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Mapping Land Use

Land Use Change Mapping from 1999 to 2004 for the Fitzroy River Catchment



Queensland Government
Natural Resources and Water

National Land & Water Resources Audit
An Initiative of the Natural Heritage Trust

Australian Government
Bureau of Rural Sciences

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Land Use Change Mapping from 1999 to 2004 for the Fitzroy River Catchment

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(Queensland Department of Natural Resources and Water)

November 2006

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ISBN 1-7417-2347-7
November 2006

Land use change mapping was undertaken by the QLUMP team, Natural Resource Sciences, Indooroopilly and Spatial Products and Analysis, Mareeba.

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Front Page Photographs
Grazing lands photos supplied by the Statewide Landcover and Trees Study (SLATS), Department of Natural Resources and Water
Background photo supplied by Robert Hassett, Climate Impacts and Natural Resource Systems, Queensland Department of Natural Resources and Water.

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Introduction

The Department of Natural Resources and Water (NRW) through the Queensland Land Use Mapping Program (QLUMP; www.nrm.qld.gov.au/science/lump) has produced a consistent and seamless statewide land use dataset for the year 1999. This dataset and the mapping methodology are described by Witte *et al.* (2006). The 1999 land use dataset for Queensland provides the basis for monitoring and mapping of land use change.

Information on land use change is important for reporting on trends within catchments or regions. Spatial land use change data is critical for monitoring processes within the landscape and the effectiveness of natural resource management objectives relating to these. This includes salinity and water quality, rates of soil erosion, acidification, nutrient decline and carbon losses. Changing patterns in land use also have strong links to economic and social activities within a catchment or region.

Land use change mapping from 1999 to 2004 has occurred in the Fitzroy, Johnstone and Burdekin River catchments. This report briefly documents the methodology used for mapping land use change in the Fitzroy River catchment and the various products:

- the 1999 land use dataset which includes a number of improvements and corrections to the previous 1999 dataset
- the 2004 land use dataset
- the land use change dataset from 1999 to 2004
- summary statistics derived from the above spatial datasets
- the results of the accuracy assessment.

Funding for this project was provided by the National Land and Water Resources Audit and the Queensland Department of Natural Resources and Water.

QLUMP is part of the Australian Collaborative Land Use Mapping Program (ACLUMP; www.brs.gov.au/landuse) which is coordinated by the Bureau of Rural Sciences (BRS) in Canberra and involves agencies in all states and territories of Australia. ACLUMP promotes the development of nationally consistent land use and land management practices information for Australia. BRS (2006) provides the guidelines for ACLUMP including principles and definitions.

Catchment overview

The Fitzroy River catchment is approximately 14.26 million hectares in area and stretches from the Carnarvon Gorge National Park in the West to Rockhampton on the central Queensland coast. It is the largest river basin on the Queensland east coast and contains the regional centres of Rockhampton, Emerald, Biloela and Taroom.

The catchment is dominated by savannah woodlands and grasslands, with livestock grazing the primary land use. Production forestry, cropping and National Parks comprise the next major uses, and extensive mining areas are also present in the catchment area. Cereals and cotton are the major crops grown.

Objectives

The primary objectives of this project were to:

- develop a methodology to map land use change which is applicable to a broad range of catchments
- apply this methodology to the Fitzroy River catchment and produce a detailed land use dataset for 2004
- produce an improved land use dataset for 1999 which includes more detailed attributing of crops and horticulture land uses
- produce a land use change layer between the years of 1999 and 2004
- assess and describe the accuracy of the land use data.

These datasets can then be utilised for a range of natural resource management applications.

Methodology

An effective method for detecting and mapping land use change has been developed and applied in the Fitzroy River catchment. The methodology makes best use of available spatial information, satellite imagery, airphotos, expert knowledge and field survey. It involves successive stages of data collation, interpretation, verification, validation and production of final outputs.

The mapping scale is 1:50,000 with a minimum mapping unit of 1ha and a width of 50 metres for linear features.

The Fitzroy catchment was clipped from the statewide 1999 land use data (for details see Witte *et al.*, 2006) and formed the basis for the 2004 land use dataset. The 1999 and 2004 datasets were then improved and updated, primarily by interpretation of Landsat TM and ETM+ imagery, multi-temporal MODIS imagery, scanned aerial photography and inclusion of expert local knowledge. This was performed in ERDAS Imagine by overlaying the land use datasets on Landsat imagery (1999, 2000, 2001, 2004) and digitising or modifying areas previously omitted or incorrectly mapped (1999 mapping) as well as areas of actual and potential land use change (2004).

Automated interpretation of 16-day MODIS NDVI images (April 2000 to December 2004) was used to detect potential agricultural land use changes and provided valuable information on crop/pasture rotations. Detailed interpretation of Landsat imagery and airphotos was used to verify and delineate a subset of these potential land use changes.

A number of additional datasets were utilised to identify potential land use changes, including:

- woody vegetation change mapping by the Statewide Landcover and Trees Study (SLATS)
- the Queensland Valuations and Sales System (QVAS) data
- the digital cadastral database (DCDB)
- estates data (National Parks, Forest Reserves, State Forests and Timber Reserves)

Digitised areas of uniform land use type were assigned to classes according to the Australian Land Use and Management Classification Version 6 (ALUM Version 6; see Appendix 1 and BRS 2006 for more detail). Local authorities, regional QNRW, other state government departments, landholders and managers supplied information and confirmed land uses not identified from the satellite images and other data. Field checking was undertaken in areas where the land use was still uncertain.

When mapping land use change, cropping and horticultural areas in both the 1999 and 2004 land use datasets were attributed to the tertiary level of ALUMC Version 6 wherever possible. Previously,

cropping and horticultural areas were attributed to the secondary level with the exception of *sugar*, *irrigated sugar* and *irrigated cotton*.

