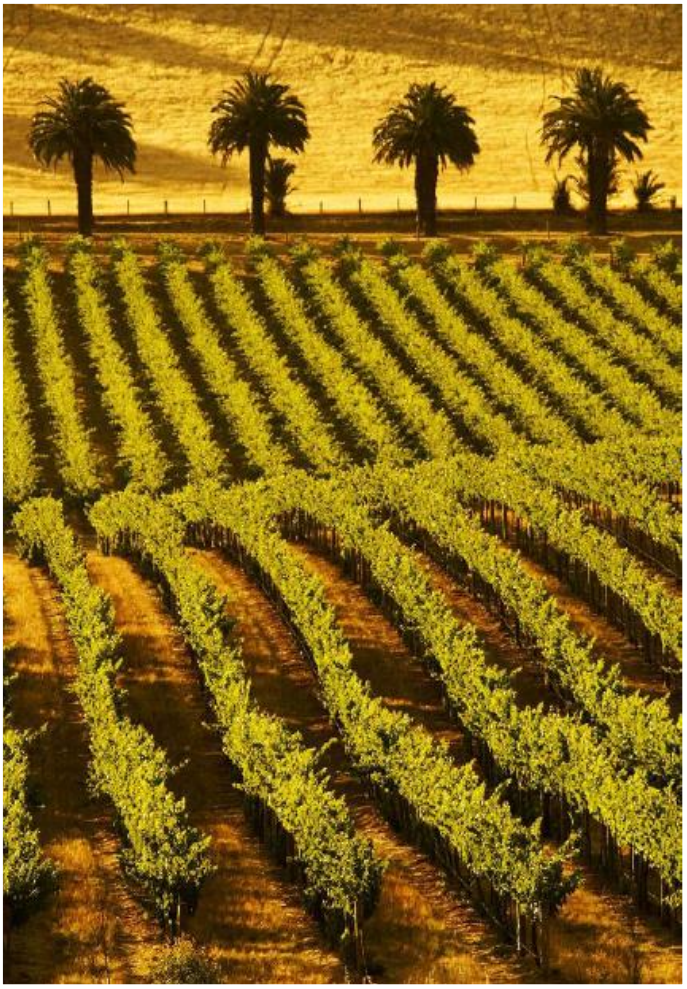


Workshop 1: Steps to create land accounting tables

Monitoring Land cover change in the Burnett Mary, Queensland between 2005-06 to 2010-11.

Chapter 1: Introduction

1.1 WHAT IS LAND ACCOUNTING?

Land accounting measures the change in the land and its attributes resulting from the impact of human and natural activity. The value of a set of land accounts is the ability to measure these attributes by examining stocks at different points in time to support policy around sustainable economic and environmental management.

A land account consists of a series of tables, maps and graphs that show the economic, social and environmental interactions with land measured in both hectares and in dollar terms.

1.2 Background

Land, as an asset, represents a major proportion of Australia's national economic value. This value was $3,614.4 billion in June 2010 (Australian System of National Accounts – National Balance Sheet, 5204.0). The land assets in Australia are owned, leased or used by governments, businesses and individuals for a variety of purposes and activities.

Essentially all economic activities involve the use of some land (except for activities such as fishing) and there is a range of economic transactions related to land, either directly or indirectly (as an input to production or as a store of wealth). Administrative arrangements, such as zoning laws, constrain the availability of land for particular purposes.

In Australia, land value is driven by physical characteristics such as location, vegetation cover, accessibility, climate, biodiversity, soils and mineral resources, as well as other factors such as land zoning and man-made improvements applied to the land and surrounds (e.g. proximity to main roads). Use of land can also result in degradation or improvements to the asset over time; for example, mining operations commencing in forested areas may destabilise natural ecosystems even though the land is usually required to be returned to its former status once the mining operations have ceased.

Although there are many sources of data available to quantify the characteristics of land and how these characteristics change over time, the lack of integration of these data has meant that the information has not been fully utilised to support sound policy decisions. In response to this situation, the ABS developed and released Land Account: Great Barrier Reef

Region, Experimental Estimates, 2011 (4609.0.55.001) in order to gain familiarity with the concepts and methods used to produce land accounts and review the quality and limitations of available data sources.

Internationally, the United Nations Statistical Division has produced a framework, the System of Environmental-Economic Accounts (SEEA), which became an international standard in 2012. Australia already produces annual water and energy accounts consistent with the standard.

Great Barrier Reef Land Account

The first ABS Land Account in the Great Barrier Reef (GBR) was selected as it provided consistent, good quality and freely available source of land use and land cover data. The GBR was also selected as the catchments have a direct impact on the Great Barrier Reef which is the world's largest coral reef system.

The process of developing a land account can be a complex procedure. A small region like the GBR provided a good opportunity to develop a proof of concept as realization of certain methods and to demonstrate its feasibility. By tracking changes in land use and land cover over time policy makers within the GBR are able to:

- Better understand the relationships between the land and the economy;
- identify critical gaps and deficiencies in land data;
- examine the effectiveness or efficiency of private and public environmental protection and natural resource management expenditures;
- support more targeted policy development by showing how land is used by different parts of the economy and how different economic activities may deplete or degrade the productive capacity of land; and
- identify which industries currently own or manage land that is of significance to carbon storage and exchange.

1.3. Case study

Land cover change in the Burnett Mary Natural Resource Management (NRM) in Queensland, Australia.

This study will focus on monitor land cover change in the Burnett Mary Natural Resource Management (NRM) region in Queensland, Australia between 2005-06 and 2010-11. The methodologies provided are transferable and can be implemented for other regions and jurisdictions to produce land based statistics on land use or land cover.

The Burnett Mary Region encompasses a land area of more than 56,000 square kilometres. Approximately 300,000 people live rural, regional and coastal lifestyles and the region is one of the fastest growing regions within Australia

Extensive primary production is conducted within the region including, cane, horticulture, citrus and tree crops, grain crops, viticulture, dairy and grazing. Commercial forestry and tourism are also major industries represented within the region. The region is incredibly biodiverse and contains many unique and endangered species.

The outcomes of this study will be to populate the Land Account tables proposed in the System of Environmental-Economic Accounting 2012 Central Framework. This includes;

Land cover net change matrix (hectares)

An example of an unpopulated land cover net change matrix is presented in Table 1. This presents the opening and closing stocks of rateable value or land area for different land uses or land covers. In addition it presents the net increase and net decrease of land uses and land covers according to the land use or land cover it was converted from (in the case of increases), or to (in the case of decreases). Finally, it presents a total net change for each land use or land cover.

The opening stock was calculated by summing all land use or land cover values by type for the beginning of the reference period. The closing stock was calculated by summing the opening stock and the total net change in rateable value or land area for each land use or land cover type. It is important to understand that the matrices show net changes, which

may mask information. For example, if 100 hectares of 'Livestock Grazing' is lost in one place but added elsewhere, then no net change would be shown.

Physical account for land cover (hectares)

An example of an unpopulated physical account for land cover is presented in Table 2. It shows the opening and closing areas for different land cover types and various additions and reductions in those areas over the accounting period. The data used in this example does not provide sufficient contextual information to attribute reasons for change.

Table 1. Land cover net change matrix

Land cover	Opening Stock 2005-06	Cultivated and managed land - irrigated	Cultivated and managed land - rainfed	Herbaceous vegetation	Marine Water	Primarily non-vegetated - aquatic or regularly flooded	Primarily non-vegetated - terrestrial	Wetlands	Woody-shrubs	Woody-trees	Total Net Change	Closing Stock 2010-11
Cultivated and managed land - irrigated												
Cultivated and managed land - rainfed												
Herbaceous vegetation												
Marine Water												
Primarily non-vegetated - aquatic or regularly flooded												
Primarily non-vegetated - terrestrial												
Wetlands												
Woody-shrubs												
Woody-trees												

Table 2. Phvsical account for land

	Cultivated and managed land - irrigated	Cultivated and managed land - rainfed	Herbaceous vegetation	Marine Water	Primarily non-vegetated - aquatic or regularly flooded	Primarily non-vegetated - terrestrial	Wetlands	Woody-shrubs	Woody-trees	Total
Opening Stock 2005-06	**106,875.00**	**483,243.75**	**592,181.25**	**12,712.50**	**17,075.00**	**18,043.75**	**18,256.25**	**931.25**	**4,326,725.00**	**5,576,043.75**
Additions to stock										
Manage expansion										
Natural expansion										
Upwards reappraisals										
Total additions to stock	25,706.25									
Reductions to stock										
Managed regression										
Natural regression										
Downward reapprasials										
Total reductions to stock	7,681.25									
Closing Stock 2010-11	**124,900.00**	**746,887.50**	**296,700.00**	**12,712.50**	**17,387.50**	**18,043.75**	**24,156.25**	**1,343.75**	**4,333,912.50**	**5,576,043.75**

1.4. Land cover data

Land cover is the physical surface of the earth, including the various soils, vegetation, geology, water bodies, and human built environments (e.g. agriculture, etc). Land cover is often captured using remote sensing. Some land uses, such as agriculture, share the same characteristics as land cover. However, in many other cases, land use can not be readily discriminated from land cover. For example, where the land cover is woodland, the land use may be sheep grazing.

