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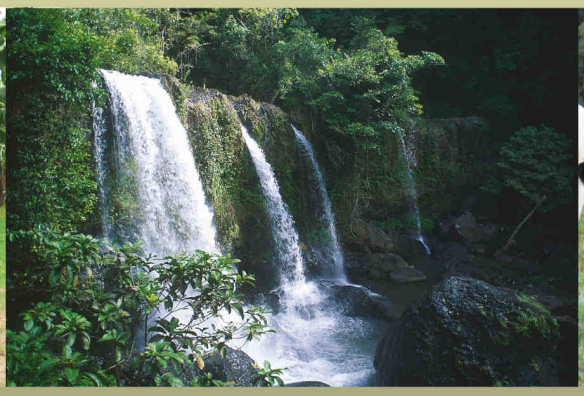
Mapping Land Use

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

The Department of Natural Resources, Mines and Water (NRMW) 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 Jonstone 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 Queensland Department of Natural Resources, Mines and Water and the Australian Government's $3 Billion Natural Heritage Trust through the Department of the Environment and Heritage.

Catchment overview

The Johnstone River Catchment is approximately 235,443 hectares in area and is located in far north Queensland. The area extends from the Atherton Tableland to the coast as far down as Innisfail. The catchment has undergone significant changes over the past few decades resulting in approximately 50% of the catchment being cleared for human settlement and agricultural practices. The remainder of the catchment is tropical rainforest, listed under the Wet Tropics of Queensland World Heritage Area.

During the initial land use mapping for the year 1999 a wide diversity of agricultural practices were noted including bananas, sugarcane, dairy and livestock grazing, predominantly beef.

Objectives

The primary objectives of this project were to:

- further develop and improve the methodology to map land use change which is applicable to a broad range of catchments
- apply this methodology to the Burdekin 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.

This data 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 Johnstone 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 50m for linear features.

The Johnstone 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, 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).

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)
- National Park, State Forest and Timber Reserves data.

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

During the process of mapping land use change, cropping and horticultural areas in both the 1999 and 2004 land use datasets were attributed to the tertiary level of ALUM 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 completed 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 was undertaken for the 2004 land use map and the land use change layer using a stratified random sample to assess thematic (attribute) accuracy under the ALUM classification. Note that only a subset of classes was sampled for this exercise. Some classes that are defined by tenure and are assumed correct (such as *national parks*) were not assessed. Classes which are small in total area (<10,000ha) and don't occur frequently (<10 polygons) were also not sampled, but the polygons were checked using imagery, photography and in some cases field survey. The number of points assessed for the remaining classes was determined based on the area that each class occupies within the catchment.

Land use was assessed at each point through interpretation of Landsat imagery, aerial photographs and referral to ancillary datasets. Where the land use could not be determined confidently through this process, the point was assessed in the field or the landholder was contacted directly.

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

Products

1999 and 2004 land use data

Figure 1shows the 1999 and Figure 2 the 2004 land use data for the Johnstone catchment using the secondary level of the ALUM classification (see Appendix 1 for the classification).