Using the 2004 and improved 1999 land use datasets as inputs, a differencing algorithm was developed using a python script. This produced a dataset representing the change between the two images (1999-2004) including the land use change classes (eg. from *grazing natural vegetation* to *cropping*) which were included in the attribute table.

An independent validation of the 1999 and 2004 land use maps as well as the land use change layer was undertaken. This used a stratified random sampling methodology to assess thematic (attribute) accuracy under the ALUM classification. It should be noted that only a subset of classes was sampled for this exercise. The primary focus of the accuracy assessment was for agricultural land use classes, and non-agricultural land uses were not specifically sampled.

Land use was assessed by a combination of landholder survey and by QLUMP officer assessment. 387 letters were sent to landholders throughout the catchment on 10th July 2006. Each letter included a map with a marked point. Landholders were asked to describe the land use for 1999 and 2004 at that point. Points were selected randomly from agricultural land use classes, and no individual landholder received more than two letters. 228 responses were received with sufficient information to determine the land use at each marked point. An additional 48 points were also assessed through interpretation of Landsat imagery, aerial photographs and referral to ancillary datasets. These were primarily focussed on determining the accuracy of the land use change map.

Further information on data specifications and land use mapping procedures are provided by BRS (2006).

Products

1999 and 2004 land use data

Figure 1 shows the 2004 land use map with data aggregated to the secondary level of the ALUM classification (see Appendix 1 for the classification).

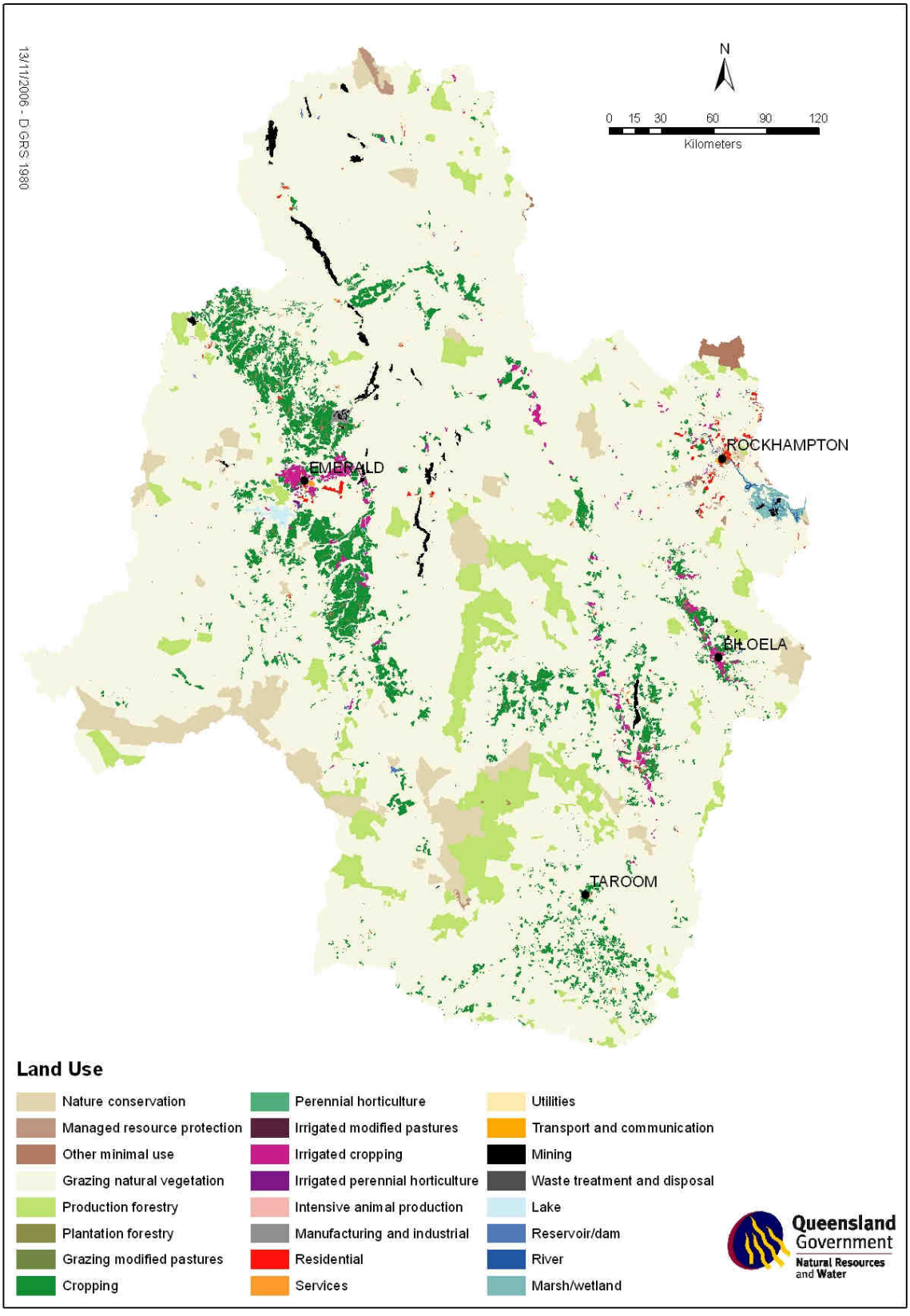


Figure 1: 2004 land use map for the Fitzroy River catchment

Some tertiary classes, such as *irrigated cotton* (part of *irrigated cropping*), *dairies* (part of *intensive animal production*), *rural residential* (part of *residential*) and various classes under *nature conservation* have been mapped, but were not shown separately in Figure 1.

The 1999 land use map is not included in this report, as most differences (change) between this and the 2004 map would be difficult to observe at report scale. Tables 1 and Table 2 show the summary statistics for the 1999 and 2004 land use datasets respectively.

