these training sites, precisely. All other areas under different levels of vegetation (from vegetated area to a mix of bare ground and grass) were classified into vegetated areas.

4.2.2 Classification Level II: The re-classification was carried out with two classes of level I to generate four classes. After observing the NDVI, image classification was conducted through selecting training sites using the 2.5m and 10m SPOT images. Only 3 classes were found out of four, and the class A2 ("aquatic or regularly flooded areas under primarily vegetated category") (see Figure 3) were not found in Mt Isa region.

4.2.3 Classification Level III: In the 3rd level, FAO LCCS has 8 sub classes to represent all land surface features on the earth. The availability of the area under each class is directly depending on the regional features of land cover of each respective area. A clear example is, in a remote desert region with no human settlements or any vegetation, it may just comprise of only one class (B16, A6: Loose and Shifting Sand) from these 8 classes. The Mt Isa region has a predominantly dry climate and no vegetated lands under aquatic or regularly flooded conditions exit. We found five classes out of eight original classes at this level (see Level III in Figure 3) with regard to Mt Isa region.

4.2.4 Classification Level IV: The 4th level of the classification is the challenging phase of the land cover mapping under FAO LCCS, which set to identify classes closer to real world land cover with clearly demarcated boundaries. As an example, even after extensive studies, the LCC for Tasmania conducted in 2006 had 14 classes at local level, but one of them, "seabird rookery complex" found no matching class in FAO LCCS to be assigned (Atyeo and Thackway 2006). Fundamentally, the 4th level or local level class generation has to be conducted through applying more detail "classifiers" (Di Gregorio, 2005), as FAO LCCS requires.

In this study we used very high resolution 2.5m satellite images and ground survey information to build classifiers for the 4th level. Additionally, spectral characteristics of SPOT 10m images played a strong role in the classification process. Figure 3 shows the simplified flow of this process, which presents all four levels with regard to the Mt Isa map. *Classifiers* used 4th level of the classification under FAO system to generate classes in level IV for Mt Isa and Hughenden maps are presented in Table 05 and 06.