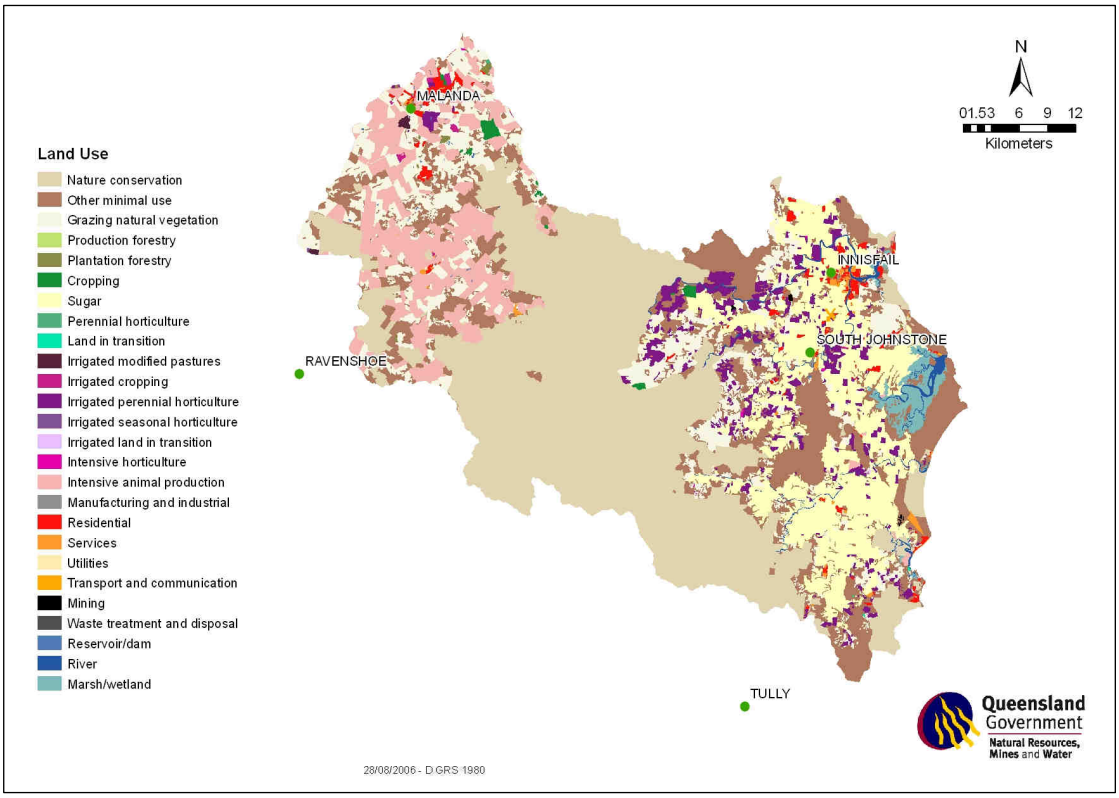

Figure 1: 1999 land use map for the Johnstone River catchment

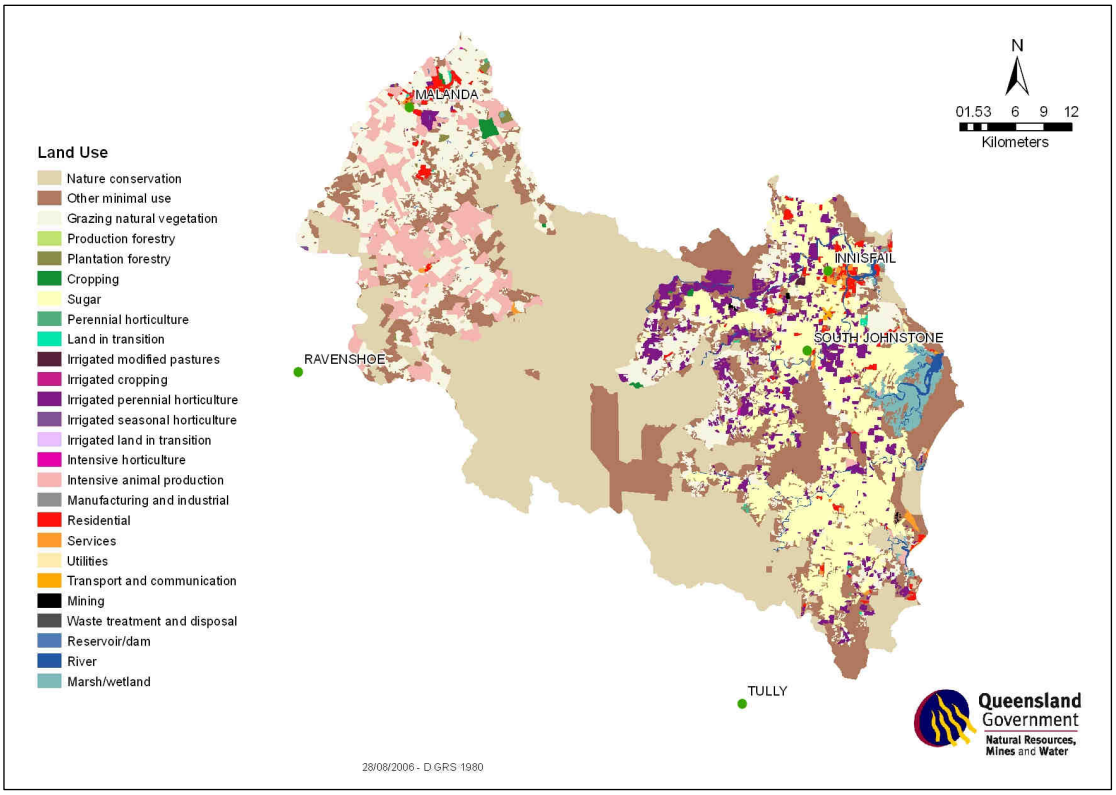

Figure 2: 2004 land use map for the Johnstone River catchment

Some tertiary classes, such as *irrigated sugar* (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 Figures 1 and 2.

