Review of Australian Land Use Mapping and Land Management Practice

Govinda Prasad Baral, Kevin McDougall, Albert Chong
Faculty of Engineering and Surveying & Australian Centre for Sustainable Catchments
University of Southern Queensland, Toowoomba 4350 QLD, Australia
GovindaPrasad.Baral@usq.edu.au, kevin.mcdougall@usq.edu.au, chonga@usq.edu.au

ABSTRACT*:*

Land use information plays a vital role in effective management of natural resources in any country. The land use and land cover mapping is always a dynamic issue in every country because of the changing nature of the land use. Australia is experiencing similar traits. Knowledge of land use change patterns has important implications for sustainable development and sustainable environmental management. It helps in the management of water, soil, nutrients, plants and animals and provides relationship between land use dynamics and economics and social condition in urban and regional area. Although Australia has a long history of land use mapping and land management practice, no systematic study of the land use mapping status and land management practice can be confirmed.

With the establishment of the Commonwealth Advisory Committee on the Environment in June 1972, later known as the Australian Advisory Committee on the Environment, the Australian government gave prime importance to land use and the environment. The committee recommended to the government that "Land use is fundamental to any consideration of the environment." The committee also found an urgent need for an efficient, co-ordinated, and comprehensive system of national and state land use planning. Subsequently, many organizations and institutions like BRS, ACLUMP, CSIRO, QDERM, and DPI started on land cover/land use mapping from national to catchment level and many Land Care groups began working on land management the local level. This study reviews the status of the land use mapping and land management practices as implemented in Australia

KEYWORDS: Land use, Land cover, ALUMP, Land Management Practice, Australia

1. BACKGROUND

On June 13th, 1992, nearly 100 heads of states, the biggest gathering of heads of states, met during "Earth Summit" in Rio de Janerio, Brazil to discuss the environment and development. This led to Agenda 21 - a very important document to guide the development of earth in a sustainable manner (AGENDA 21 1992). This document emphasizes the necessity of research to determine the capacity of land and the interaction among various land uses and environmental processes. Agenda 21 defines land as a "physical entity as well as a system of natural resources". Land resources include the soil, minerals, water, plants and animals in all their biological and generic diversity. An integrated approach to land use will provide a broader perspective from which to make informed choices regarding safest and most efficient use of land resources.

Below are a few programs and activities related to this research, from 19 of such programs suggested by Agenda 21 (AGENDA 21 1992).

1. Improved planning and management systems require more appropriate tools for data collection and interpretation. Detailed land inventories must be undertaken to determine the actual capacities of local land area.

2. Far more research is needed regarding land resource use potential and the interactions between the various factors affecting land use. Pilot projects based on an integrated approach to land use must be developed and tested. The results of these projects must be distributed to local and community land use planning groups in order to enable them to make decisions based on the latest available information.

These two programs suggested by Agenda 21 emphasize the need for improved methods of data collection, interpretation and implementation of land use maps at the local level. This highlights the relevance of this research since this research reviews the existing status of land use mapping in Australia against the notion of Agenda 21

Knowledge of land use change pattern has important implications in sustainable development and sustainable environmental management (Cheng et al. 2008; Tiwari et al. 2010). Australia has a long history of land use mapping and land management practice (AACE 1974) but no systematic studies of the status of land use mapping and the land management practice were found.

National Land and Water Resources Audit convened a land cover workshop in Canberra on the 24th July 2007 (Audit 2007). A pre-workshop meeting was held to determine the agenda and identify who should attend. Representatives from various levels of government, who had a vested interest in land cover identified user requirements for a number of natural resource themes such as soils, water and vegetation. User needs, applications and gaps were also identified. Many speakers highlighted the necessity of improvement of the land use classification method and establishing collaboration and partnership between the stakeholders to avoid duplication of work. One of the key issues and challenges determined by the workshop was that a refined "Classification system needs to be determined/developed/endorsed. There are many land cover classification systems. An Australian standard classification system will need to be determined by the co-investors and collaborators" (Audit 2007).