The land cover data used in this study has been sourced from Geoscience Australia's National Dynamic Land Cover Dataset (DLCD). The DLCD is the first nationally consistent and thematically comprehensive land cover reference for Australia. It provides a base-line for identifying and reporting on change and trends in vegetation cover and extent.

The DLCD includes snapshots of vegetation greenness for each 250 by 250 metre grid cell with each layer based on 2 years of Moderate Resolution Imaging Spectroradiometer (MODIS) data. The classification scheme used to describe land cover categories in the DLCD conforms to the 2007 International Organization for Standardization (ISO) land cover standard (19144-2). The DLCD shows Australia's land cover grouped into several broad classes. These reflect the structural character of vegetation, ranging from cultivated and managed land covers (crops and pastures) to natural land covers such as forest and grasslands.

The source data for the DLCD is a time series of Enhanced Vegetation Index (EVI) data from the MODIS on the Terra and Aqua satellites operated by National Aeronautics and Space Administration (NASA).

ABS has used DLCD based on MODIS data as the source of land cover information for all State & Territory Land Accounts produced in Australia

1.5. Statistical Geography

A statistical geography provides the extra dimension of location to statistics. A statistical geography effectively divides the area of interest, on which the statistics are collected, into spatial categories, called statistical areas, which allow the user to see not just how the data

varies but also where it varies. An effective statistical geography is one which supports many uses and enables comparisons over time.

In Australia land accounts have been disseminated on two statistical geographies including State & Territory & Natural Resource Management (NRM) regions.

State & Territory: Australia is a federation consisting of six states and three federal territories. The Australian mainland consists of five of the six federated states (with the sixth state, Tasmania, being located on an island in close proximity to the mainland) and three federal territories (including the small, somewhat anomalous Jervis Bay Territory) which constitute the world's sixth-largest country by total area. All states and two of the three internal territories have their own parliaments and administer themselves; all remaining territories are administered by the federal government

Natural Resource Management regions: In Australia Natural Resource Management (NRM) regions are a key set of geographical boundaries used to report Environmental based statistics. 56 regional NRM organisations cover all of Australia and its estuarine and coastal areas. NRM's are about the planning and delivery of programs that support healthy and productive country, viable communities and sustainable industries.

CHAPTER 2: GIS data preparation

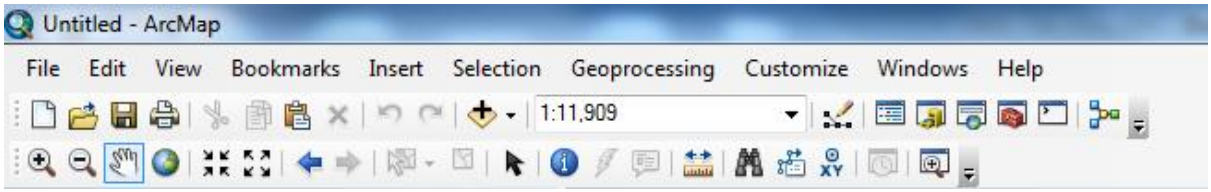
Land based data is generally collected in a spatially enabled based format. The production of a Land Account requires an ability store, manipulate, analyse, manage, and present spatial data.

In this study Geoscience Australia's (GA) Dynamic Land Cover Dataset (DLCD) will be used as the primary input dataset. The DLCD has been provided for two accounting periods (2005-06 and 2010-11) in a raster grid format. ESRI ArcMap will be used to prepare and structure the data into a tabular based format. A statistical software package such as Microsoft Excel will then be used present the data in the SEEA Land Accounting table format.

2.1. ArcMap setup

Begin this study by opening the ESRI ArcMap (Info) software package from your computer or laptop. ArcMap is the main component of Esri's ArcGIS suite of geospatial processing programs, and is used primarily to view, edit, create, and analyze geospatial data.

Please ensure that the Standard Tabular, Tools Toolbar and Spatial Analyst extension are enabled. The toolbars can be turned on under the Customize > Toolbars menu, while the Spatial Analyst extension is enabled under Customize > Extension.



The Standard toolbar most typically appears at the top of the ArcMap application window and is used for map printing, creating a new map, opening an existing map, saving your map, starting related ArcGIS applications, and more.

The Tools toolbar is used for map navigation and query within the active data frame.

ArcGIS Spatial Analyst tools let you analyse spatial relationships, build spatial models, and perform complex raster operation

2.2. Loading input data

This study will require three key datasets to populate the SEEA land cover tables (see Table 1 & 2). This includes;

- **NRM_AUST_2012** – Vector (polygon) layer of all Natural Resource Management (NRM) regions in Australia. The Burnett Mary NRM will be used for this study.

- **DLCDv2_ 2005_2006_NNG_QLD** – Raster grid of Dynamic Land Cover Dataset (DLCD) representing a two year interval (2005-06) of land cover data in Queensland. This will be used to populate the opening stock in the land cover tables.

- **DLCDv2_ 2010_2011_NNG_QLD** – Raster grid of Dynamic Land Cover Dataset (DLCD) representing a two year interval (2010-11) of land cover data in Queensland. This will be used to populate the opening stock in the land cover tables.

All three datasets have been stored in a Geodatabase \Bandung_Training_Oct_2015\Input_data.gdb\

GIS formats

Land use and land cover data is often stored in a range of different GIS formats. This study examines the process of manipulating raster (grid) land cover data into the land accounting format. Similar methods (with minor process variations) can be adapted to produce statistics from vector based data.

Vector: A representation of the world using points, lines, and polygons. Vector models are useful for storing data that has discrete boundaries, such as country borders, land parcels, and streets

Raster: A representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface.

What is a geodatabase

At its most basic level, an ArcGIS geodatabase is a collection of geographic datasets of various types held in a common file system folder, a Microsoft Access database, or a multiuser relational DBMS (such as Oracle, Microsoft SQL Server, PostgreSQL, Informix, or IBM DB2). Geodatabases come in many sizes, have varying numbers of users and can scale from small, single-user databases built on files up to larger workgroup, department, and enterprise geodatabases accessed by many users.

Load the NRM boundaries (NRM_AUST_2012) and land cover data (DLCDv2_2005_2006_NNG_QLD and DLCDv2_2010_2011_NNG_QLD) in ESRI ArcMap using the Add Data button from the Standard toolbar in ArcMap.

2.3. Subset study region

This study will focus on the Burnett Mary Natural Resource Management (NRM) region only. The boundary for this NRM will need to be subset from the National NRM layer. Use the Select by Attribute tool to subset the 'Burnett Mary' NRM as shown on the left. This query will select the Burnett Mary NRM region in the 'NRM_AUST_2012' attribute table.