Table 1 and Table 2 provide 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	130,701	56.19
1.1	Nature conservation	91,761	39.45
1.3	Other minimal use	38,940	16.74
2	Production from relatively natural environments	27,943	12.01
2.1	Grazing natural vegetation	27,940	12.01
2.2	Production forestry	3	<0.01
3	Production from dryland agriculture and plantations	35,374	15.21
3.1	Plantation forestry	305	0.13
3.3	Cropping	35,018	15.05
3.3.5	Sugar*	34,310	14.75
3.4	Perennial horticulture	30	0.01
3.6	Land in transition	21	0.01
4	Production from irrigated agriculture and plantations	8,992	3.87
4.2	Irrigated modified pasture	185	0.08
4.3	Irrigated cropping	271	0.12
4.4	Irrigated perennial horticulture	8,515	3.66
4.5	Irrigated seasonal horticulture	8	<0.01
4.6	Irrigated land in transition	13	0.01
5	Intensive uses	24,630	10.59
5.1	Intensive horticulture	54	0.02
5.2	Intensive animal production**	20,646	8.88
5.3	Manufacturing and industrial	225	0.10
5.4	Residential	2,695	1.16
5.5	Services	804	0.35
5.6	Utilities	4	<0.01
5.7	Transport and communication	114	0.05
5.8	Mining	80	0.04
5.9	Waste treatment and disposal	7	<0.01
6	Water	4,977	2.14
6.2	Reservoir/dam	121	0.05
6.3	River	1,908	0.82
6.5	Marsh/wetland	2,947	1.27
	Grand total	232,615	100

* The area of *sugar* is a subset of the total area of *cropping*.
** *Intensive animal production* in this case mostly refers to dairies.

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

Land Use Code	Land Use Classes	Area ha	Area %
1	Conservation and natural environments	130,252	56.00
1.1	Nature conservation	86,074	37.00
1.3	Other minimal use	44,178	18.99
2	Production from relatively natural environments	35,895	15.43
2.1	Grazing natural vegetation	35,892	15.43
2.2	Production forestry	3	0.00
3	Production from dryland agriculture and plantations	33,588	14.44
3.1	Plantation forestry	433	0.19
3.3	Cropping	32,959	14.17
3.3.5	Sugar*	32,476	13.96
3.4	Perennial horticulture	30	0.01
3.6	Land in transition	166	0.07
4	Production from irrigated agriculture and plantations	10,607	4.56
4.2	Irrigated modified pasture	78	0.03
4.3	Irrigated cropping	14	<0.01
4.4	Irrigated perennial horticulture	10,485	4.51
4.5	Irrigated seasonal horticulture	21	<0.01
4.6	Irrigated land in transition	8	<0.01
5	Intensive uses	17,142	7.37
5.1	Intensive horticulture	54	0.02
5.2	Intensive animal production**	13,088	5.63
5.3	Manufacturing and industrial	226	0.10
5.4	Residential	2,736	1.18
5.5	Services	820	0.35
5.6	Utilities	4	<0.01
5.7	Transport and communication	114	0.05
5.8	Mining	93	0.04
5.9	Waste treatment and disposal	7	<0.01
6	Water	5,131	2.21
6.2	Reservoir/dam	124	0.05
6.3	River	1,908	0.82
6.5	Marsh/wetland	3,099	1.33
	Grand total	232,615	100

* The area of *sugar* is a subset of the total area of *cropping*.
** *Intensive animal production* in this case mostly refers to dairies

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

Data limitations

The ALUM class *grazing modified pasture* has not been included in QLUMP and 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.

Areas mapped as *dairies* include grazing areas and fodder crops. Cadastral parcels are often used to identify the extent of a dairy farm. It's possible that parts of these parcels include other land uses, such as grazing beef cattle. These areas may have been wrongly 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 both a snapshot 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 would still be cropping.

A number of data sources are 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's possible, that areas mapped as *irrigated cropping,* for example, are only 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