2. CLARIFICATION OF TERMINOLOGY

There is often confusion among the terms 'land use' and 'land cover'. They may be applied in the same context, perhaps because of the common use of remotely sensed satellite imagery or photography for mapping. The distinction between 'land use' and 'land management practice' is also not always well understood (Lesslie 2004). A number of land related terms and classifications are often used to describe the earth's surface characteristics, the production capability of land, the uses to which land is put and the ways in which land is managed. Mixed use of terminology can cause confusion as to the specific component being described or assessed by particular initiatives (Audit 2007).

2.1. Land Cover

Land Cover is the observed biophysical cover on the earth's surface (Gregorio & Jenson 2000). Land cover refers to the observed physical surface of the earth, including various combinations of vegetation types, soils, exposed rocks, water bodies (BRS 2006).

2.2. Land Use

Land use refers to the purpose to which land is committed, including the production of goods (such as crops, timber and manufacturing) and services (such as defence, recreation, and biodiversity and natural resources protection). Some land uses, such as cropping, have a characteristic land cover pattern. These land uses frequently appear in land cover classifications. Other land uses, such as nature conservation, are not readily discriminated by a characteristic land cover pattern. For example, where the land cover is woodland, land use may be timber production or nature conservation (BRS 2006).

Figure 1 below illustrates the differences between land use and land cover and their implications

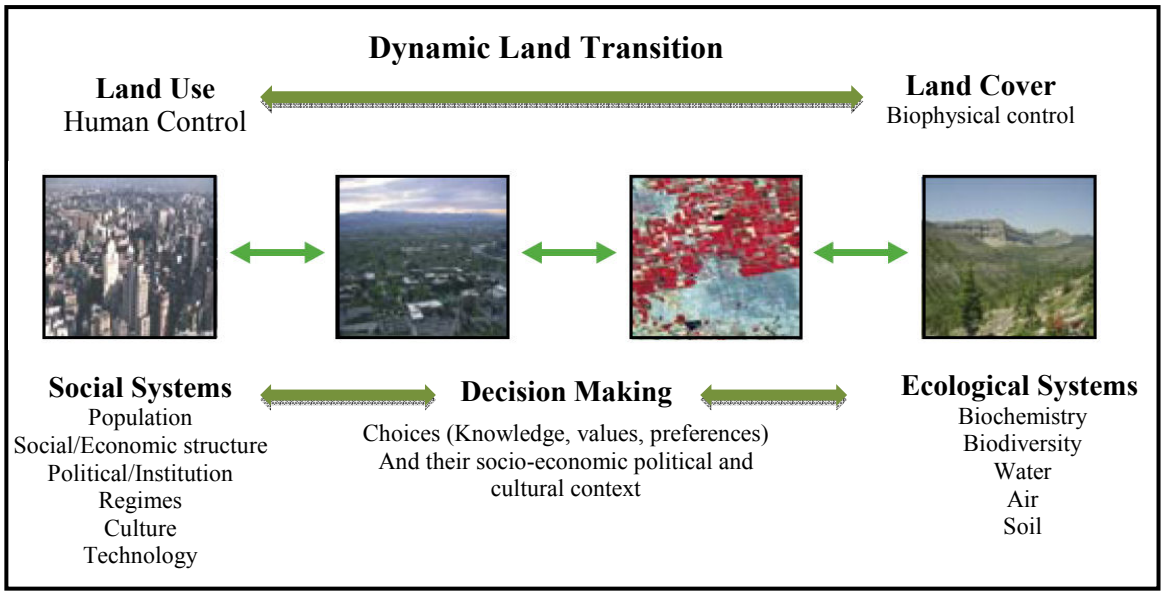

Figure 1. Land use - land cover relations (Adapted from Global Plan Report (GLP 2005))

2.3. Land management practice

Land management practice means the approach taken to achieve a land use outcome — the 'how' of land use (e.g. cultivation practices, such as minimum tillage and direct drilling). Some land management practices, such as stubble disposal practices and tillage rotation systems, can be discriminated by their characteristic land cover patterns (ACLUMP 2010a).