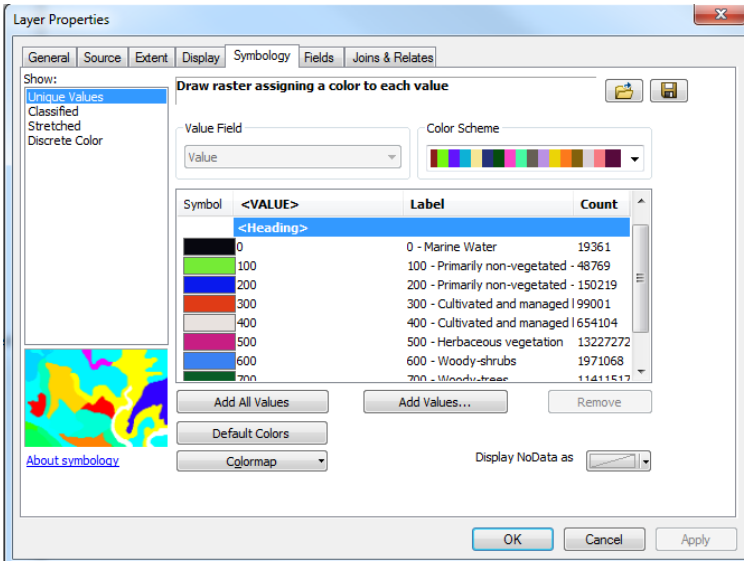
Right click the NRM_AUST_2012 layer in the Table of Contents and click Selection > Create Layer from Selected Features. This will create a new layer for the Burnett Mary NRM region. Right click this new layer in the Table of Contents > Data > Export Data. A new Geodatabase should be created to store this dataset. In the Saving Data tool navigate to the \Bandung_Training_Oct_2015\ folder. Click the New File Geodatabase button and name this geodatabase \Working_Data.gdb\. Export this layer as 'Burnett_Mary_NRM' into this new geodatabase. Remove the temporary and National NRM layer and load the exported version back into ESRI ArcMap.

2.4. Symbology

By default the land cover grids will be symbolised as a stretched colour ramp ranging between 0-800. In reality the data is categorical and needs to be reflected as such. We can change the Symbology by individually clicking the land cover layers (starting with CDv2_2005_2006_NNG_QLD) in the ArcMap's Table of Contents and navigating to Properties. Click the Symbology tab > Show Unique Values. In this example a layer file has

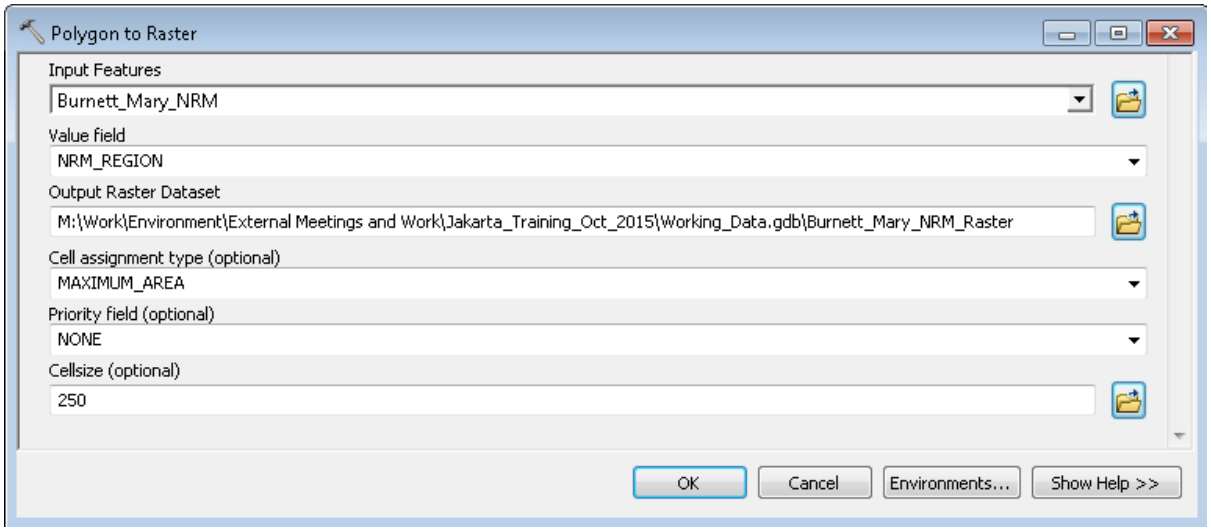
been created which stores symbology properties. However classes can also be individually set and labelled in this tab if required. Click the Import > Open button to load the layer file which can be found in the following folder:
\Bandung_Training_Oct_2015\DLCDv2_classification.lyr

By importing this layer file we have automatically classified the data with suitable labels. This provides more contextual information about the data. Repeat this process for DLCDv2_2010_2011_NNG_QLD.



2.5. Polygon to Raster

The land cover data has been provided in a raster grid format 250x250m ^{2}. The format and projection of this data has been defined by Geoscience Australia to allow for a consistent and comparable dataset. For simplification the reporting region (Burnett Mary NRM) will also be converted into a comparable raster grid format to streamline data integration. The ESRI ArcMap 'Polygon to Raster' tool enables users to convert polygon features to a raster dataset. Replicate settings as shown below.



Cell assignment is set as Maximum Area (we want the maximum area of a polygon feature with a cell to be signed to that cell) and cell size to 250 which matches the Land Cover data.

Spatial projections

Users should consider how their data has been projected and ensure that this is consistent between years.

Spatial data implicitly has coordinate values in either geographic or projected coordinates. A geographic coordinate system (GCS) uses a three-dimensional spherical surface to define locations on the earth; whereas, a projected coordinate system is defined on a flat, two-dimensional surface. Unlike a geographic coordinate system, a projected coordinate system has constant lengths, angles, and areas across the two dimensions. However, we need to explicitly define the coordinate system of our data. If we have undefined data, then we can use the Define Projection tool to define it.

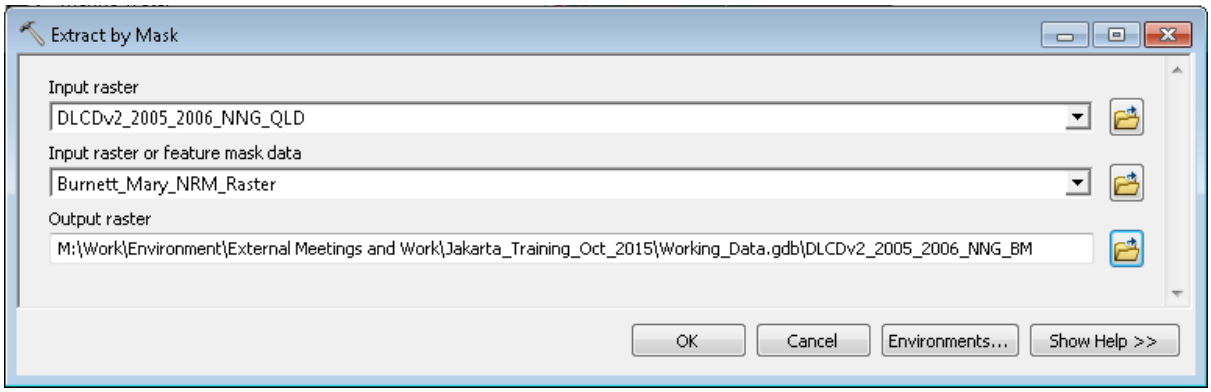
Under Environment Settings tab CHECK output coordinates are in GDA94 Australia Albers and ensure Processing Extent > Snap Raster is set to 'DLCDv2_2010_2011_NNG_QLD'. By default, the output from this tool may have an "undefined coordinate system". If this occurs, you can associate the file with the correct projection (Australia Albers) using the Define Projection tool.

The output of this tool should create a new raster layer 'Burnett_Mary_NRM_Raster' which is a 250x250 metre gridded representing of the original vector NRM boundary. Please note some generalisation will occur around the boundary edges.

2.6. Extract by mask

The land cover data provided covers the entire State of Queensland for both 2005-2006 and 2010-2011. For this study we are only focusing on the Burnett Mary NRM region. It is recommended that users clip the extent of the land cover data to match this study region to reduce processing time.

The ArcMap Extract by Mask tool can be used to extract the cells of a raster that correspond to the areas defined by a mask. In this example the 'DLCDv2_2005_2006_NNG_QLD' is the input raster and 'Burnett_Mary_NRM_Raster' the mask.



This process should also be repeated for the 2010-11 DLCD dataset. The output rasters should be named 'DLCDv2_2005_2006_NNG_BM' and 'DLCDv2_2010_2011_NNG_BM' respectively.