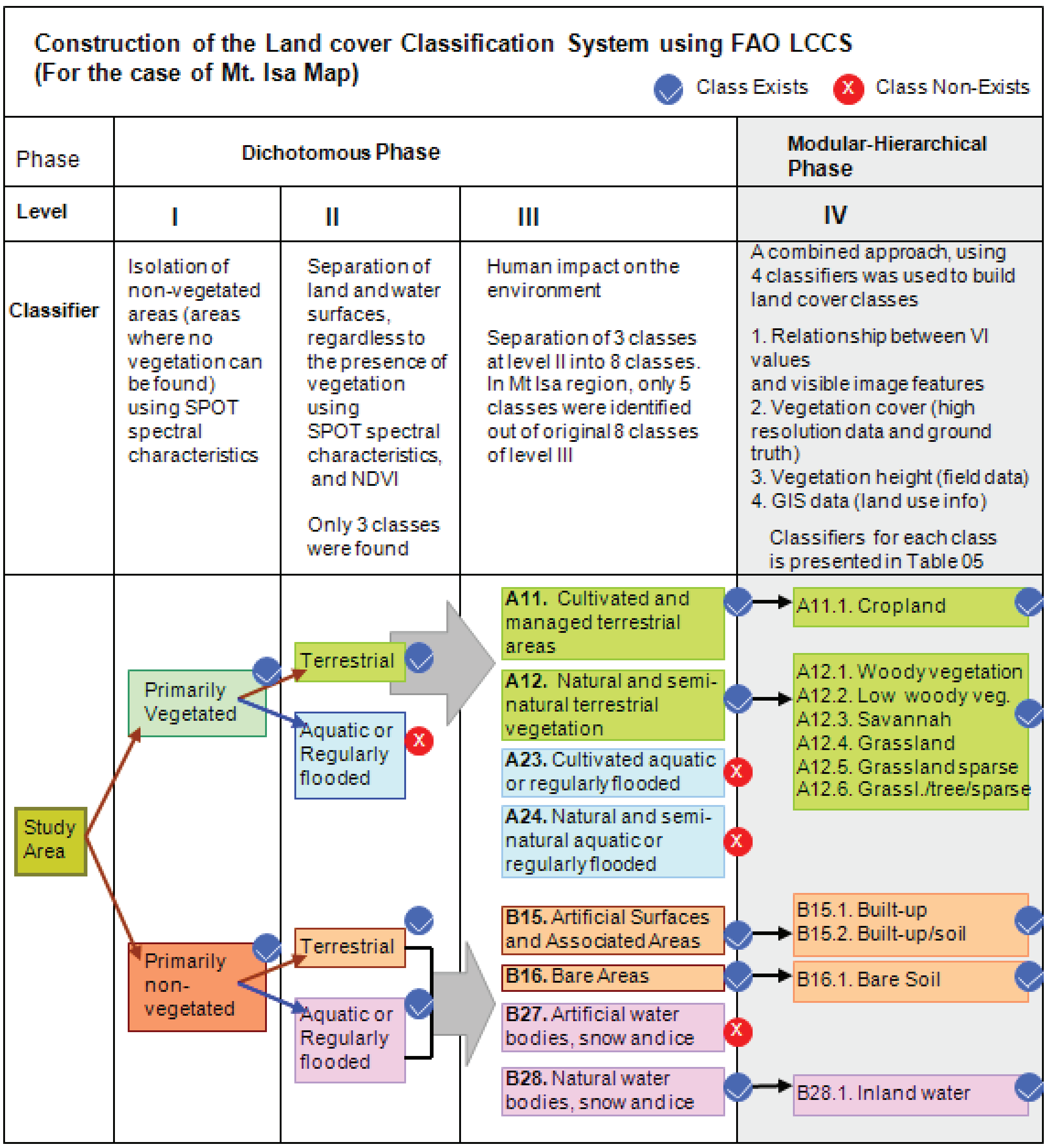

Figure 3. Building the classification scheme according to the FAO LCCS

Table 5. Land cover classes mapped in Mt Isa region full SPOT scene under FAO LCCS system

Class Code	Class name	Classifiers	FAO LCCS Classifier Codes
A11.3.	Cropland	Visually identified training sites using 2.5m data and field investigation + high NDVI value (around 0.6)	**A11** A3 Herbaceous D4 Surface irrigated
A12.1.	Woody vegetation	Visually identified training sites using 2.5m data and field investigation + high NDVI value (higher than 0.3) + closed woodlands (> 60%) + tree height is over 2.5m	**A12** A1 Woody A1 A10 Closed A10 B1 Height 7 - 2 m
A12.2.	Low Woody vegetation	Visually identified training sites using 2.5m data and field investigation + high NDVI value (higher than 0.3) + open woodlands (10 - 40%+ tree height is over 1m	**A12** A1 Woody A21 Open B14 Height 5 - 05m
A12.3.	Savannah	Visually identified training sites by smooth texture on 2.5m image + areas under low NDVI value (below or around 0.3), and Shrubs (Sparse) + Graminoids observed from field investigation	**A12** A4 Shrub A6 Graminoids A14 Sparse (1% - 15% Shrubs and trees)
A12.4.	Grassland (wetlands)	Visually identified training sites by smooth texture on 2.5m image + areas with moderate to high NDVI value (0.3 - 05), dominate by Graminoids observed from field investigation	**A12** A6 Graminoids C1 Spatial distribution
A12.5.	Grassland sparse	Visually identified training sites from areas under low NDVI value (below 0.3), with Sparsely distributed Graminoids, observed from field investigation	**A12** A6 Graminoids A14 Sparse
A12.6.	Grassland/tree/ sparse	Special spectral feature of soil color caused by rocky terrain, identified by 10m and 2.5m data, verified by field investigations.	**A12**, A6 Graminoids A4 Shrubs, A14 Sparse A3 Tree Sparse A14
B15.1.	Built-up	Visually identified training sites using 2.5m data and field investigation	**B15** Urban Areas A13
B15.2.	Built-up/soil	Visually identified training sites using 2.5m data and field investigation	**B15** A12 Industrial and other
B16.1.	Bare soil	Visually identified training sites using 2.5m data and field investigation	**B16** A5 Unconsolidated Bare soil
B28.1.	Inland water	Visually identified training sites using 2.5m data	**B28**. A1 Water

5. Results of the Case Studies

This paper mainly emphasizes the characteristics of Australian land surface and the application of FAO LCCS to classify that into land cover classes. In the process, land cover maps for the two test sites, Mt Isa and Hughenden were produced.