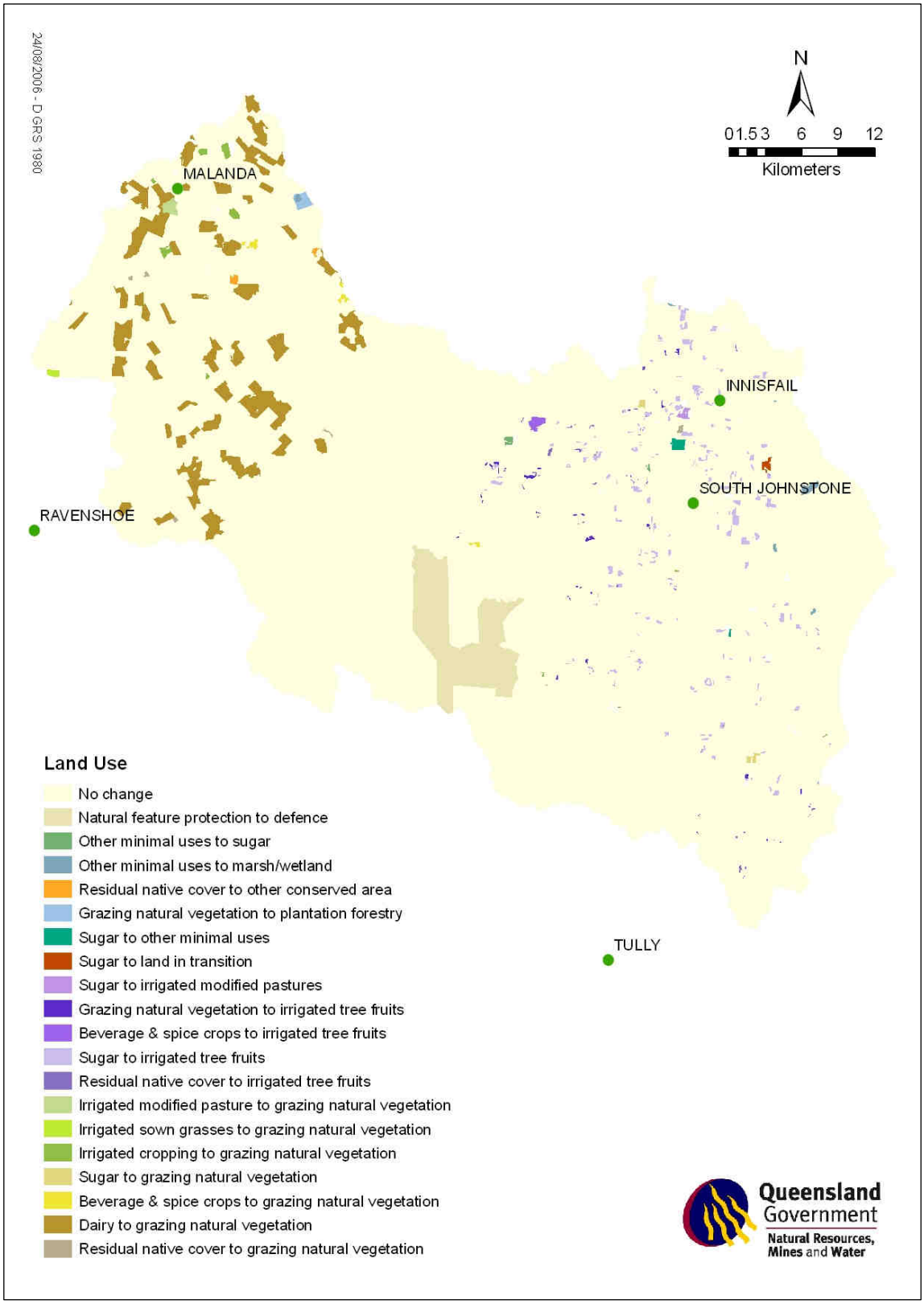

Figure 3: 1999 - 2004 land use change map for the Johnstone River catchment

The total area of land use change from 1999 to 2004 in the Johnstone River catchment is 15,692 hectares. That's 6.74% of the catchment. A breakdown of the change classes by area is shown in Table 3. The major changes are *dairy* to *grazing natural vegetation* (7,601 ha), *natural feature protection* to *defence* (5,757 ha), *irrigated cropping* to *grazing natural vegetation* (252 ha), *grazing natural vegetation* to *irrigated tree fruits* (175 ha) and *sugar* to *bananas* (155 ha).