2.4. Land capability and land suitability

Land capability assesses the limitations to land use imposed by land characteristics and specifies management options. Land suitability (assessed as part of the process of land evaluation) is the fitness of a given type of land for a specified kind of use(ACLUMP 2010a).

3. LAND USE AND DEVELOPMENT

The development and use of land has been a fundamental human activity since the dawn of agriculture and the permanent human settlements. Hamlets, villages, towns, and cities evolved to accommodate larger populations and the developing needs of society for livelihood, security, commerce, and culture (Randolph 2004). Information on land use and land management practices is essential for the sustainable management and economic development of natural resources. Information regarding the current state of resources and how they are being managed is required to predict future states. It is also crucial to the understanding of land degradation processes, for predicting their potential outcomes as well as for the evaluation of natural resource and agricultural investment strategies (Rowland & Calvert 2000). The industrial revolution, the expansion of the railway and transportation, the advancement in communication means and so on changed the urban settlement pattern and the land development. Most people live in urban and suburban areas hence considerable attention is given to land use of such areas. John Randolph in his book Environmental Land Use Planning and Management (Randolph 2004) states "Rural and small-town land use and development are also important in environmental land use management for three regions. First, these greenfield areas are home to important ecological, cultural, and agricultural resources. Second, inherent use of rural land for resource production of agriculture, forestry, and mineral extraction has considerable environmental impact. And third, rural places are increasingly attractive as people grow weary of the congestion and lifestyle of the city and suburbs. As a result, sprawling patterns of rural development are impacting them at an increasing rate"