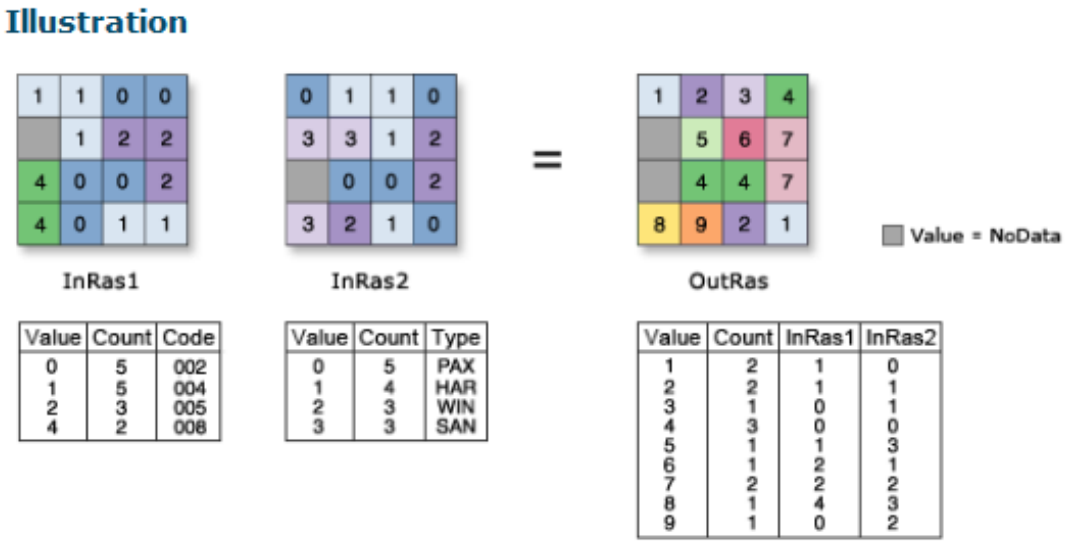
Symbology can be reapplied to these new datasets (see Step 2.4).

2.7. Combine

Next the ArcMap Combine tool will be used to combine the land cover grids (DLCD) for both 2005-06 and 2010-11 into a single raster dataset.

The Combine function assigns a unique value for each combination of values at each location and assigns the value to the value item in the attribute table of the output raster. The original value items, or the alternative field values if specified, are added to the output raster's attribute table: one for each input raster. The name of the input rasters is assigned to the item names. Each of these items carries the unique input combination of values from the input rasters that combined to produce the output value. These items retain the

parentage that was used to produce the values for the output raster. This has been illustrated in the example below:

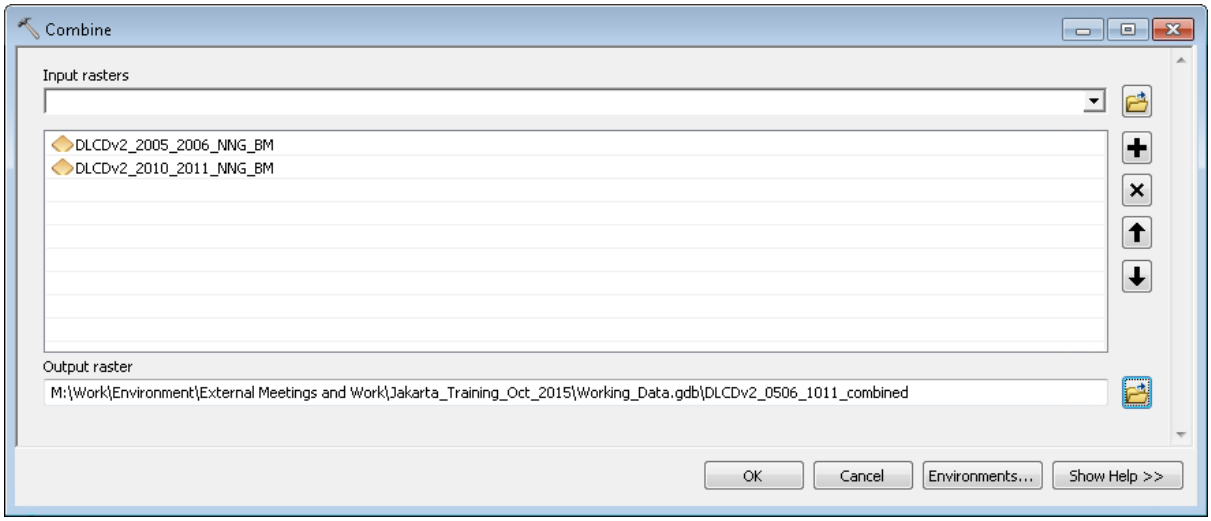


Value	Count	Code
0	5	002
1	5	004
2	3	005
4	2	008

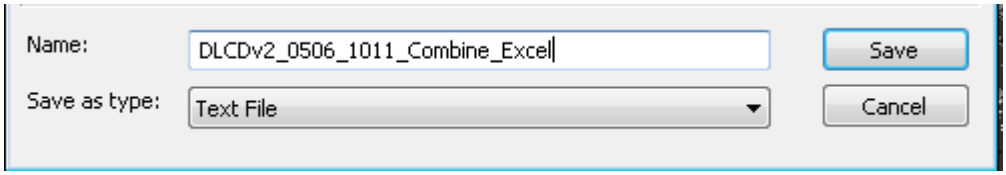
Value	Count	Type
0	5	PAX
1	4	HAR
2	3	WIN
3	3	SAN

Value	Count	InRas1	InRas2
1	2	1	0
2	2	1	1
3	1	0	1
4	3	0	0
5	1	1	3
6	1	2	1
7	2	2	2
8	1	4	3
9	1	0	2

The output file from the Combine tool should be named ‘DLCDv2_0506_1011_combined’.



A copy of the ‘DLCDv2_0506_1011_combined’ layer will also need to be exported as a tabular dataset (i.e. comma delimited file). This file will provide a look-up table between the unique values for each combination of land cover categories between 2005-06 and 2010-11. Right click the ‘DLCDv2_0506_1011_combined’ layer in the ArcMap Table of Contents > Open Attribute Table > Table Options > Export. Set the output table to the working folder \Bandung_Training_Oct_2015\ (not Geodatabase), name the output ‘DLCDv2_0506_1011_Combine_Excel’ and change the Save as type to Text file. Execute the export procedure.

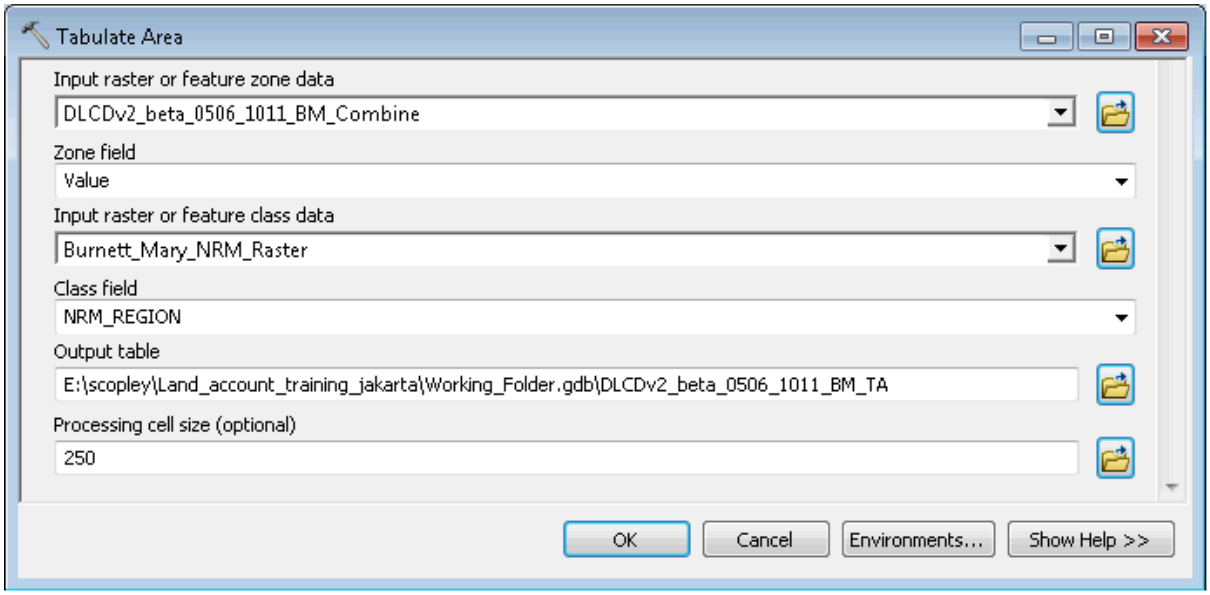


Do not add this output file to the current workspace.