Land Use Code	Land Use Classes	Area ha	Area %
1	Conservation and natural environments	635,018	4.45
1.1	Nature conservation	547,856	3.84
1.2	Managed resource protection	19,898	0.14
1.3	Other minimal use	67,264	0.47
2	Production from relatively natural environments	12,564,537	88.13
2.1	Grazing natural vegetation	11,578,235	81.21
2.2	Production forestry	986,302	6.92
3	Production from dryland agriculture and plantations	798,567	5.60
3.1	Plantation forestry	13	<0.01
3.2	Grazing modified pastures**	454	<0.01
3.3	Cropping	797,589	5.59
4	Production from irrigated agriculture and plantations	81,097	0.57
4.2	Irrigated modified pastures**	100	<0.01
4.3	Irrigated cropping	79,059	0.56
4.3.5	Irrigated sugar*	99	<0.01
4.3.6	Irrigated cotton*	25,020	0.18
4.4	Irrigated perennial horticulture	1,938	0.01
5	Intensive uses	118,503	0.83
5.2	Intensive animal production	1,111	0.01
5.3	Manufacturing and industrial	9,324	0.07
5.4	Residential	26,465	0.19
5.5	Services	6,557	0.05
5.6	Utilities	1,054	0.01
5.7	Transport and communication	1,689	0.01
5.8	Mining	72,210	0.51
5.9	Waste treatment and disposal	91	<0.01
6	Water	59,270	0.42
6.1	Lake	14,162	0.09
6.2	Reservoir/dam	10,550	0.07
6.3	River	5,861	0.04
6.5	Marsh/wetland	28,697	0.20
	Grand total	14,256,991	100

* The area of *irrigated sugar* and *irrigated cotton* are subsets of the total area of *irrigated cropping*.
** *grazing modified pastures* and *irrigated modified pastures* in this case refers to areas of *Leucaena* that were mapped opportunistically. They are not an accurate representation of the total extent of *Leucaena* in the catchment.

Table 1: Summary statistics of land uses in 1999 in the Fitzroy River catchment

Land Use Code	Land Use Classes	Area ha	Area %
1	Conservation and natural environments	706,004	4.95
1.1	Nature conservation	619,011	4.34
1.2	Managed resource protection	19,898	0.14
1.3	Other minimal use	67,095	0.47
2	Production from relatively natural environments	12,483,087	87.56
2.1	Grazing natural vegetation	11,537,856	80.93
2.2	Production forestry	945,231	6.63
3	Production from dryland agriculture and plantations	801,344	5.62
3.1	Plantation forestry	13	<0.01
3.2	Grazing modified pastures**	35	<0.01
3.3	Cropping	800,780	5.62
3.3.5	Sugar*	246	<0.01
3.4	Perennial horticulture	517	<0.01
4	Production from irrigated agriculture and plantations	85,755	0.60
4.2	Irrigated modified pastures**	100	<0.01
4.3	Irrigated cropping	82,399	0.58
4.3.5	Irrigated sugar*	99	<0.01
4.3.6	Irrigated cotton*	24,971	0.18
4.4	Irrigated perennial horticulture	3,256	0.02
5	Intensive uses	120,265	0.84
5.2	Intensive animal production	1,111	0.01
5.3	Manufacturing and industrial	9324	0.07
5.4	Residential	26,541	0.19
5.5	Services	6558	0.05
5.6	Utilities	1,054	0.01
5.7	Transport and communication	1,725	0.01
5.8	Mining	73,861	0.52
5.9	Waste treatment and disposal	91	<0.01
6	Water	60,535	0.43
6.1	Lake	14,162	0.09
6.2	Reservoir/dam	11,815	0.08
6.3	River	5,861	0.04
6.5	Marsh/wetland	28,697	0.20
	Grand total	14,256,991	100

* The area of *sugar* is a subset of the total area of *cropping* and the area of *irrigated sugar* and *irrigated cotton* are subsets of the total area of *irrigated cropping*.
** *grazing modified pastures* and *irrigated modified pastures* in this case refers to areas of *Leucaena* that were mapped opportunistically. They are not an accurate representation of the total extent of *Leucaena* in the catchment.

Table 2: Summary statistics of land uses in 2004 in the Fitzroy River catchment

The above tables show that grazing is by far the major land use in the Fitzroy catchment occurring on over 11 million ha or approximately 80.9% of the catchment in 2004 and 81.2% in 1999. Production forestry is the second major land use occurring over 945,231 ha (6.6%) of the catchment in 2004 and 986,302 ha (6.9%) in 1999. The estimate for *cropping* (dryland) is 800,780 ha (5.62%)

for 2004 and 797,589ha (5.59%) for 1999. Nature conservation covers 619,011 ha (4.34%) in 2004 and 547,857 ha (3.84%) in 1999.

Data limitations

The ALUMC class *grazing modified pasture* and *irrigated modified pastures* are usually not included in QLUMP data. All grazing in Queensland is classed as *grazing natural vegetation*, due to the difficulty in identifying and separating these classes using imagery, aerial photography and field observation. *Grazing modified pasture* and *irrigated modified pastures* are listed in the summary statistics (Tables 1 and 2) but in this case refer only to specific areas of the fodder crop *Leucaena*. This was mapped opportunistically in the Fitzroy catchment and does not provide an accurate representation of the total area of *Leucaena* in the catchment.

Areas mapped as *dairies* include grazing areas and associated fodder crops. Cadastral parcels are often used to identify the extent of a dairy farm. It is possible that parts of these parcels include other land uses, such as grazing beef cattle. Such areas may have been incorrectly classified as *dairy*.