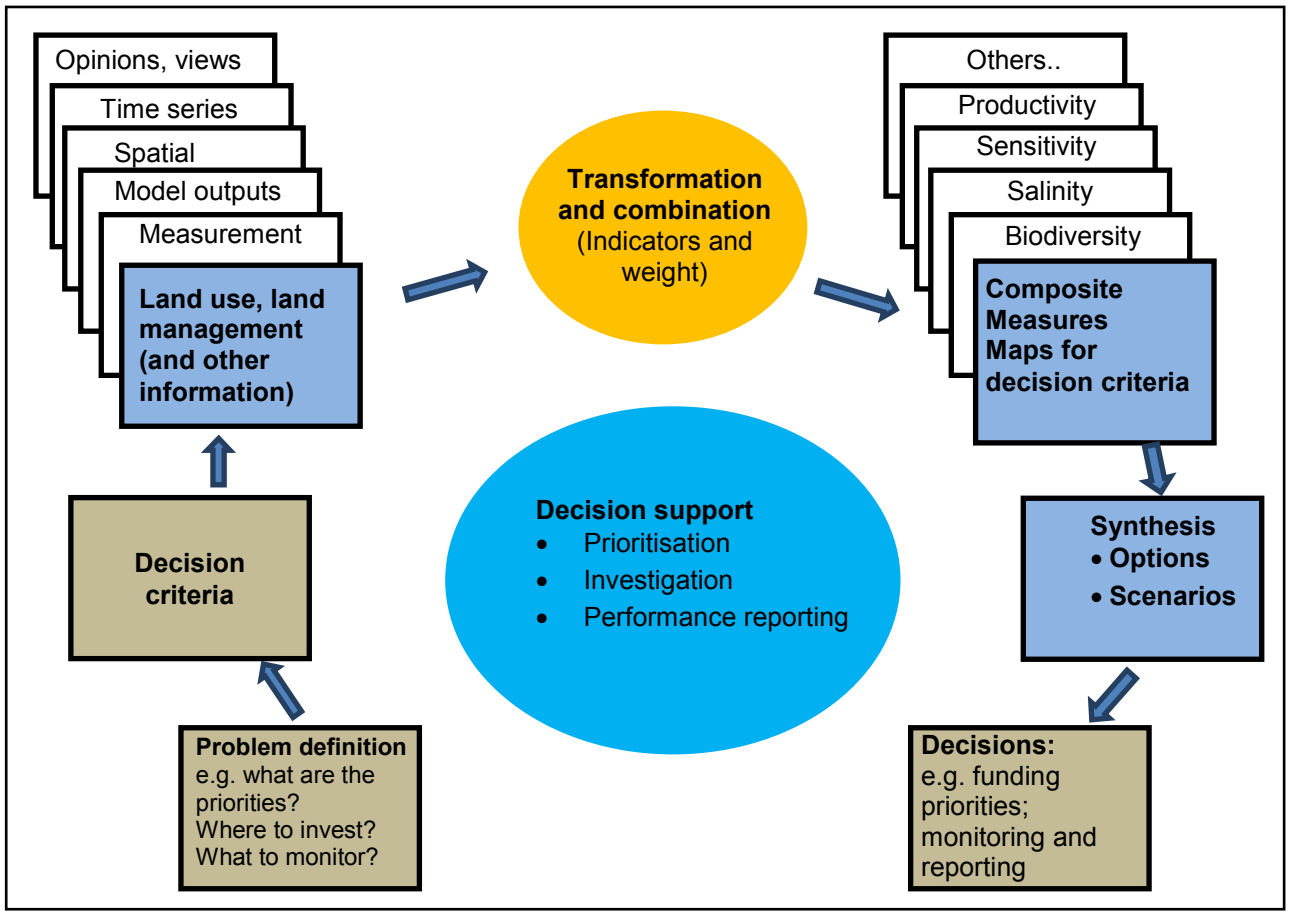

Figure 2. The contribution of land use and land management practices information to policy and program decision making (Adapted from ACULUMP(2010b))

Whatever the reason, development and land use are interdependent (Figure 2); forming the basis for sustainable land use management which is the basis for urban and rural land use planning.

4. HISTORY OF LAND USE IN AUSTRALIA

With the establishment of the Commonwealth Advisory Committee on the Environment in June 1972, later known as the Australian Advisory Committee on the Environment, the Australian government gave prime importance to land use and the environment. The committee recommended to the government that "Land use is fundamental to any consideration of the environment, and that land use management is one of the most important single elements affecting the quality of environment"(AACE 1974). The committee also found an urgent need for an efficient, co-ordinated, and comprehensive system of national and state land use planning as part of the broad spectrum of natural resources planning and management.

Similar views were also reflected in reports from the United Nations Conference on the Human Environment, in Stockholm June 1972, stressing the importance of resource management for the preservation and improvement of the environment, and including recommendations aimed at promoting the development of methods of integrated planning and management of natural resources (AACE 1974). The map and table below show land use distribution in Australia (Figure 3 and Table 1).

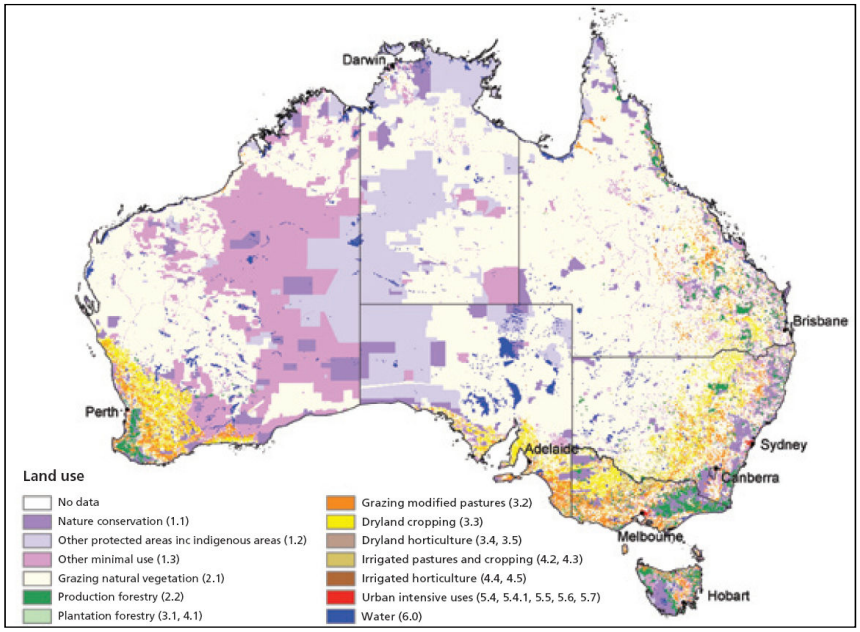

Figure 3. Land use mapping at national scale for the National Land & Water Resources Audit ALUM Classification (v6)