Land Use Code 1999	Land Use Class 1999	Land Use Code 2004	Land Use Class 2004	Area of change (ha)	Area of Catchment (%)
5.2.1	Dairy	2.1.0	Grazing natural vegetation	7,601	3.27
1.1.4	Natural feature protection	1.3.1	Defence	5,757	2.47
4.3.0	Irrigated cropping	2.1.0	Grazing natural vegetation	252	0.11
2.1.0	Grazing natural vegetation	4.4.1	Irrigated tree fruits	175	0.08
3.3.5	Sugar	4.4.1	Irrigated tree fruits	155	0.07
1.3.0	Other minimal uses	6.5.0	Marsh/wetland	152	0.07
4.2.0	Irrigated modified pastures	2.1.0	Grazing natural vegetation	129	0.06
2.1.0	Grazing natural vegetation	3.1.0	Plantation forestry	125	0.05
1.3.3	Residual native cover	4.4.1	Irrigated tree fruits	119	0.05
3.3.2	Beverage & spice crop	2.1.0	Grazing natural vegetation	115	0.05
3.3.5	Sugar	1.3.0	Other minimal uses	113	0.05
3.3.2	Beverage & spice crop	4.4.1	Irrigated tree fruits	111	0.05
3.3.5	Sugar	2.1.0	Grazing natural vegetation	82	0.04
1.3.3	Residual native cover	2.1.0	Grazing natural vegetation	80	0.03
1.3.3	Residual native cover	1.1.7	Other conserved area	70	0.03
3.3.5	Sugar	3.6.0	Land in transition	59	0.03
3.3.5	Sugar	4.2.0	Irrigated modified pasture	58	0.02
4.2.4	Irrigated sown grasses	2.1.0	Grazing natural vegetation	55	0.02
1.3.0	Other minimal uses	3.3.5	Sugar	54	0.02
1.3.3	Residual native cover	6.3.0	Land in transition	48	0.02
2.1.0	Grazing natural vegetation	3.6.0	Land in transition	47	0.02
1.3.0	Other minimal uses	4.4.1	Irrigated tree fruits	33	0.01
4.4.1	Irrigated tree fruits	3.3.5	Sugar	33	0.01
3.3.5	Sugar	5.2.6	Aquaculture	31	0.01
1.3.0	Other minimal uses	2.1.0	Grazing natural vegetation	31	0.01
4.4.1	Irrigated tree fruits	4.4.4	Irrigated vine fruits	21	0.01
1.3.0	Other minimal uses	4.4.0	Irrigated perennial horticulture	21	0.01
2.1.0	Grazing natural vegetation	5.4.2	Rural residential	20	0.01
4.6.0	Irrigated land in transition	4.4.1	Irrigated tree fruits	13	0.01
3.3.5	Sugar	5.4.2	Rural residential	13	0.01
2.1.0	Grazing natural vegetation	4.5.0	Irrigated seasonal horticulture	12	0.01
2.1.0	Grazing natural vegetation	4.2.0	Irrigated modified pastures	11	<0.01
3.6.0	Land in transition	5.2.6	Aquaculture	11	<0.01
3.3.5	Sugar	5.8.2	Quarries	10	<0.01
4.4.1	Irrigated tree fruits	4.2.0	Irrigated modified pasture	10	<0.01
4.5.4	Irrigated vegetables & herbs	4.5.0	Irrigated seasonal horticulture	8	<0.01
1.3.3	Residual native cover	5.4.3	Rural living	8	<0.01
4.4.1	Irrigated tree fruits	4.6.0	Irrigated land in transition	8	<0.01
3.3.5	Sugar	5.5.0	Services	7	<0.01
4.3.2	Irrigated beverage & spice crop	3.1.0	Plantation forestry	5	<0.01
4.4.1	Irrigated tree fruits	2.1.0	Grazing natural vegetation	5	<0.01
1.3.0	Other minimal uses	5.4.3	Rural living	5	<0.01
1.3.0	Other minimal uses	5.5.3	Recreation & culture	4	<0.01
5.5.3	Recreation & culture	5.5.2	Public services	3	<0.01
2.1.0	Grazing natural vegetation	3.3.5	Sugar	3	<0.01
4.4.5	Irrigated shrub nuts, fruits & berries	3.3.5	Sugar	3	<0.01
5.4.0	Residential	5.5.0	Services	3	<0.01
1.3.3	Residual native cover	5.8.2	Quarries	3	<0.01
1.3.0	Other minimal uses	3.6.0	Land in transition	2	<0.01
2.1.0	Grazing natural vegetation	4.4.3	Irrigated tree nuts	2	<0.01
Total				15,692	6.74

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

Accuracy assessment

1999 land use data

The original version of the 1999 dataset demonstrated an overall accuracy of 90.6%. Accuracy assessment was not undertaken for the improved 1999 land use data, however it is expected that the total accuracy would be in line with the 2004 map (82.2%; see below). While a decrease in total accuracy is indicated between 1999 and 2004 i.e. 90.6% versus 82.2%, this is most likely due to changes in the accuracy assessment procedure rather than a decrease in the accuracy of the map.

2004 land use data

The 2004 land use dataset was accuracy assessed using 168 points. The total accuracy is 80.52% (0.74, 0.86) and the Kappa is 0.753 (0.672, 0.822). Values in parentheses after the estimate represent 95% posterior intervals, reflecting the uncertainty of the estimate. The estimates of total accuracy and Kappa are estimates of the overall accuracy of the map. The total accuracy is an estimate of the total area that 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.

Table 4 provides the error matrix for the accuracy assessment of the 2004 land use data. For each of the sample points, the true land class was determined (reference data) based on 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.

For the majority of classes, the reference data agreed with the map data. For example, 30 reference points were identified to be *grazing natural vegetation*. For 22 of those points, the map data was also *grazing* and therefore correct. For eight of the points the map data was incorrect with three points falling onto the mapped class *residual native cover*, one point on *irrigated perennial horticulture* and four points on *intensive animal production* (*dairy* in this case).

The column propn in Table 4 is the relative proportion in area of the classes that were assessed, not of the catchment as a whole. For example, national parks aren't assessed, so the area occupied by national parks is first removed from the total area before the proportions are calculated. This column will thus sum to 100%.

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 here 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.