5.1 Mt. Isa, the Arid Region

The vicinity of Mt Isa city represents the vast inner Australian arid landscape. The centre of the mapped area (Mt Isa city) associates with a large mining complex, which is one of the largest in Australia. The built-up area of the city with 23,000 people is restricted to a small area, though its urban limits cover 43,310 square kilometres (Mt Isa city council, 2008). Due to the harsh climate, no major farming areas can be seen closer to the city, except ranching activities. Figure 4 (2 upper photographs), shows typical red-soil "outback" (Australian term for remote area) environment around Mt Isa.

Table 6. Land cover classes of Hughenden area (full SPOT scene) under FAO LCCS

Class Code	Class name in the map	Classifiers	FAO LCCS Classifier Codes
A11.3.	Cropland	Visually identified training sites using 2.5m data and field investigation + high NDVI value (around 0.6)	**A11** A3 Herbaceous D4 Surface irrigated
A12.1.	Woody vegetation (closed)	Visually identified training sites using 2.5m data and field investigation + high NDVI value (higher than 0.3) + closed woodlands (> 60%) + tree height is over 2.5m	**A12** A1 Woody A10 Closed B1 Height 7 - 2 m
A12.2.	Woody vegetation (open)	Visually identified training sites using 2.5m data and field investigation + high NDVI value (higher than 0.3) + open woodlands (10 - 40%) + tree height is over 1m	**A12** A1 Woody A21 Closed to Open B14 Height 5 - 05m
A12.3.	Low woody vegetation	Visually identified training sites by smooth texture on 2.5m image + areas under low NDVI value (below or around 0.3), and trees, Shrubs (Sparse) + Graminoids observed from field investigation	**A12** A4 Shrub A6 Graminoids A14 Sparse (1% - 15% Shrubs and trees)
A12.4.	Low woody vegetation in red soil	Visually identified training sites by smooth texture on 2.5m image + areas with moderate to high NDVI value (0.3 - 05), dominate by trees and Graminoids observed from field investigation	**A12** A6 Graminoids, A3 Trees, C1 Spatial distribution (continues)
A12.5.	Low woody vegetation, open	Visually identified training sites with trees from areas under low NDVI value (below 0.3), with Sparsely distributed Graminoids (grass), observed from field investigation	**A12 Cover:** A3 Trees, A4 Shrubs A6 Graminoids A14 Sparse (<20-10 -4%)
A12.6.	Low woody vegetation on slopes	Special spectral feature of soil color caused by rocky terrain, identified by 10m and 2.5m data, verified by field investigations.	**A12 Cover:** A6 Graminoids A4 Shrubs, A14 Sparse A3 Tree Sparse A14
A12.7.	Mix vegetation closed	Special spectral feature of soil color caused by rocky terrain, identified by 10m and 2.5m data, verified by field investigations.	**A12 Cover:** A5 Forbs, A6 Graminoids A4 Shrubs, A14 Sparse A3 Tree
A12.8.	Grass/herb land closed	Visually identified training sites observed from field investigation with moderate NDVI value in Graminoids (grass)	**A12 Cover:** A5 Forbs A10 Closed (>60-70%)
A12.9.	Grassland closed	Visually identified training sites observed from field investigation with moderate NDVI value in Graminoids (grass)	**A12 Cover:** A6 Graminoids A10 Closed (>60-70%)
A12.10.	Grassland open	Visually identified training sites observed from field investigation with low NDVI value in Graminoids (grass)	**A12 Cover:** A6 Graminoids A12 Open (about 50%)
B28.1.	Inland water	Visually identified training sites using 2.5m data	**B28. Inland Water bodies, snow & ice** A1 Water: Natural Water bodies

Through a careful observation of spectral characteristics of SPOT 10m images and vegetation index images as explained in section 3.3, the land cover map of Mt Isa was produced with 11 land cover classes under the 4th level (Figure 5). An accuracy assessment of the Mt Isa map was carried out using the 2.5m SPOT image. Using a systematic random sample, 128 points were selected from the area covered by 2.5m image and checked against the classified image data. Samples were under-represented on land cover types with very low areas of coverage, but all major land cover types were counted. Results showed an overall accuracy of 82% for Mt Isa map.