Table 1. ACLUMP National scale land uses 2005–06(ACLUMP 2010b)

Land use	Area (Sq. Km)
Nature conservation	571,483
Other protected areas including Indigenous uses	1,015,359
Minimal use	1,242,715
Grazing natural vegetation	3,558,785
Production forestry	114,314
Plantation forestry	23,929
Grazing modified pastures	720,182
Dryland cropping	255,524
Dryland horticulture	1,092
Irrigated pastures	10,011
Irrigated cropping	12,863
Irrigated horticulture	3,954
Intensive animal and plant production	3,329
Intensive uses (mainly urban)	16,822
Rural residential	9,491
Waste and mining	1,676
Water	125,618
Total	7,687,147

The committee recommended that because of the necessity of a national survey of land attributes, research on ecological relationships, national resource data banks and inventories be investigated as these form the basis for land use mapping and conducting research in this field. After that many organizations and institutions like BRS, ACLUMP, CSIRO, SLATS, DPI etc. worked on land cover/land use mapping in national to catchment level and many Land Care groups started working on land management at the local level.

Before 1999 the availability of detailed mapping in Australia was limited and uncoordinated. Australian and State government agencies independently produced land use mapping at a range of scales using a variety of cartographic methods and classification systems. A collaborative national land use mapping initiative was established in 1999 by the Audit, the Department of Agriculture, Fisheries and Forestry (DAFF), the Bureau of Rural Sciences (BRS), the Murray-Darling Basin Commission and State agency partners. In 2000 DAFF accepted leadership for the national coordination of land use information and BRS took on responsibility for the development of ACLUMP. This is continued under the Audit's current national information coordination arrangements. Mapping products are now in strong demand, and there is widespread adoption of agreed standards (ACLUMP 2010d). Australian Bureau of Agriculture, Resource Economics and Sciences (ABARES) under Department of Agriculture, Fishery and Forestry is formed by merging the Bureau of Rural Sciences and the Australian Bureau of Agriculture and Resource Economics in July 2010. The merger enabled the bureau to provide an integrated research offering to allow evidence-based policy making by both science and economic analysis and advice (ABARES 2011). At the state level, Queensland Land Use Mapping Program (QLUMP) maps Queensland at catchment scale using Australian Land Use and Management (ALUM) classification scheme which has a three-tiered hierarchical structure with primary, secondary and tertiary classes (Rowland et al. 2002).

5. LAND USE MAPPING AND MANAGEMENT INITIATIVES IN AUSTRALIA

Land cover had been identified as a critical information need for national and regional reporting and decision making by the National Land & Water Resources Audit (the Audit), Geoscience Australia (GA), the Bureau of Rural Sciences (BRS), the Commonwealth Scientific Industrial Research Organisation (CSIRO) and most of the national coordinating committees (representing all jurisdictions). There have been a number of land cover related projects undertaken in Australia by Australian Government departments, including the Agricultural Land Cover Change (ALCC) Project, the National Vegetation Information System (NVIS), Australian Land Use and Management (ALUM), Vegetation Assets and Transition (VAST) and the Australian Greenhouse Office National Carbon Accounting System (NCAS) Land Cover Change Program (Audit 2007).

The major initiatives for land use/land cover mapping are presented in the following sub-sections.

5.1. ACCLUMP

The Australian Collaborative Land Use Mapping Program (ACLUMP) is a consortium of Australian and State Government partners. The program is part of the national natural resource information co-ordination arrangements established by the National Land & Water Resources Audit (the Audit). ACLUMP promotes the development of nationally consistent land use and land management practices and information for Australia (ACLUMP 2010d). ACLUMP activities are financially supported by program partners, the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality.