		Reference Data																
		Stockroute	Residual native cover	Grazing natural vegetation	Plantation forestry	Sugar	Land in transition	Irrigated modified pastures	Irrigated perennial horticulture	Intensive animal production	Residential	Services	Transport & communication	Rerservoir/dam	River	Marsh/wetland	total	propn (%)
Map Data	Stockroute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Residual native cover	0	**37**	3	0	1	0	0	0	0	0	0	0	0	0	0	41	26.04
	Grazing natural vegetation	0	0	**22**	0	1	0	0	1	4	0	0	0	1	0	0	29	26.33
	Plantation forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32
	Sugar	0	0	0	0	**15**	0	0	0	0	0	0	0	0	0	0	15	23.27
	Land in transition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13
	Irrigated modified pastures	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	1	0.12
	Irrigated perennial horticulture	0	2	1	1	4	0	0	**9**	0	0	0	0	0	0	0	17	7.68
	Intensive animal production	0	1	4	0	0	0	0	0	**10**	0	0	0	0	0	0	15	9.75
	Residential	1	0	0	0	0	0	0	0	0	**8**	0	0	0	0	0	9	1.99
	Services	0	1	0	0	0	1	0	0	0	2	**5**	1	0	0	0	10	0.59
	Transport & communication	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08
	Rerservoir/dam	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	1	0.11
	River	0	2	0	0	0	0	0	1	0	0	0	0	0	**6**	1	10	1.37
	Marsh/wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**	10	2.22
	Total	1	43	30	1	21	1	1	11	14	10	5	1	2	6	11	158	100

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

User's and producer's accuracies of 2004 data

User's and producer's accuracies are per-class measures of accuracy. User's accuracy for class *i* is the conditional probability that a site is correct according to the reference data collected, given it was mapped as class *i*. Producer's accuracy for class *j* is the conditional probability that the map will show a site as class *j* given its true state is class *j*. For example, the user's accuracy for class *sugar* is 0.98. If a random sample of 100 points chosen from areas on the map in this class were checked in the field, we would expect around 98 of them to be correct. This suggests that the mapped class *sugar* is approximately 98% correct. The producer's accuracy for this class is 0.854. If we randomly selected 100 sites from the field which we know to be in this class, we would expect around 85 of them to be mapped correctly. The uncertainty of the estimates is summarised by using 95% posterior intervals. For *sugar*, we can say that there is a 95% probability that the user's accuracy lies between 0.844 and 1.

Class	User's			Producer's		
	50.00%	95% interval		50.00%	95% interval	
Stockroute	n/a	n/a	n/a	0.000	0.000	0.000
Residual native cover	0.898	0.782	0.965	0.902	0.807	0.957
Grazing natural vegetation	0.752	0.574	0.881	0.781	0.668	0.878
Plantation forestry	0.000	0.000	0.001	0.000	0.000	0.001
Sugar	0.982	0.844	1.000	0.854	0.754	0.926
Land in transition	0.000	0.000	0.000	0.000	0.000	0.000
Irrigated modified pastures	0.596	0.031	0.993	1.000	0.929	1.000
Irrigated perennial horticulture	0.512	0.293	0.735	0.802	0.490	0.964
Intensive animal production	0.648	0.393	0.850	0.628	0.412	0.843
Residential	0.844	0.546	0.981	0.927	0.678	0.988
Services	0.460	0.189	0.747	1.000	0.735	1.000
Transport & communication	n/a	n/a	n/a	0.000	0.000	0.000
Rerservoir/dam	0.611	0.034	0.992	0.079	0.005	0.668
River	0.563	0.261	0.821	1.000	0.692	1.000
Marsh/wetland	0.958	0.728	0.999	0.933	0.707	0.996

Table 5: User's and producer's accuracy for the Johnstone River catchment in 2004

The majority of land use classes in this catchment have been mapped accurately. The two largest assessable land use classes in this catchment (*other minimal use* and *sugar*) have been mapped with a high user's and producer's accuracy. The next major class by area is *grazing natural vegetation* with user's and producer's accuracies of 0.743 and 0.769 respectively. The accuracy values for *intensive animal production* (*dairy)* (0.648, 0.628) suggest that some areas of *dairy* have been mapped wrongly. Table 4 shows that *dairy* has sometimes been confused with *grazing natural vegetation*.

Some classes with low accuracies have insufficient sample points to provide precise estimates. User's accuracy for *irrigated perennial horticulture* is 0.51, however from the 95% interval (0.293, 0.735) we see that more sample points would be required to confidently determine how accurate this class is. Similarly, other land uses with moderate accuracy are *intensive animal production* (15 points) and *services* (10 points) each having relatively wide confidence intervals. *reservoir/dam* has one point only which provides very little information on the true accuracy of the class.

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. This is not the case for any of the land use classes mapped for the Johnstone River catchment.

1999 to 2004 land use change data

A random sample of 22 sites was also generated from areas identified as change between the 1999 and 2004 datasets, to assess the accuracy of the change layer. The accuracy of the areas mapped as change was estimated to be 73.3% with a 95% credible interval of 52.7% - 88.5%. There is no information available on the probability of missed change.

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 25m.