5.2 Hughenden, the Grassland Region

An extensive fieldwork program was conducted to cover all pre-identify ground truth spots with some uncertainty in Hughenden area. Mitchell Grassland was identified as the dominant land cover type in Hughenden area (Figure 6). Large cattle farms spread all over the area with extremely low number of permanent settlements. Image processing methods used for Hughenden image were same as methods used for Mt Isa map. Also, spectral characteristics clearly helped to separates some classes within woody vegetation, where soil types have influenced to for tree types on

Figure 4. Typical land cover types in Mt Isa area (top 2 photos) and Hughenden

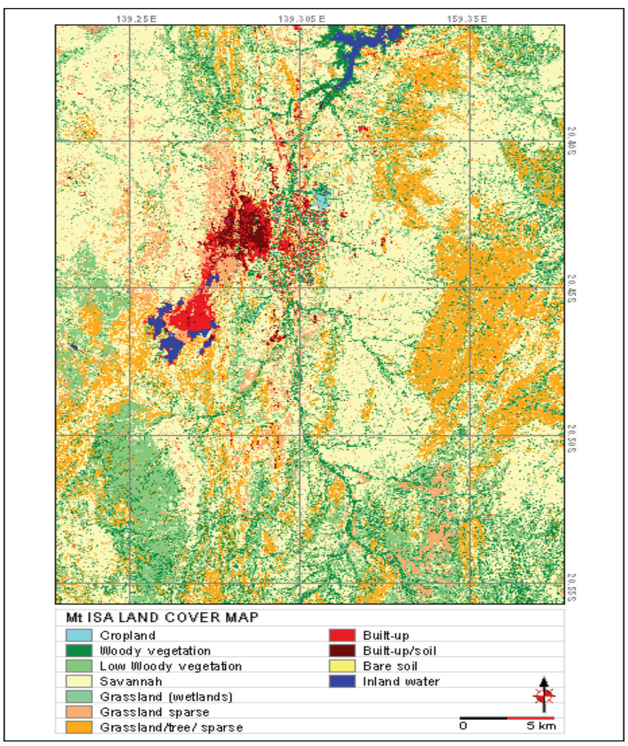

Figure 5. Land cover map of Mt Isa region

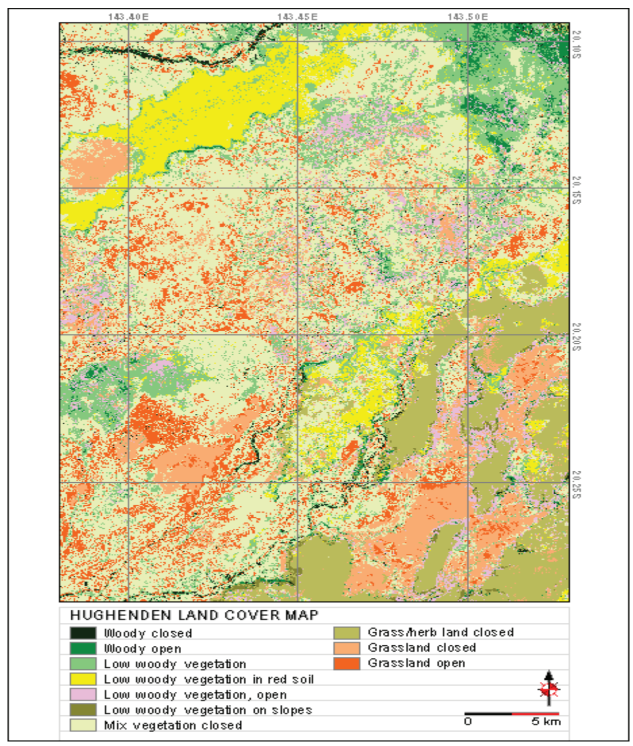

Figure 6. Land cover map of Hughenden

respective soil type (Class A 12.6, Low woody vegetation on slopes). The Figure 7 shows an area for these vegetation type changes along the rocky slopes and fertile table-shape mountains and valleys where grasslands and riparian forests are located. We noticed some deviation of spectral signatures on images with the ground survey evidences, mainly due to wet weather followed after the image date in Hughenden.