Land uses that are linear, such as roads and railways, are generally not mappable at a scale of 1:50,000 with a specified minimum mapping width of 50m and 100m respectively. As a result, the area estimates of these linear features represent only a small proportion of the actual area under this land use in Queensland. This is of relevance to the following land use classes:

- *stock route* (under *other minimal use*)
- *transport and communication*
- *utilities*
- *channel/aqueduct*.

The 1999 and 2004 land use datasets are snapshots in time showing what was considered the primary land use for each of those years. However, some effort was given to distinguishing between an actual land use change and a rotation. For example, an area that is usually cropped, but is not used for a particular purpose in the year of interest, was still mapped as cropping in the 2004 dataset even though no crop was present in that year. This was not considered an actual land use change, but rather a rotation, as the primary land use for that paddock was still cropping.

A number of data sources were used to identify *irrigated cropping* and *irrigated horticulture*. This includes irrigation infrastructure mapping, the location of water entitlements (irrigation licences), local knowledge, field survey and image interpretation. It is possible, that areas mapped as irrigated cropping, for example, may only be irrigated on a supplementary basis and were not actually irrigated in either 1999 or 2004.

The ephemeral nature of many water features can lead to confusion as they may be present in imagery of one date and either absent or of differing extent in imagery of subsequent or previous dates. As a result, there are likely to be errors and omissions and some disagreement in the mapping of features such as farm dams, reservoirs, lakes, wetlands and other water features.

The metadata for the datasets should be consulted for details on the mapping of specific classes.

1999 to 2004 land use change data

The total area of mapped land use change from 1999 to 2004 in the Fitzroy River catchment is 94,529 hectares. That's 0.66% of the catchment. A breakdown of the change classes by area is shown in Table 3. The major changes were *production forestry* to *natural feature protection* (44,374 ha), *grazing natural vegetation* to *other conserved area* (predominantly nature refuges) (27,462 ha) and *grazing natural vegetation* to *cropping* (5,826 ha).

Land Use Code	Land Use Class	Land Use Code	Land Use Class	Area of change	Area of Catchment
1999	1999	2004	2004	ha	%
2.2.0	Production Forestry	1.1.4	Natural feature protection	44,374	0.31
2.1.0	Livestock Grazing	1.1.7	Other conserved area	27,462	0.19
2.1.0	Livestock Grazing	3.3.0	Cropping	5,826	0.04
2.1.0	Livestock Grazing	2.2.0	Production Forestry	2,840	0.02
2.1.0	Livestock Grazing	4.3.0	Irrigated Cropping	2,753	0.02
3.3.0	Cropping	2.1.0	Livestock Grazing	2,040	0.01
3.3.0	Cropping	4.3.0	Irrigated Cropping	2,006	0.01
2.1.0	Livestock Grazing	5.8.0	Mining	1,647	0.01
4.3.0	Irrigated Cropping	3.3.0	Cropping	1,378	0.01
2.1.0	Livestock Grazing	6.2.0	Reservoir/dam	1,160	0.01
2.1.0	Livestock Grazing	4.4.0	Irrigated Perennial Horticulture	1,122	0.01
3.2.2	Woody fodder plants	2.1.0	Livestock Grazing	419	<0.01
3.3.0	Cropping	6.2.0	Reservoir/dam	272	<0.01
2.1.0	Livestock Grazing	3.3.5	Sugar	246	<0.01
3.3.0	Cropping	4.4.0	Irrigated Perennial Horticulture	194	<0.01
1.3.0	Other Minimal Use	3.3.0	Cropping	152	<0.01
4.3.6	Irrigated cotton	2.1.0	Livestock Grazing	109	<0.01
2.1.0	Livestock Grazing	4.3.6	Irrigated cotton	92	<0.01
6.2.0	Reservoir/dam	4.3.0	Irrigated Cropping	66	<0.01
4.3.0	Irrigated Cropping	2.1.0	Livestock Grazing	61	<0.01
2.1.0	Livestock Grazing	5.4.0	Residential	61	<0.01
6.2.0	Reservoir/dam	3.3.0	Cropping	58	<0.01
6.2.0	Reservoir/dam	2.1.0	Livestock Grazing	45	<0.01
2.1.0	Livestock Grazing	5.7.3	Railways	37	<0.01
1.3.3	Residual native cover	1.1.7	Other conserved area	35	<0.01
4.3.6	Irrigated cotton	3.3.0	Cropping	27	<0.01
2.1.0	Livestock Grazing	5.4.2	Rural residential	14	<0.01
1.3.0	Other Minimal Use	4.3.0	Irrigated Cropping	12	<0.01
2.1.0	Livestock Grazing	3.4.0	Perennial Horticulture	6	<0.01
4.3.0	Irrigated Cropping	6.2.0	Reservoir/dam	4	<0.01
4.3.6	Irrigated cotton	6.2.0	Reservoir/dam	3	<0.01
1.3.3	Residual native cover	5.4.0	Residential	3	<0.01
6.2.0	Reservoir/dam	1.3.0	Other Minimal Use	3	<0.01
3.3.0	Cropping	5.8.0	Mining	2	<0.01
5.4.0	Residential	5.5.3	Recreation & culture	1	<0.01
			Total	94,529	0.66

Table 3: Summary statistics for land use changes between the years of 1999 and 2004 in the Fitzroy River catchment

The 1999 to 2004 change map suggests that 14,162,000 ha in the Fitzroy River catchment have not changed. The accuracy assessment described in the following section suggests that possibly 0.74% or approximately 92,000ha of this area have undergone a change. The evidence for missed change came from only two points, both reporting a destocking of an area, one to become residual native

cover, the other to other minimal uses. It appears unlikely then, that much of this missed change is in fact of major impact.