5.1.1. Stakeholders in land use mapping and management in Australia

Listed below are the major players in land use mapping and management activities especially those who are partners of ACLUMP:-

State agency partners:

- New South Wales - Department of Infrastructure, Planning and Natural Resources
- Northern Territory - Department of Infrastructure, Planning and Environment
- Western Australia - Department of Agriculture
- Queensland - Department Environment and Resources Management

- South Australia - Department of Water, Land and Biodiversity Conservation
- Victoria - Department of Primary Industries
- Tasmania - Department of Primary Industries, Water and the Environment

Australian Government partners:

- Department of Agriculture, Fisheries and Forestry
- Australian Bureau of Agriculture, Resource Economics and Sciences (ABARES)
- National Land & Water Resources Audit
- Murray-Darling Basin Commission
- Australian Greenhouse Office

Others:

- Natural Heritage Trust
- National Action Plan for Salinity and Water Quality
- Local Authorities
- Land care groups

5.2. LUMIS

The mechanism for developing a collaborative program to record and map land management practices is a Land Use and Management Information System (LUMIS). The first of concern to LUMIS is information about actual on-ground action by resource managers. The second is that information about capacity and willingness of managers to make changes in how they manage, is highly relevant but outside the scope of LUMIS (ACLUMP 2010c).

The LUMIS development is advised by the National Committee for Land Use and Management Information (NCLUMI). Its membership includes Australian and State Government partners. Its work is sponsored by the Australian Government Department of Agriculture, Fisheries and Forestry with day-to-day management provided by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). NCLUMI and its technical advisory group(s) need to ensure that LUMIS development maintains consistency with the Australian Land Use and Management (ALUM) classification.(ACLUMP 2010c)

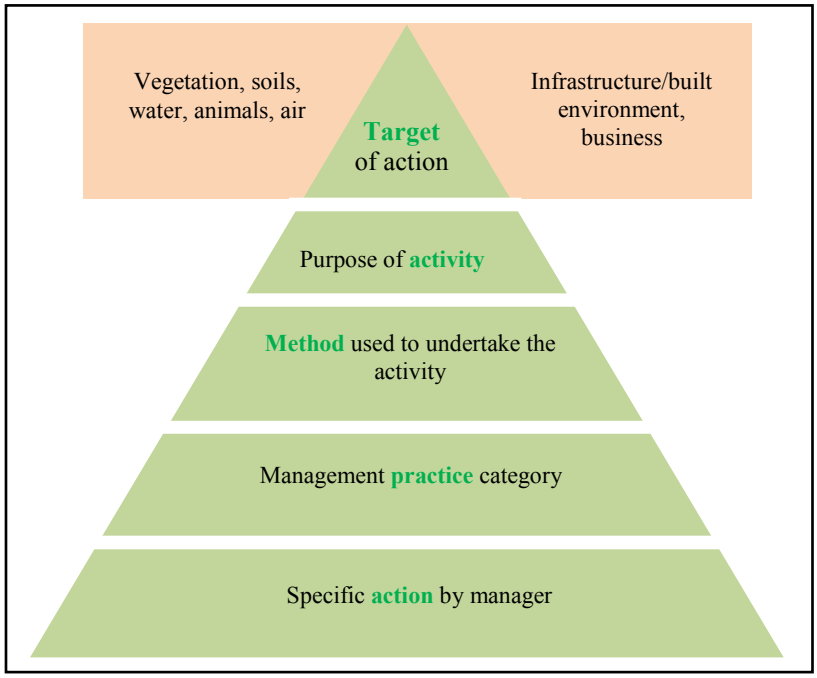

Figure 4: LUMIS's hierarchical system from target to action (BRS 2011)

There are too many different management actions across Australia to collect and map them individually. To deal with this problem, LUMIS groups related management actions into a number of standardised categories. These categories — what we are calling 'practices' — can be

hierarchically organised to show their direct relationships to the primary 'object' that is being managed (e.g. vegetation or water or animals). LUMIS will accommodate land management practices information compiled at varying levels of detail and mapping scale. It will also include technical specifications for spatial sampling and data collection. Figure 4 shows the hierarchical system of LUMIS (BRS 2011).