2.8. Tabulate area

The final step in ArcMap involves creating a cross-tabulation between the combined land cover data 'DLCDv2_0506_1011_combined' and the reporting NRM region 'Burnett_Mary_NRM_Raster'.

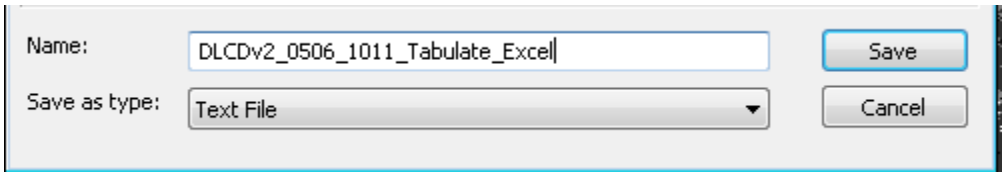
The ArcMap Tabulate Area tool is used to create cross tabulate areas between the two datasets. This is a type of zonal tool which takes a value raster as input and calculate for each cell a function or statistic using the value for each cell and all cells belonging to the same zone. The Zonal tools are grouped by how the zones are specified, by a single input value raster, or by a second zone raster. Replicate the settings as shown below:



Export the table into the \Bandung_Training_Oct_2015\Working_data.gdb\ Geodatabase as 'DLCDv2_0506_1011_Tabulate' .

The output file will be automatically added to your ArcMap workspace. We can now export the results of Tabulate Area to Microsoft Excel.

Right click the 'DLCDv2_0506_1011_Tabulate_Excel' layer in the ArcMap Table of Contents > Open Attribute Table > Table Options > Export. Set the output table to the working folder \Bandung_Training_Oct_2015\ (not Geodatabase), name the output 'DLCDv2_0506_1011_Tabulate_Excel' and change the Save as type to Text file. Execute the export procedure.



Do not add this output file to the current workspace. The physical change and net change matrices of land cover will be constructed from this output table in Microsoft Excel.

CHAPTER 3: Excel data preparation

Following Chapter 1 the land cover data will now be structured in a tabular dataset such as a comma delimited file (.csv). Statistical software such as Microsoft Excel, SAS Enterprise Guide or SPSS can now be used to restructure the data into the SEEA Land Account format. For this study Microsoft Excel has been used due to its availability and simplicity.

3.1. Land cover classification

In Step 2.7 we exported a table called 'DLCDv2_0506_1011_Combine_Excel' as a comma delimited file (csv). This included a unique value for each combination of land cover categories between 2005-06 and 2010-11. This table provides the basis to classifying land cover types for the output land account tables.

Open this .csv in Microsoft Excel (File > Open). You will be presented with the Text Import Wizard. Click Delimited as you file type that best describes the data. The delimiter should then be set to Comma, Next and Finish.

The imported data includes several columns including;

- OBJECTID - count of rows;
- Value - unique identifier for all land cover combinations;
- Count – number of contributors for each unique combination;
- DLCDv2_beta_2005 – land cover codes for 2005-06; and
- DLCDv2_beta_2010 – land cover codes for 2010-11.

Currently the land cover data only includes codes for 2005-06 (DLCDv2_beta_2005) and 2010-11 (DLCDv2_beta_2010). Table 3 below presents the land cover classification applied to Geoscience Australia's Dynamic Land Cover Dataset (DLCD). This is based on the Food and Agriculture Organization (FAO) Land Cover Classification System (LCCS). To provide contextual information to the land accounting tables the land cover codes will need to be labelled in Microsoft Excel.

Table 3. Land cover classification

Land cover code	Land cover label	Land cover description
0	Marine Water	Marine Water.
100	Primarily non-vegetated - terrestrial	Terrestrial non-vegetated areas.
200	Primarily non-vegetated - aquatic or regularly flooded	Aquatic or regularly flooded non-vegetated areas.
300	Cultivated and managed land - irrigated	Cultivated and managed land with artificial application of water to the land or soil.
400	Cultivated and managed land - rainfed	Cultivated and managed land reliant on rainfall for water.
500	Herbaceous vegetation	A plant that has leaves and stems that die down at the end of the growing season to the soil level. They have no persistent woody stem above ground.
600	Woody-shrubs	A small to medium-sized woody plant.
700	Woody-trees	A large sized woody plant.
800	Wetlands	land consisting of marshes or swamps; saturated land.

Add two new column titles to the spreadsheet 'DLCDv2_ 2005_2006_label' and 'DLCDv2_ 2010_2011_label' in 1F and 1G respectively. These will be used to label the land cover codes for both accounting periods.

A nested IF Statement in Microsoft Excel can be constructed to add the land cover labels to the classifications table. The syntax of the IF Statement is =IF (Logic_Test, Value_if_True, Value_if_False). An example of the full nested IF Statement is shown in the screenshot below. It is recommended that users attempt to create this syntax themselves based on the information in Table 3.

	A	B	C	D	E	F	G
1	OBJECTID	Value	Count	DLCDv2_beta_2005	DLCDv2_beta_2010	DLCDv2_beta_2005_label	DLCDv2_beta_2011_label
2	1	1	2,887.00	100	100	Primarily non-vegetated - terrestrial	Primarily non-vegetated - terrestrial
3	2	2	67,491.00	400	400	Cultivated and managed land - rainfed	=IF(E3=0,"Marine Water",IF(E3=100,"Primarily non-vegetated - terrestrial",IF(E3=200,"Primarily non-vegetated - aquatic or regularly flooded",IF(E3=300,"Cultivated and managed land - irrigated",IF(E3=400,"Cultivated and managed land - rainfed",IF(E3=500,"Herbaceous vegetation",IF(E3=600,"Woody-shrubs",IF(E3=700,"Woody-trees",IF(E3=800,"Wetlands",))))))))
4	3	3	2,473.00	200	200	Primarily non-vegetated - aquatic or regularly flooded	
5	4	4	644,660.00	700	700	Woody-trees	
6	5	5	2,034.00	0	0	Marine Water	
7	6	6	32	600	500	Woody-shrubs	
8	7	7	1,871.00	800	800	Wetlands	
9	8	8	42,452.00	500	700	Herbaceous vegetation	
10	9	9	38,178.00	700	400	Woody-trees	

=IF(D2=0,"Marine Water",IF(D2=100,"Primarily non-vegetated - terrestrial",IF(D2=200,"Primarily non-vegetated - aquatic or regularly flooded",IF(D2=300,"Cultivated and managed land - irrigated",IF(D2=400,"Cultivated and managed land - rainfed",IF(D2=500,"Herbaceous vegetation",IF(D2=600,"Woody-shrubs",IF(D2=700,"Woody-trees",IF(D2=800,"Wetlands",)))))))))

Once the syntax has been constructed it can be copied for all cells in column F and G.

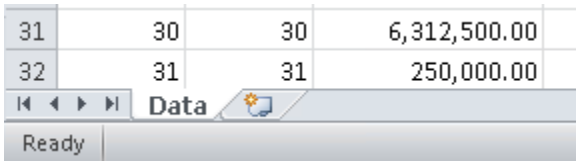
Save this file over the original text file exported from ArcMap 'DLCDv2_0506_1011_Combine_Excel.txt'. This will be converted to a tab delimited format.

3.2. Import and classify tabulated data

Following the same procedure as Step 3.1 import the 'DLCDv2_0506_1011_Tabulate_Excel' and save the results an Excel Spreadsheet (xls or xlsx). This table includes:

- OBJECTID - count of rows;
- Value - unique identifier for all land cover combinations; and
- BURNETT_MARY – NRM region with total area (squared kilometres) of each land cover combination.