Accuracy assessment

The accuracy assessment provided reference data suitable for assessing the 1999 land use map, the 2004 land use map and the map describing the change in land use between these two dates. 276 points concentrating on agricultural land use were available for the assessment. For each of the sample points, the true land class was determined (reference data) based on landholder survey, field work, aerial photograph interpretation, landholder contact or expert knowledge. These points were then compared to the mapped class (map data) and the information summarised in the error matrix. The accuracy is summarised in terms of total accuracy, kappa and user's and producer's accuracies. Each accuracy parameter is reported using a point estimate and a 95% posterior interval.

Total accuracy provides an estimate of the overall accuracy of the map, and can be expressed as the probability that a point is mapped correctly. Total accuracy can be misleading, particularly when one class dominates the others. The Kappa statistic attempts to overcome this problem by adjusting for chance agreement. A common rule of thumb suggests a value of Kappa between 0.6 and 0.8 represents moderate agreement between the map and the ground truth, a value greater than 0.8 suggests strong agreement. Values less than 0.2 suggest the map is little better than a map produced by random allocation.

The user's and producer's accuracies summarise the map's accuracy on a per-class basis. User's accuracy for class *A* is the probability that a point mapped as *A* is truly in class *A*. If we estimated the user's accuracy of class *A* to be 84%, then from a random sample of 100 points chosen from areas on the map in this class, around 84 would be found to be correct when checked in the field. Producer's accuracy for class *B* is the conditional probability that the map will show a site as class *B* given its true state is class *B*. If the producer's accuracy for class *B* were 84%, then from a random sample of 100 points known to be in class *B* around 84 would also be in class *B* according to the map. An accurate map should have high user's and producer's accuracies.

The per-class estimates of accuracy are often not very precise, since only part of the total sample points are used to estimate them. As a guide, if the upper bound of the interval for either user's or producer's accuracy is less than 0.5, this can indicate a true misclassification problem, rather than one due to inadequacies in sample size.

1999 land use data

The 1999 land use dataset was accuracy assessed using 276 points. The total accuracy is 94.6% (0.92,0.97) and Kappa is 0.67 (0.55,0.79). Table 4 provides the error matrix for the accuracy assessment of the 1999 land use data.

For the majority of classes, the reference data agreed with the map data. For example, 238 reference points were identified to be *grazing natural vegetation*. For 227 of those points, the map data was also *grazing* and therefore correct. For 11 of the points the map data was incorrect with six points falling onto the mapped class *residual native cover*, three points in the class *cropping* and two points in the class *other minimal uses.* Two classes, *other minimal uses* and *residual native cover* were not sampled and so user's accuracies are not reliable for these classes. User's accuracies for the remaining classes are all above 0.6. Producer's accuracies for *other minimal uses* and *residual native cover* are estimated as 0 since there is no data available to determine whether these are ever mapped correctly. Producer's accuracies for other classes are high, with no values less than 0.83. The results suggest that significant areas of *other minimal uses* and *residual native cover* have been misclassified as *grazing natural vegetation*. Table 5 provides the user's and producer's accuracies for the 1999 dataset.

		Reference Data								
		Other minimal uses	Residual native cover	Grazing natural vegetation	Cropping	Irrigated cropping	Irrigated cotton	Perennial horticulture	total	propn (%)
Map Data	Other minimal uses	**0**	0	0	0	0	0	0	0	0.29
	Residual native cover	0	**0**	0	0	0	0	0	0	0.04
	Grazing natural vegetation	2	6	**227**	3	0	0	0	238	92.43
	Cropping	0	0	3	**20**	0	0	0	23	6.36
	Irrigated cropping	0	0	0	1	**5**	0	0	6	0.43
	Irrigated cotton	0	0	1	0	0	**3**	0	4	0.20
	Perennial horticulture	0	1	0	0	1	0	**3**	5	0.00
	Totals	2	7	231	24	6	3	3	276	100

Table 4: Error matrix for the Fitzroy River catchment 1999 land use dataset

Class	User's			Producer's		
	50.00%	95% interval		50.00%	95% interval	
Other minimal uses	0.000	0.000	1.000	0.000	0.000	0.419
Cropping	0.880	0.716	0.969	0.826	0.649	0.946
Residual native cover	0.000	0.000	1.000	0.000	0.000	0.017
Grazing natural vegetation	0.955	0.924	0.976	0.988	0.976	0.995
Irrigated cropping	0.862	0.471	0.994	0.998	0.988	1.000
Irrigated cotton	0.778	0.284	0.987	1.000	1.000	1.000
Perennial horticulture	0.612	0.201	0.931	1.000	1.000	1.000

Table 5: User's and producer's accuracy for the Fitzroy River catchment in 1999

2004 land use data

The 2004 land use dataset was accuracy assessed using 280 points. The total accuracy is 92.6% (0.89,0.95) and the Kappa is 0.59 (0.48,0.71). Table 6 provides the error matrix for the accuracy assessment of the 2004 land use data.

For the majority of classes, the reference data agreed with the map data. For example, 35 reference points were identified to be *cropping*. For 28 of those points, the map data was also *cropping* and therefore correct. For seven of the points the map data was incorrect with three points falling onto the mapped class *grazing natural vegetation* and four points in *irrigated cropping.*

User's accuracies are not reliable for classes *residual native cover* and *other minimal uses* since no sample points were chosen from these classes. The producer's accuracies for these classes will thus be 0. The class *irrigated cotton* had a very small sample size, with only one correct point and one incorrect point. It thus has a low user's accuracy (0.45) with very wide intervals (0.02,0.97).

User's accuracies for the remaining classes (*cropping, grazing natural vegetation, irrigated cropping and perennial horticulture)* are all above 0.5. Producer's accuracy for *irrigated cropping* is low (0.36), suggesting that a significant area of this class has been missed. From the error matrix, it appears that irrigated cropping is confused in some cases with dryland cropping. Table 7 provides the user's and producer's accuracies for the 1999 dataset.