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

References

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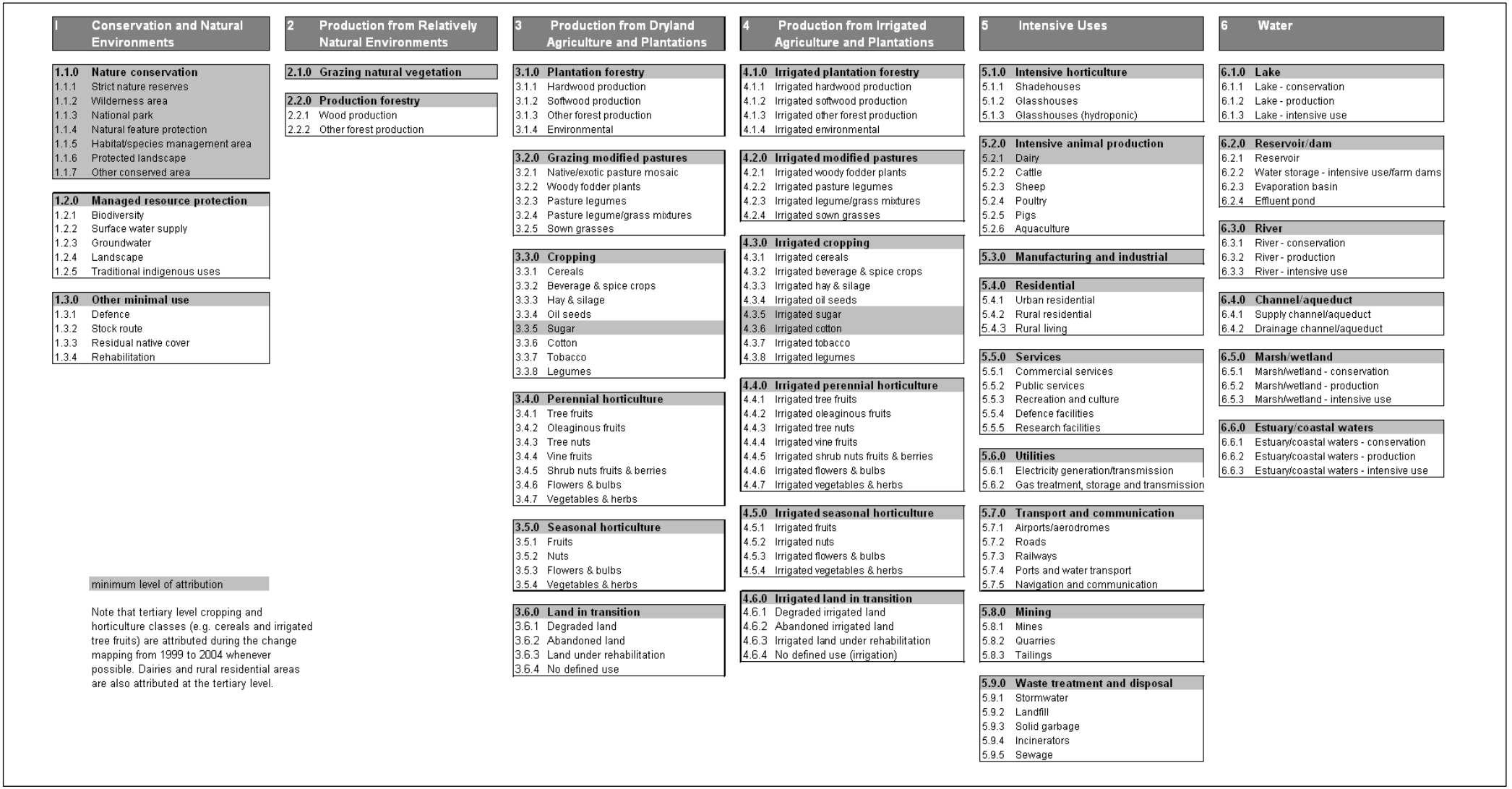
Appendix 1: ALUM classification version 6



1 Conservation and Natural Environments	
1.1.0	**Nature conservation**
1.1.1	Strict nature reserves
1.1.2	Wilderness area
1.1.3	National park
1.1.4	Natural feature protection
1.1.5	Habitat/species management area
1.1.6	Protected landscape
1.1.7	Other conserved area
1.2.0	**Managed resource protection**
1.2.1	Biodiversity
1.2.2	Surface water supply
1.2.3	Groundwater
1.2.4	Landscape
1.2.5	Traditional indigenous uses
1.3.0	**Other minimal use**
1.3.1	Defence
1.3.2	Stock route
1.3.3	Residual native cover
1.3.4	Rehabilitation

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.

2 Production from Relatively Natural Environments	
2.1.0	**Grazing natural vegetation**
2.2.0	**Production forestry**
2.2.1	Wood production
2.2.2	Other forest production