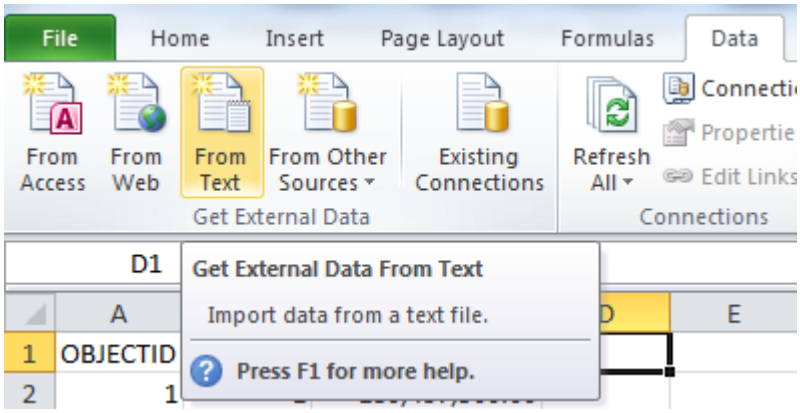
Rename the DLCDv2_0506_1011_Tabulate_Excel worksheet as 'Data'.



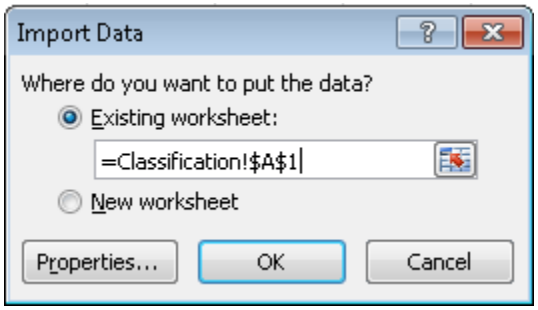
The Value field provides a common identifier between the tabulated land cover data in the Burnett Mary and the classification codes and labels. We will now add the output of Step 3.1 (DLCDv2_0506_1011_Combine_Excel.csv') as a separate tab within the current spreadsheet. This will enable us to link the two together and add the land cover classification to the 'Data' worksheet for both 2005-06 and 2010-11.

In the bottom left of Excel click the Insert Workshop button. This will add a new worksheet called 'Sheet1'. Rename this to 'Classification' .

Open the 'Classification' sheet and navigate to Data tab and click the Get External Data > From Text button



Users will be prompted with an Import Text File window. Navigate and open the DLCDv2_0506_1011_Combine_Excel.txt' file. Import this file as a Tab delimited text file as previously demonstrated in Step 3.1. Import this data in A1 in the existing (Classification) worksheet.



The land cover labels in the 'Classifications' worksheet can now be added to 'Data' worksheet based on the common Value field. The VLOOKUP function in Excel is a simple method which allows us to add data from one worksheet to another. The follow is the syntax for the VLOOKUP function:

VLOOKUP (lookup_value, table_array, col_index_num, [range_lookup])

- **Lookup_value** - The value you want to look up. The value you want to look up must be in the first column of the range of cells you specify in table-array.
- **Table_array** - The range of cells in which the VLOOKUP will search for the lookup_value and the return value.
- **Col_index_num** - The column number (starting with 1 for the left-most column of table-array) that contains the return value.
- **[range_lookup]** - A logical value that specifies whether you want VLOOKUP to find an exact match or an approximate match.

Add two new column names in the 'Data' worksheet 'DLCDv2_2005_2006_label' and 'DLCDv2_ 2010_2011_label' in D1 and E1, respectively. We will populate these columns using the VLOOKUP function with the corresponding land cover labels from the 'Classifications' worksheet. The following is an example of the VLOOKUP function for D2 (DLCDv2_beta_2005_label)

=VLOOKUP(B2,Classification!B1:G39,5,FALSE)

- **lookup_value** is the Value column from the 'Data' worksheet = B2

- **table_array** is the full range of cells starting from the Value column in the 'Classification' worksheet = Classification!B1:G39
- **Col_index_num** is the column number (starting from the table arry range) of the return value, in this case the land cover label for 2005-06 = 5
- **[range_lookup]** is set to FALSE as we want to search on the exact value.

This formula can then be copied across the entire D column. The formula will also have to be replicated for column E (DLCDv2_beta_2010_label) but with a col_index_num of 6.

3.3. Converting units

By default ArcMap produced area calculations in square kilometres based on the Australia Albers projection. However the Australian Bureau of Statistics measures the majority of its area based information in hectares, including land use information the Australian Agricultural Census. Table 4 below provides the conversion table between square kilometres (km^2) and several other common area measurements:

Table 4. Square kilometre conversion

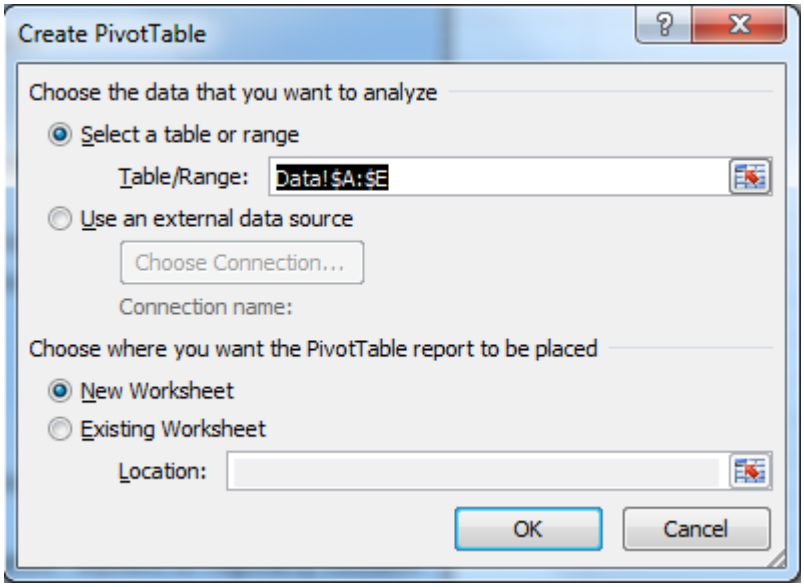
Measurement	**1 km2 is equal to**
Sqaure metres	1,000,000.00
Hectares	100.00
Sqaure miles	0.39
Acre	247.10

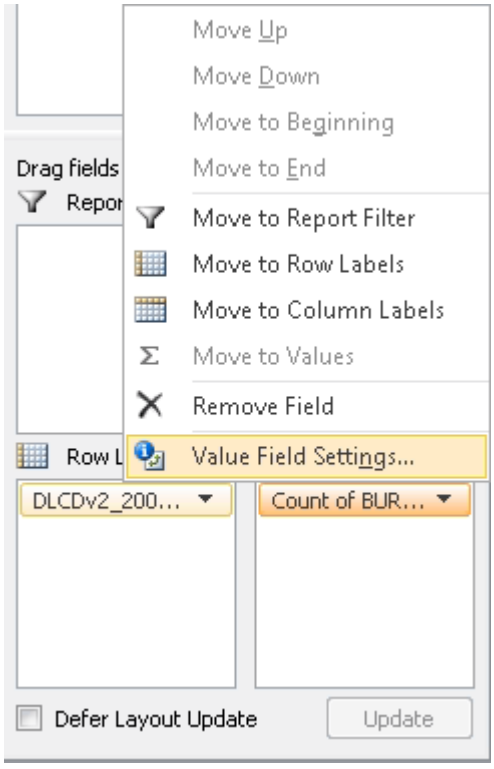
We can convert square kilometres to hectares using Microsoft Excel. This can be done by dividing the km^2 value by 10,000. In the 'Data' worksheet add a new column heading in cell F1 labelled 'BURNETT_MARY_HECTARES'. Insert the formula to convert km^2 to hectares in F2 (=C2/10000) and copy it across that entire column.

It is recommended that countries use the standard measurement which best suits their local requirements for land account data.

3.4. Pivot table

The data will now be transformed into a matrix using Microsoft Excels Pivot table function. Start by selecting all the columns and rows in the 'Data' worksheet. Click the Insert Tab on the Excel toolbar and open the PivotTable tool. Replicate the settings as shown below:





This will create a new worksheet called 'Sheet2' which includes the PivotTable setup menu on the left-hand side. In this example DLCDv2_ 2005_2006_label should be set as the Row Label, DLCDv2_2010_2011_label as the Column label and BURNETT_MARY_HECATRES as the Value.