		Reference Data									
		Other minimal uses	Residual native cover	Grazing natural vegetation	Cropping	Irrigated cropping	Irrigated cotton	Perennial horticulture	Reservoir/dam	total	propn (%)
Map Data	Other minimal uses	**0**	0	0	0	0	0	0	0	0	0.29
	Residual native cover	0	**0**	0	0	0	0	0	0	0	0.04
	Grazing natural vegetation	3	7	**211**	4	0	0	0	0	225	92.37
	Cropping	0	0	3	**28**	4	0	0	0	35	6.34
	Irrigated cropping	0	0	1	1	**11**	0	0	0	13	0.45
	Irrigated cotton	0	0	1	0	0	**1**	0	0	2	0.20
	Perennial horticulture	0	1	0	0	1	0	**3**	0	5	0.00
	Totals	3	8	214	33	16	1	3	0	280	100

Table 6: Error matrix for the Fitzroy River catchment 2004 land use dataset

Class	User's			Producer's		
	50.00%	95% interval		50.00%	95% interval	
Other minimal uses	0.000	0.000	1.000	0.000	0.000	0.304
Cropping	0.807	0.649	0.914	0.762	0.579	0.911
Residual native cover	0.000	0.000	1.000	0.000	0.000	0.014
Grazing natural vegetation	0.939	0.903	0.965	0.990	0.981	0.996
Irrigated cropping	0.860	0.610	0.978	0.360	0.195	0.648
Irrigated cotton	0.469	0.023	0.966	1.000	1.000	1.000
Perennial horticulture	0.603	0.185	0.923	1.000	1.000	1.000

Table 7: User's and producer's accuracy for the Fitzroy River catchment in 2004

1999 to 2004 land use change data

A random sample of 48 sites were also generated from areas identified as change between the 1999 and 2004 datasets, to assess the accuracy of the change layer. Points were selected in agricultural areas only. The total accuracy of the land use change map was estimated to be 99.2% (0.98,0.99) and the kappa is 0.19 (0.06,0.56). Table 8 provides the error matrix for the accuracy assessment of the 1999 to 2004 land use change data.

User's accuracy for *change* is 0.76 (0.62,0.86), suggesting that a considerable area of mapped change has been overestimated. Producer's accuracy for change is also low at 0.11 (0.04,0.45) suggesting that there is a considerable area of missed change. User's accuracy for *no*-change appears high at 0.99 (0.98,0.99), although with such a large imbalance in class sizes a slight misclassification probability can be important. The evidence for missed change came from two points received from the landholder survey. One involved a change from *grazing natural vegetation* to *residual native cover*, the other a change from *grazing natural vegetation* to *other minimal uses*.

Table 9 provides the user's and producer's accuracies for the 1999 to 2004 land use change dataset.

		Reference Data			
		change	No change	total	Propn (%)
Map Data	change	**36**	11	47	0.12
	no change	2	**227**	229	99.88
	Totals	38	238	276	100

Table 8: Error matrix for the Fitzroy River catchment 1999 to 2004 land use change dataset

Class	User's			Producer's		
	50.00%	95% interval		50.00%	95% interval	
Change	0.755	0.617	0.857	0.107	0.035	0.447
No change	0.993	0.977	0.999	0.999	0.999	0.999

Table 9: User's and producer's accuracy for the Fitzroy River catchment 1999 to 2004 land use change dataset

Discussion

Sometimes points that differ between the map and the reference data are due to positional or spatial errors. Inaccurate registration of datasets is an example of spatial error. Thematic errors are the incorrect labelling of an area due to difficulties in determining the true land use in that area, or by oversight or other operational errors. Spatial errors influence thematic accuracy. The purpose of accuracy assessment is to assess the thematic accuracy of land use data. However, the separation of spatial and thematic errors can be difficult and was not undertaken. As a result, the accuracy assessment reflects properties of the land use data as a whole.

Results of the accuracy assessment presented above should be considered an assessment of the agricultural land uses only. Of note is that a significant area mapped as *grazing natural vegetation* may actually be either *other minimal uses* or *residual native cover.* For the purposes of land use mapping, *grazing natural vegetation* includes all areas which could be grazed, since it is not usually possible to determine areas within a grazing property that don't have stock on them unless they are clearly inaccessible. The land holder survey carried out as part of this accuracy assessment allows an estimate to be made of the area of ungrazed land mapped as *grazing natural vegetation*. It is unlikely that traditional accuracy assessments would allow this separation.

The results also suggest some difficulties in mapping land use change. The user's accuracy for change (0.76) suggests the maps overestimate some areas. The change results also suggest that a considerable area of agricultural or grazing land mapped as unchanged between 1999 and 2004 may in fact have undergone some change. Although the user's accuracy for *no-change* is high (0.99), this still leaves the probability of 0.0074 that an area mapped as non-change has in fact changed. The Fitzroy change map has an area of un-changed agricultural land of around 12,411,000 ha. A misclassification of 0.74% means that potentially 92,000 ha of change has been missed. The evidence for missed change came from only two points, both reporting a destocking of an area, one to become *residual native cover*, the other to *other minimal uses*. It appears unlikely then, that much of this missed change is in fact of major impact.

Metadata

Metadata documents have been produced for the improved 1999 and the 2004 land use datasets, as well as 1999 to 2004 land use change data.

Data format and availability

The land use datasets are stored in raster format (.img files) with a pixel size of 25 metres.

Digital copies of the 1999 and 2004 land use data, 1999 to 2004 land use change data and related metadata documents can be obtained from the NRSc data coordinator (NRScDataCoordinator@nrm.qld.gov.au).

References

Bureau of Rural Sciences (2006). *Land Use Mapping at Catchment Scale*, 3rd edition, Department of Agriculture, Fisheries and Forestry, Canberra.