5.3. Land use classification schemes

The ALUM Classification has a three-tiered hierarchical structure with primary, secondary and tertiary classes broadly structured in terms of the potential degree of modification and impact on a putative 'natural state' (essentially unmodified native land cover).

Primary and Secondary classes relate to land use - the prime use of the land defined in terms of the management objectives of the land manager. Tertiary classes can include commodity groups, commodities, land management practice, or land cover (e.g. vegetation) information. Tertiary agriculture classes have been based on Australian Bureau of Statistics commodity groups as well as dominant land management practices.

ALUM Primary classes are as given below-

a) *Conservation and natural environments* - Land used primarily for conservation purposes, based on the maintenance of the essentially natural ecosystems present.
b) *Production from relatively natural environments* - Land used primarily for primary production with limited change to the native vegetation.
c) *Production from dryland agriculture and plantations* - Land used mainly for primary production, based on dryland farming systems.
d) *Production from irrigated agriculture and plantations* - Land used mostly for primary production based on irrigated farming.
e) *Intensive uses* - Land subject to extensive modification, generally in association with closer residential settlement, commercial or industrial uses.
f) *Water* - Water features. Water is regarded as an essential aspect of the classification, but it is primarily a cover type.

The classification is intended to be flexible such that new land uses or management systems can be accommodated as long as there is no conflict with other existing items.

5.4. Land use classification method used in Australia

Land-use history – the number, type, and duration of previous land uses – is relevant to many questions (Kasel & Bennett 2007).

A joint Commonwealth-State workshop in February 1999 agreed that a modified version of a classification scheme developed by Baxter and Russell in 1994 would be suitable as a land use classification for Australia (BRS 2006). It would promote the creation of nationally consistent, although not necessarily uniform, land use data sets, meet a wide range of user needs, and make the best use of existing data and available resources (BRS 2002). A flow diagram showing the land use mapping method used in Australia is given below (Figure 5).