3 Production from Dryland Agriculture and Plantations	
3.1.0	**Plantation forestry**
3.1.1	Hardwood production
3.1.2	Softwood production
3.1.3	Other forest production
3.1.4	Environmental
3.2.0	**Grazing modified pastures**
3.2.1	Native/exotic pasture mosaic
3.2.2	Woody fodder plants
3.2.3	Pasture legumes
3.2.4	Pasture legume/grass mixtures
3.2.5	Sown grasses
3.3.0	**Cropping**
3.3.1	Cereals
3.3.2	Beverage & spice crops
3.3.3	Hay & silage
3.3.4	Oil seeds
3.3.5	Sugar
3.3.6	Cotton
3.3.7	Tobacco
3.3.8	Legumes
3.4.0	**Perennial horticulture**
3.4.1	Tree fruits
3.4.2	Oleaginous fruits
3.4.3	Tree nuts
3.4.4	Vine fruits
3.4.5	Shrub nuts fruits & berries
3.4.6	Flowers & bulbs
3.4.7	Vegetables & herbs
3.5.0	**Seasonal horticulture**
3.5.1	Fruits
3.5.2	Nuts
3.5.3	Flowers & bulbs
3.5.4	Vegetables & herbs
3.6.0	**Land in transition**
3.6.1	Degraded land
3.6.2	Abandoned land
3.6.3	Land under rehabilitation
3.6.4	No defined use

4 Production from Irrigated Agriculture and Plantations	
4.1.0	**Irrigated plantation forestry**
4.1.1	Irrigated hardwood production
4.1.2	Irrigated softwood production
4.1.3	Irrigated other forest production
4.1.4	Irrigated environmental
4.2.0	**Irrigated modified pastures**
4.2.1	Irrigated woody fodder plants
4.2.2	Irrigated pasture legumes
4.2.3	Irrigated legume/grass mixtures
4.2.4	Irrigated sown grasses
4.3.0	**Irrigated cropping**
4.3.1	Irrigated cereals
4.3.2	Irrigated beverage & spice crops
4.3.3	Irrigated hay & silage
4.3.4	Irrigated oil seeds
4.3.5	Irrigated sugar
4.3.6	Irrigated cotton
4.3.7	Irrigated tobacco
4.3.8	Irrigated legumes
4.4.0	**Irrigated perennial horticulture**
4.4.1	Irrigated tree fruits
4.4.2	Irrigated oleaginous fruits
4.4.3	Irrigated tree nuts
4.4.4	Irrigated vine fruits
4.4.5	Irrigated shrub nuts fruits & berries
4.4.6	Irrigated flowers & bulbs
4.4.7	Irrigated vegetables & herbs
4.5.0	**Irrigated seasonal horticulture**
4.5.1	Irrigated fruits
4.5.2	Irrigated nuts
4.5.3	Irrigated flowers & bulbs
4.5.4	Irrigated vegetables & herbs
4.6.0	**Irrigated land in transition**
4.6.1	Degraded irrigated land
4.6.2	Abandoned irrigated land
4.6.3	Irrigated land under rehabilitation
4.6.4	No defined use (irrigation)

5 Intensive Uses	
5.1.0	**Intensive horticulture**
5.1.1	Shadehouses
5.1.2	Glasshouses
5.1.3	Glasshouses (hydroponic)
5.2.0	**Intensive animal production**
5.2.1	Dairy
5.2.2	Cattle
5.2.3	Sheep
5.2.4	Poultry
5.2.5	Pigs
5.2.6	Aquaculture
5.3.0	**Manufacturing and industrial**
5.4.0	**Residential**
5.4.1	Urban residential
5.4.2	Rural residential
5.4.3	Rural living
5.5.0	**Services**
5.5.1	Commercial services
5.5.2	Public services
5.5.3	Recreation and culture
5.5.4	Defence facilities
5.5.5	Research facilities
5.6.0	**Utilities**
5.6.1	Electricity generation/transmission
5.6.2	Gas treatment, storage and transmission
5.7.0	**Transport and communication**
5.7.1	Airports/aerodromes
5.7.2	Roads
5.7.3	Railways
5.7.4	Ports and water transport
5.7.5	Navigation and communication
5.8.0	**Mining**
5.8.1	Mines
5.8.2	Quarries
5.8.3	Tailings
5.9.0	**Waste treatment and disposal**
5.9.1	Stormwater
5.9.2	Landfill
5.9.3	Solid garbage
5.9.4	Incinerators
5.9.5	Sewage

6 Water	
6.1.0	**Lake**
6.1.1	Lake - conservation
6.1.2	Lake - production
6.1.3	Lake - intensive use
6.2.0	**Reservoir/dam**
6.2.1	Reservoir
6.2.2	Water storage - intensive use/farm dams
6.2.3	Evaporation basin
6.2.4	Effluent pond
6.3.0	**River**
6.3.1	River - conservation
6.3.2	River - production
6.3.3	River - intensive use
6.4.0	**Channel/aqueduct**
6.4.1	Supply channel/aqueduct
6.4.2	Drainage channel/aqueduct
6.5.0	**Marsh/wetland**
6.5.1	Marsh/wetland - conservation
6.5.2	Marsh/wetland - production
6.5.3	Marsh/wetland - intensive use
6.6.0	**Estuary/coastal waters**
6.6.1	Estuary/coastal waters - conservation
6.6.2	Estuary/coastal waters - production
6.6.3	Estuary/coastal waters - intensive use