Witte, C, van den Berg, D, Rowland, T, O'Donnell, T, Denham, R, Pitt, G and Simpson, J 2006. *Mapping Land Use in Queensland – Technical Report on the 1999 Land Use Map for Queensland*, Department of Natural Resources, Mines and Water, Brisbane.

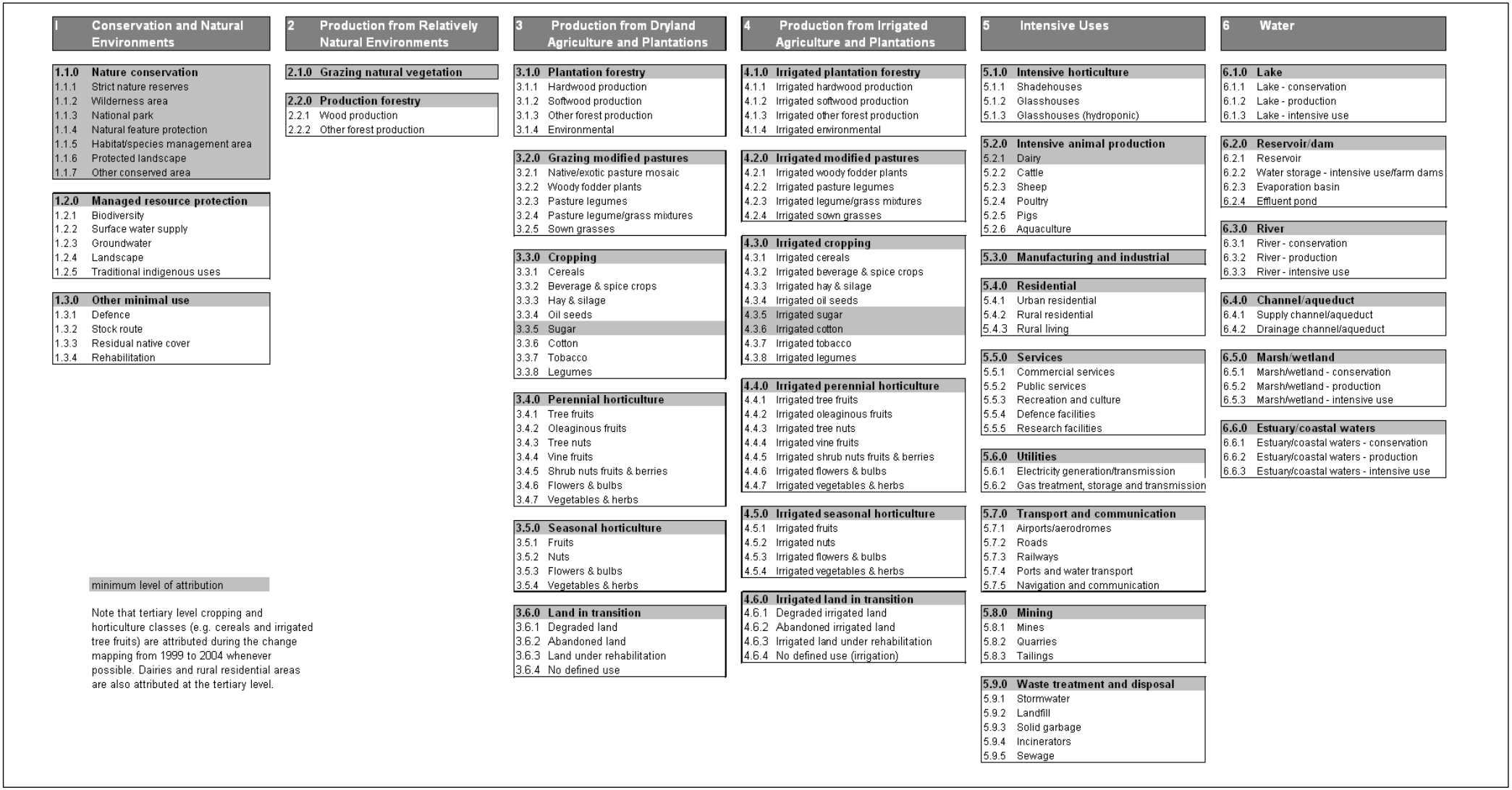
Acknowledgements

The authors would like to acknowledge the National Land and Water Resources Audit and the Queensland Department of Natural Resources and Water for providing funding for this project and the Bureau of Rural Sciences for successfully coordinating ACLUMP.

Dr Lucy Randall (Bureau of Rural Sciences) provided valuable assistance and information regarding interpretation and classification of multi-temporal MODIS imagery for land use change mapping.

Local experts including Kevin McCosker (DPIF, Rockhampton), Mike Ashton (DPIF, Indooroopilly), John Arrowsmith (DPIF, Brisbane), Bruce Cowie (NRW, Biloela), Bill Wilkinson and George Bourne (NRW, Emerald) as well as officers from the Fitzroy Basin Association provided detailed information on land use changes, cropping seasons and rotational practices.