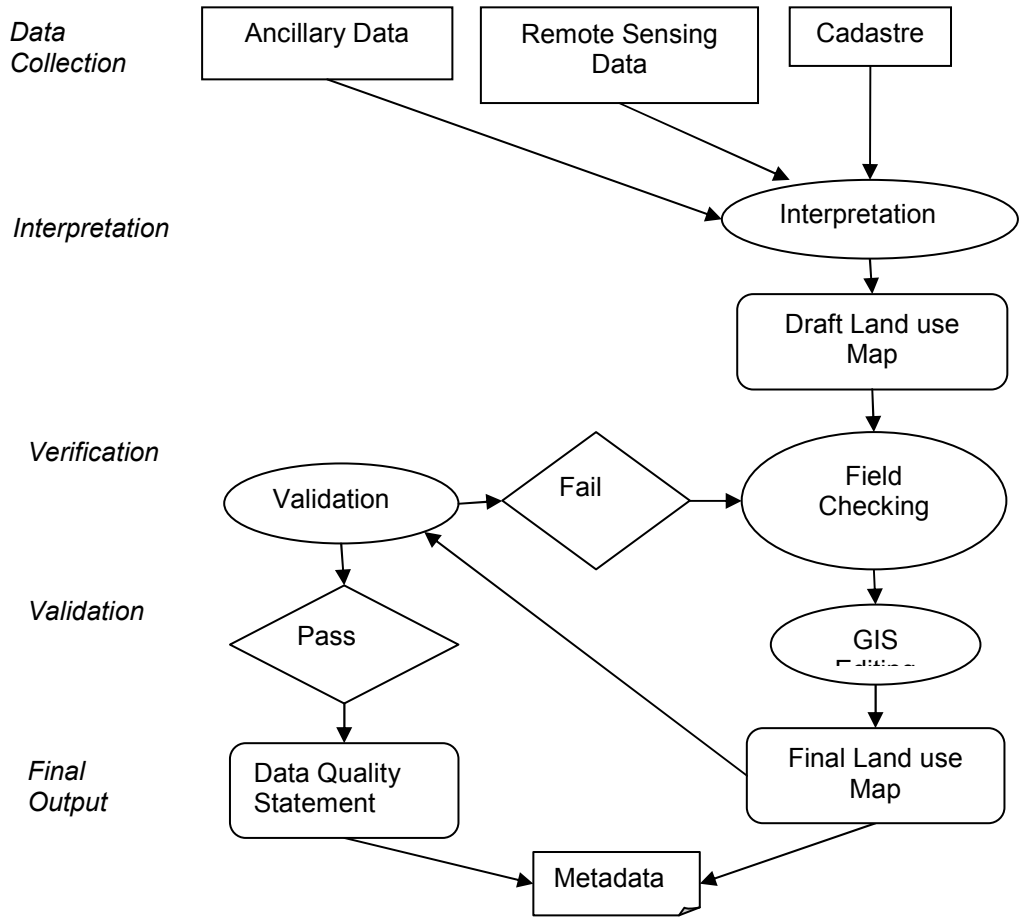

Figure 5: Land use mapping procedure (Rowland et al. 2002)

6. CHALLENGES AHEAD

Sustainable land management is a central challenge in the sustainable management of earth systems and resources. On the one hand, land management must ensure a growing supply of food and other resources to human populations, which are expected to grow for decades to come. On the other hand, management of land to procure these resources is linked with potentially negative consequences in the form of climate change, biodiversity loss and pollution. Moreover, local alteration of land use and land cover can have global consequences, requiring local and regional solutions to global problems and the cooperation of the world's policymakers, land managers, and other stakeholders in land management at local, regional and global scales(Ellis 2010).

Land use information is currently being used in Australia to manage catchment salinity, nutrient and sediment problems, measure greenhouse gas emissions and sinks, assess agricultural productivity and opportunities for agricultural diversification, for land value determination, in local and regional planning, pest and disease control and emergency response planning. Vegetation management, monitoring greenhouse gas emission from tree clearing, rural leasehold land strategy, controlling spread of woody weeds, dam safety and water use, water quality monitoring are the major drivers for land use mapping. Although there is huge requirement for up to date and precise land use data, there are still many challenges to overcome. Issues of spatial and temporal scales that are fit for the purpose of planning and development at national land regional level is to be addressed. It is essential to define/modify land use/cover classes according to the needs of the users.

Listed below are few of many challenges for Australian land use mapping against the user requirement.

- developing effective mapping tools for land use decision makers
- establishing appropriate land use mapping standards and specifications

- using existing data from land use layers to create a baseline, avoid mismatching and conflicting data
- avoiding duplication of effort between different data sets
- facilitating and coordinating land use mapping across jurisdictions
- time series land use data creation
- greater resolution land use/cover information using multi sensor images as an alternative to Landsat images
- introducing new applications like water quality, riparian vegetation.

7. CONCLUSION AND RECOMMENDATIONS

It is obvious that state and local agencies have requirements of higher scale data than Australian Government agencies. Existing National Scale (1:1 000 000 to 1:2 500 000), and Regional and Catchment scale (1:25 000 – 1:250 000) land use dataset may not be sufficient to meet the increasing demand of users. Higher scale land use datasets are the up to sub-catchment level (up to 1:10 000) is the requirement of time. This is only possible if we have a cohesive partnership between the stakeholders to avoid the duplication of work and sharing data, resources and knowledge. A consistent set of land use classes should be developed and the current land use classification scheme should be modified for the automation of classification process and to make it friendly across different satellite sensors. A common repository of time series data sets in different scale should be created. A mechanism should be developed to serve these very large data sets to meet client requirements.

This study reviewed the state-of-the-art status of Australian land use mapping. As stated before, up to date and accurate land use information is the basis of sustainable development and sustainable environment. To keep an equal footing between the development and environment such up to date land use information plays an important role.

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