For Hughenden map, we checked 89 field data points in the field (spots those were uncertain in initial classification) and found 77 points matched with the classification. Hence, we calculated an approximate accuracy assessment Figure for Hughenden map as 86%, assuming 77 places out of 89 have been correctly classified or mapped. It’s important to emphasize the potential negative impact of seasonal

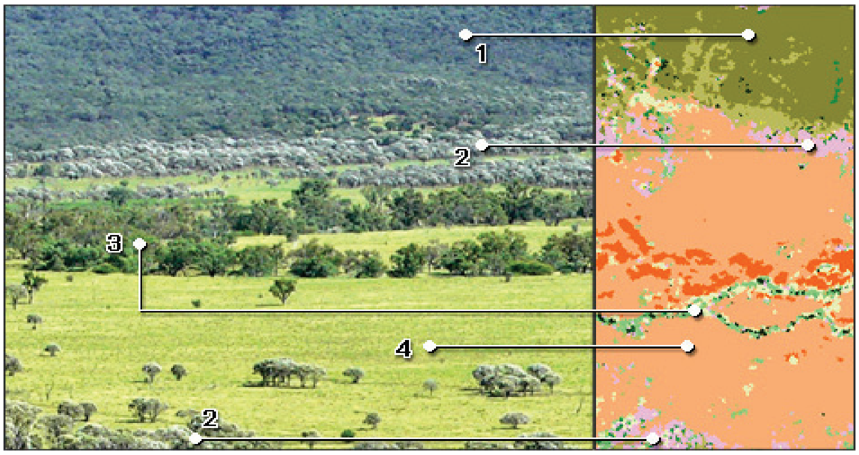

Figure 7. A selected location of Hughenden map shows its relation to the actual land cover types on the ground. (1) Low woody vegetation on slopes (2) Low woody vegetation, open (3) (Riparian forest) Woody closed, Woody open, Low woody vegetation (4) Grassland closed

variations in vegetation cover to the classification accuracy if multi-temporal satellite data and multi-season field investigations were not used in the mapping process. Table 06 presents land cover classes and FAO classification system class codes for Hughenden map.

5.3 The Qualitative Aspects of New Maps

This study was conducted to apply the FAC LCCS system for rural Australian land cover products. Initially, two full SPOT image scenes were classified and only sub-regions of 1000 km^2 were presented in this study in order to present clearer maps. To maintain homogeneity within each land cover class, classes have to be built with broad and easy to understand classifiers. A large number of classes based on micro-level local information is appropriate for local level detail mapping, and such a scheme must be organized in order to be accommodated within the national level land cover maps.

We have used an approach based on spectral values and visual observation of super-resolution (2.5m colour images) images, which can be a basic need for any classification. We then added field observation information to the training site selection, class refining process, and accuracy assessment, which strengthens the classifiers used to break level 3 classes into the 4th or final level classes. As explained earlier, the classification gave satisfactory levels of accuracy while both maps being accommodated in the classification scheme based on FAO LCCS.

As explained in previous sections, classification gave satisfactory levels of accuracy with both maps. Generally, both land cover map were strongly related to the respective land cover feature on the ground. Figure 7 shows the relationship between classified land cover classes and actual ground features in a selected location from Hughenden area. In this example, a clear discrimination between green (No. 1) and silver colour (No. 2) tree clusters is visible and correctly classified in the map. Some land cover classes were not classified well (e.g., grassland, open - bright orange colour), due to the surface wetness changes between image acquired date and photo taken date. However, riparian forest (No. 3) is well mapped with number of trees types (Woody closed, Woody open, Low woody vegetation).

6. Conclusions

Australia's agriculture and mining based economy requires an accurate assessment of land use and land cover. However, mapping the country at 10m or finer resolution has just started and over 90% of the country is yet to be mapped. This study classified two distinctly different landscape plots in rural Queensland, Australia. The prime objective of the study was to build the classification system common for both regions using the fundamental approach of FAO Land Cover Classification System (FAO LCCS). The FAO LCCS has three initial class levels based on a priori (pre-defined) classification approach and the 4th detail level or the Modular-Hierarchical Phase. A careful observation of the spectral information against super resolution satellite data and ground survey information were used to select the classifiers for 4th level of the classification. For each map, different land cover types were identified under diverse geo-physical and climatic conditions for each respective region. Some classes ended with same name and same class identifier when the classifiers were similar to each other (e.g.; A12.2. woody open class in Hughenden map). The results showed a promising outcome for mapping different rural regions of Australia under a single classification scheme introduced by FAO. The maps were completed with a high accuracy and 10m spatial resolution will be a useful planning tool as well as a guide for mapping rest of the state as well as other rural areas of the country.

Acknowledgements

Authors are thankful to Mr. Jeremy Hayden of Southern Gulf catchments for providing satellite data and facilitating field investigation opportunity in mapped areas.

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