By default the Value will be presented as a count. This can be changed by clicking 'Count of BURNETT_MARY_HECATRES' under the Value option and navigation to the Value Field Setting (as shown

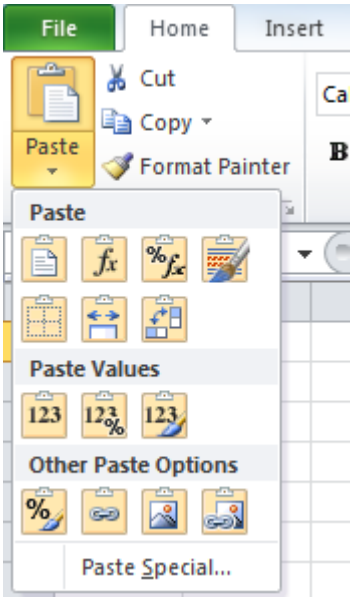
on the left). Change the summarise value field to Sum and click OK. Rename this worksheet as ‘Pivot’.

The information presented in the ‘Pivot’ worksheet shows the total opening and closing stock of land cover in 2005-06 and 2010-11 (Grand totals) and the total (or gross) land area in hectares that remained or moved between categories over this period.

Chapter 4. Land cover net change matrix

A net change matrix is one of the two table structures proposed for land accounts within the System of Environment-Economic Accounts (SEEA) Central Framework 2012. The net change of land cover (2005-06 to 2010-11) can be produced from the information available in the 'Pivot' worksheet.

Unlike total (or gross) change, net change can be positive or negative. It is important to understand that net changes are highly aggregated and need to be used with care. For example, if 100 hectares of agriculture land is lost in one place but added elsewhere, then no net change would be shown across the reporting.

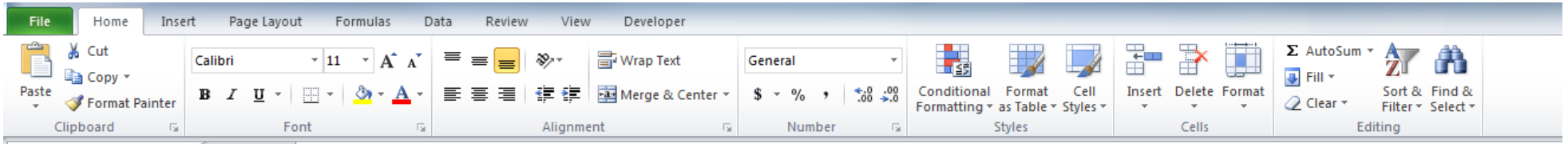


4.1. Copy and format pivot table

A copy of the 'Pivot' worksheet should be pasted into a new worksheet called 'Gross change' at A1. The Values (V) Paste function (as shown on the left) should be used as this provides data only with no excel formulas.

The data pasted in 'Gross change' needs to be reformatted to provide a better structured and functional table. An example of the data is shown in Table 5. Attempt to replicate this format.

Table 5. Total change in land cover 2005-06 to



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Land cover	Cultivated and managed land - irrigated	Cultivated and managed land - rainfed	Herbaceous vegetation	Marine Water	Primarily non-vegetated - aquatic or regularly flooded	Primarily non-vegetated - terrestrial	Wetlands	Woody-shrubs	Woody-trees		Grand Total	
2	Cultivated and managed land - irrigated	99,193.75	6,456.25	1,225.00								**106,875.00**	
3	Cultivated and managed land - rainfed	24,175.00	421,818.75	3,481.25						33,768.75		**483,243.75**	
4	Herbaceous vegetation	1,531.25	79,987.50	241,956.25		262.50		2,718.75	400.00	265,325.00		**592,181.25**	
5	Marine Water				12,712.50							**12,712.50**	
6	Primarily non-vegetated - aquatic or regularly flooded			181.25		15,456.25		1,093.75	75.00	268.75		**17,075.00**	
7	Primarily non-vegetated - terrestrial						18,043.75					**18,043.75**	
8	Wetlands			293.75		1,012.50		11,693.75	62.50	5,193.75		**18,256.25**	
9	Woody-shrubs		12.50	200.00		25.00		25.00	437.50	231.25		**931.25**	
10	Woody-trees		238,612.50	49,362.50		631.25		8,625.00	368.75	4,029,125.00		**4,326,725.00**	
11													
12	**Grand Total**	**124,900.00**	**746,887.50**	**296,700.00**	**12,712.50**	**17,387.50**	**18,043.75**	**24,156.25**	**1,343.75**	**4,333,912.50**		**5,576,043.75**	
13													
14													

4.2. Transpose

A second transposed copy of the total (or gross) change table will copied and pasted in a new worksheet called ‘Gross change transposed’. The Excel Microsoft transpose function returns a vertical range of cells as a horizontal range, or vice versa.

Copy the formatted total (or gross) change table from the ‘Gross change’ worksheet. in cell A1 in ‘Gross change transposed’, navigate to the Paste function and click Transpose (T).

By calculating and subtracting the transposed table form the original we are able to calculate the net changes between the land cover categories over the accounting period.

4.3. Calculating Net change matrix output

Create a new worksheet called ‘Net change matrix’. This will be the output table which presents the land cover net change between 2005-06 and 2010-11 for the Burnett Mary NRM in Queensland.

The basic layout of the net change matrix is shown in Table 1. Attempt to replicate this structure in the ‘Net change matrix’ tab. The net change matrix will be populated from the information available in the ‘Gross Change’ and ‘Gross Change transposed’ worksheets.
In the net change matrix the ‘Opening Stock 2005-06’ and ‘Closing Stock 2010-11’ can be populated from Grand Total column and row in the ‘Gross Change’ worksheet. In this example we will only copy the ‘Opening Stock 2005-06’ which is the column Grand Total in the ‘Gross Change’ worksheet. The ‘Closing Stock 2010-11’ will be manually calculated later in the process.

Copy and paste the land cover ‘Opening Stock 2005-06’ Grand Totals using the Paste Values function. The overall region total (5,576,043 hectares) is not included as the SEEA net change matrix structure does not include an overall row total.

	A	B	C
1	**Land cover**	**Opening Stock 2005-06**	Cultivated and managed land - irrigated
2	Cultivated and managed land - irrigated	**106875**	
3	Cultivated and managed land - rainfed	**483243.75**	
4	Herbaceous vegetation	**592181.25**	
5	Marine Water	**12712.5**	
6	Primarily non-vegetated - aquatic or regularly flooded	**17075**	
7	Primarily non-vegetated - terrestrial	**18043.75**	
8	Wetlands	**18256.25**	
9	Woody-shrubs	**931.25**	
10	Woody-trees	**4326725**	

The net changes are calculated by subtraction the land cover values in 'Gross Change transposed' from 'Gross Change' worksheets. In the 'Net Change matrix' worksheet click in C2 and input the following formula:

='Gross Change transposed'!B2-'Gross Change'!B2

This formula can then be copied across the worksheet to K10. A Total Net Change can also be calculated by summing the individual net changes across each row.

Finally the Closing Stock 2010-11 can be calculated by summing the Opening Stock 2005-06 with the Total Net Change (=SUM). These values should match the Grand Total row in 'Gross Change' worksheet.

The result is the final land cover net change matrix for 2005-06 to 2010-11. Compare your results to Table 6.

What are some of key changes you can identify in this table?