Appendix 1: ALUM classification version 6



1 Conservation and Natural Environments	2 Production from Relatively Natural Environments	3 Production from Dryland Agriculture and Plantations	4 Production from Irrigated Agriculture and Plantations	5 Intensive Uses	6 Water
1.1.0 Nature conservation	**2.1.0 Grazing natural vegetation**	**3.1.0 Plantation forestry**	**4.1.0 Irrigated plantation forestry**	**5.1.0 Intensive horticulture**	**6.1.0 Lake**
1.1.1 Strict nature reserves		3.1.1 Hardwood production	4.1.1 Irrigated hardwood production	5.1.1 Shadehouses	6.1.1 Lake - conservation
1.1.2 Wilderness area	**2.2.0 Production forestry**	3.1.2 Softwood production	4.1.2 Irrigated softwood production	5.1.2 Glasshouses	6.1.2 Lake - production
1.1.3 National park	2.2.1 Wood production	3.1.3 Other forest production	4.1.3 Irrigated other forest production	5.1.3 Glasshouses (hydroponic)	6.1.3 Lake - intensive use
1.1.4 Natural feature protection	2.2.2 Other forest production	3.1.4 Environmental	4.1.4 Irrigated environmental	**5.2.0 Intensive animal production**	**6.2.0 Reservoir/dam**
1.1.5 Habitat/species management area		**3.2.0 Grazing modified pastures**	**4.2.0 Irrigated modified pastures**	5.2.1 Dairy	6.2.1 Reservoir
1.1.6 Protected landscape		3.2.1 Native/exotic pasture mosaic	4.2.1 Irrigated woody fodder plants	5.2.2 Cattle	6.2.2 Water storage - intensive use/farm dams
1.1.7 Other conserved area		3.2.2 Woody fodder plants	4.2.2 Irrigated pasture legumes	5.2.3 Sheep	6.2.3 Evaporation basin
1.2.0 Managed resource protection		3.2.3 Pasture legumes	4.2.3 Irrigated legume/grass mixtures	5.2.4 Poultry	6.2.4 Effluent pond
1.2.1 Biodiversity		3.2.4 Pasture legume/grass mixtures	4.2.4 Irrigated sown grasses	5.2.5 Pigs	**6.3.0 River**
1.2.2 Surface water supply		3.2.5 Sown grasses	**4.3.0 Irrigated cropping**	5.2.6 Aquaculture	6.3.1 River - conservation
1.2.3 Groundwater		**3.3.0 Cropping**	4.3.1 Irrigated cereals	**5.3.0 Manufacturing and industrial**	6.3.2 River - production
1.2.4 Landscape		3.3.1 Cereals	4.3.2 Irrigated beverage & spice crops	**5.4.0 Residential**	6.3.3 River - intensive use
1.2.5 Traditional indigenous uses		3.3.2 Beverage & spice crops	4.3.3 Irrigated hay & silage	5.4.1 Urban residential	**6.4.0 Channel/aqueduct**
1.3.0 Other minimal use		3.3.3 Hay & silage	4.3.4 Irrigated oil seeds	5.4.2 Rural residential	6.4.1 Supply channel/aqueduct
1.3.1 Defence		3.3.4 Oil seeds	4.3.5 Irrigated sugar	5.4.3 Rural living	6.4.2 Drainage channel/aqueduct
1.3.2 Stock route		3.3.5 Sugar	4.3.6 Irrigated cotton	**5.5.0 Services**	**6.5.0 Marsh/wetland**
1.3.3 Residual native cover		3.3.6 Cotton	4.3.7 Irrigated tobacco	5.5.1 Commercial services	6.5.1 Marsh/wetland - conservation
1.3.4 Rehabilitation		3.3.7 Tobacco	4.3.8 Irrigated legumes	5.5.2 Public services	6.5.2 Marsh/wetland - production
		3.3.8 Legumes	**4.4.0 Irrigated perennial horticulture**	5.5.3 Recreation and culture	6.5.3 Marsh/wetland - intensive use
		3.4.0 Perennial horticulture	4.4.1 Irrigated tree fruits	5.5.4 Defence facilities	**6.6.0 Estuary/coastal waters**
		3.4.1 Tree fruits	4.4.2 Irrigated oleaginous fruits	5.5.5 Research facilities	6.6.1 Estuary/coastal waters - conservation
		3.4.2 Oleaginous fruits	4.4.3 Irrigated tree nuts	**5.6.0 Utilities**	6.6.2 Estuary/coastal waters - production
		3.4.3 Tree nuts	4.4.4 Irrigated vine fruits	5.6.1 Electricity generation/transmission	6.6.3 Estuary/coastal waters - intensive use
		3.4.4 Vine fruits	4.4.5 Irrigated shrub nuts fruits & berries	5.6.2 Gas treatment, storage and transmission	
		3.4.5 Shrub nuts fruits & berries	4.4.6 Irrigated flowers & bulbs	**5.7.0 Transport and communication**	
		3.4.6 Flowers & bulbs	4.4.7 Irrigated vegetables & herbs	5.7.1 Airports/aerodromes	
		3.4.7 Vegetables & herbs	**4.5.0 Irrigated seasonal horticulture**	5.7.2 Roads	
		3.5.0 Seasonal horticulture	4.5.1 Irrigated fruits	5.7.3 Railways	
		3.5.1 Fruits	4.5.2 Irrigated nuts	5.7.4 Ports and water transport	
		3.5.2 Nuts	4.5.3 Irrigated flowers & bulbs	5.7.5 Navigation and communication	
		3.5.3 Flowers & bulbs	4.5.4 Irrigated vegetables & herbs	**5.8.0 Mining**	
		3.5.4 Vegetables & herbs	**4.6.0 Irrigated land in transition**	5.8.1 Mines	
		3.6.0 Land in transition	4.6.1 Degraded irrigated land	5.8.2 Quarries	
		3.6.1 Degraded land	4.6.2 Abandoned irrigated land	5.8.3 Tailings	
		3.6.2 Abandoned land	4.6.3 Irrigated land under rehabilitation	**5.9.0 Waste treatment and disposal**	
		3.6.3 Land under rehabilitation	4.6.4 No defined use (irrigation)	5.9.1 Stormwater	
		3.6.4 No defined use		5.9.2 Landfill	
				5.9.3 Solid garbage	
				5.9.4 Incinerators	
				5.9.5 Sewage	

minimum level of attribution

Note that tertiary level cropping and horticulture classes (e.g. cereals and irrigated tree fruits) are attributed during the change mapping from 1999 to 2004 whenever possible. Dairies and rural residential areas are also attributed at the tertiary level.