Table 6. Land cover net change matrix

Land cover	Opening Stock 2005-06	Cultivated and managed land - irrigated	Cultivated and managed land - rainfed	Herbaceous vegetation	Marine Water	Primarily non-vegetated - aquatic or regularly flooded	Primarily non-vegetated - terrestrial	Wetlands	Woody-shrubs	Woody-trees	Total Net Change	Closing Stock 2010-11
Cultivated and managed land - irrigated	**106,875.00**	-	17,718.75	306.25	-	-	-	-	-	-	18,025.00	**124,900.00**
Cultivated and managed land - rainfed	**483,243.75**	- 17,718.75	-	76,506.25	-	-	-	-	12.50	204,843.75	263,643.75	**746,887.50**
Herbaceous vegetation	**592,181.25**	- 306.25	- 76,506.25	-	-	- 81.25	-	- 2,425.00	- 200.00	- 215,962.50	- 295,481.25	**296,700.00**
Marine Water	**12,712.50**	-	-	-	-	-	-	-	-	-	-	**12,712.50**
Primarily non-vegetated - aquatic or regularly flooded	**17,075.00**	-	-	81.25	-	-	-	- 81.25	- 50.00	362.50	312.50	**17,387.50**
Primarily non-vegetated - terrestrial	**18,043.75**	-	-	-	-	-	-	-	-	-	-	**18,043.75**
Wetlands	**18,256.25**	-	-	2,425.00	-	81.25	-	-	- 37.50	3,431.25	5,900.00	**24,156.25**
Woody-shrubs	**931.25**	-	- 12.50	200.00	-	50.00	-	37.50	-	137.50	412.50	**1,343.75**
Woody-trees	**4,326,725.00**	-	- 204,843.75	215,962.50	-	- 362.50	-	- 3,431.25	- 137.50	-	7,187.50	**4,333,912.50**

14. Land Account Table – Physical account

A physical account is the second main table structure proposed for land accounts within the System of Environment-Economic Accounts (SEEA) Central Framework 2012. The physical account of land cover (2005-06 to 2010-11) can be produced from the information available in the 'Gross change' worksheet from Step 12.

14.1. Table structure

Create a new worksheet called 'Physical account'. The basic layout of the land cover physical account is shown in Table 2. Attempt to replicate this structure in the 'Physical account' worksheet. The physical account will be populated from the information available in the 'Gross Change' worksheet created in Step 13.1.

1.4.2. Opening and closing stock

As done in Step 13.3 the 'Opening Stock 2005-06' and 'Closing Stock 2010-11' can be populated using the Grand Totals presented in the 'Gross change' worksheet. In this example we will only copy the 'Opening Stock 2005-06' which is the column Grand Total in the 'Gross Change' worksheet. The 'Closing Stock 2010-11' will be manually calculated later in the process.

A Total should also be calculated by summing the 'Opening Stock 2005-2006' across the row (2) in the 'Physical account' worksheet.

	Cultivated and managed land - irrigated	Cultivated and managed land - rainfed	Herbaceous vegetation	Marine Water	Primarily non-vegetated - aquatic or regularly flooded	Primarily non-vegetated - terrestrial	Wetlands	Woody-shrubs	Woody-trees	Total
Opening Stock 2005-06	**106,875.00**	**483,243.75**	**592,181.25**	**12,712.50**	**17,075.00**	**18,043.75**	**18,256.25**	**931.25**	**4,326,725.00**	**5,576,043.75**

14.3. Calculating additions and reductions

In the physical account the additions and reduction represent the total area (hectares) added or removed from an individual land cover category across the accounting period. The 'Gross change' worksheet includes all the necessary information to populate the additions and reduction fields.

The total additions are the sum of the column (Closing Stock 2010-11) values for each land cover class where a movement between classes had been calculated in the 'Gross change' worksheet. In the example below the total additions for 'Cultivated and manage land – irrigated' is the sum of 'Cultivated and manage land – rainfed' (24,175 hectares) and 'Herbaceous vegetation' (1,531.25 hectares). The total additions were 25,706.25 hectares.

Land cover	Cultivated and managed land - irrigated
Cultivated and managed land - irrigated	99,193.75
Cultivated and managed land - rainfed	24,175.00
Herbaceous vegetation	1,531.25
Marine Water	
Primarily non-vegetated - aquatic or regularly flooded	
Primarily non-vegetated - terrestrial	
Wetlands	
Woody-shrubs	
Woody-trees	
Grand Total	124,900.00

Manually calculate the additions for all land covers in the 'Physical account table'. Do not include the value where the land cover remained unchanged, i.e Cultivated and manage land – irrigated' (row) / Cultivated and manage land – irrigated' (column).

The total reductions are the sum of the row (Closing Stock 2005-06) values for each land cover class where a movement between classes had been calculated in the 'Gross change' worksheet. This value should be represented as a negative number. This can be done by subtracting the values from 0. In the example below the total reductions 'Cultivated and

manage land – irrigated' is 0 minus the sum of 'Cultivated and manage land – rainfed' (6,456.25 hectares) and 'Herbaceous vegetation' (1,225 hectares). The total reductions were -7,681.25 hectares.

Manually calculate the total reductions for all land covers in the 'Physical account' worksheet. Do not include the value where the land cover remained unchanged, i.e Cultivated and manage land – irrigated' (row) / Cultivated and manage land – irrigated' (column).

14.4. Reason for change

The physical account also aims to explain the different additions and reductions. However the data used in this study does not provide sufficient contextual information to attribute reasons for change. These categories will remain unpopulated.

Below provides a summary of the reasons for change for the physical accounts. **Does content information exist within your country to populate these categories?**

Managed expansion represents an increase in the area of a land cover type due to human activity. For example, crop areas may be converted to tree-covered areas as a result of silvicultural measures such as planting and seeding, or tree-covered areas may be converted to crop or grassland following tree clearing. Generally, the managed expansion of one land cover type will also lead to the recording of a matching entry for managed regression of the reducing land cover types. A matching entry is not recorded if there is a managed expansion in the total area of land within scope of the account (e.g., in the case of land reclamation).

Natural expansion is an increase in area resulting from natural processes, including seeding, sprouting, suckering or layering. In the case of sparse natural vegetation and terrestrial barren land, the natural loss of vegetation from other vegetation types would lead to increases in these areas. Changes in the extent of permanent snow, glaciers and inland water bodies can also be due to natural variation, in rainfall, for example. Generally, the natural expansion of one land cover type will also lead to the recording of a matching entry

for natural regression of the reducing land cover types. A matching entry is not recorded if there is a natural expansion in the total area of land within scope of the account (e.g., in the case where land is created through volcanic activity or landslide).

Managed regression represents a decrease in the area of a land cover type due to human activity. As for managed expansion, a matching entry is recorded in all cases of managed regression, except in cases where there is a managed regression in the total land area.

Natural regression should be recorded when the area of a land cover type reduces for natural reasons. As for natural expansion, a matching entry is recorded in all cases of natural regression, except in cases where there is a natural regression in the total land area (e.g., the loss of land due to erosion by the sea).

Reappraisals can be upward or downward and can reflect changes due to the use of updated information that permits a reassessment of the size of the area of different land covers, for example, from new satellite imagery or interpretation of satellite imagery. The use of updated information may require the revision of previous estimates to ensure a continuity of time series.

14.5. Finalising physical account

The Closing Stock 2010-11 can be calculated by summing the Opening Stock 2005-06 with the total additions to stock (positive) and total reductions to stock (negative). These values should match the Grand Total row in 'Gross Change' worksheet.

The result is the final physical account of land cover for 2005-06 to 2010-11. Compare your results to Table 7.

What are some of key changes you can identify in this table?

	Cultivated and managed land - irrigated	Cultivated and managed land - rainfed	Herbaceous vegetation	Marine Water	Primarily non-vegetated - aquatic or regularly flooded	Primarily non-vegetated - terrestrial	Wetlands	Woody-shrubs	Woody-trees	Total
Opening Stock 2005-06	**106,875.00**	**483,243.75**	**592,181.25**	**12,712.50**	**17,075.00**	**18,043.75**	**18,256.25**	**931.25**	**4,326,725.00**	**5,576,043.75**
Additions to stock										
Manage expansion										
Natural expansion										
Upwards reappraisals										
Total additions to stock	25,706.25	325,068.75	54,743.75	-	1,931.25		12,462.50	906.25	304,787.50	725,606.25
Reductions to stock										
Managed regression										
Natural regression										
Downward reappraisals										
Total reductions to stock	- 7,681.25	- 61,425.00	-350,225.00	-	- 1,618.75		- 6,562.50	- 493.75	- 297,600.00	- 725,606.25
Closing Stock 2010-11	**124,900.00**	**746,887.50**	**296,700.00**	**12,712.50**	**17,387.50**	**18,043.75**	**24,156.25**	**1,343.75**	**4,333,912.50**	**5,576,043.75**